Scholarly Formation in the Age of AI: A Preliminary Generative Relational Account

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Abstract

This paper develops a preliminary Generative Relational (GR) account of scholarly formation in an environment where artificial intelligence can increasingly support retrieval, synthesis, candidate generation, formalization, translation, and scientific discovery. The analytical object is scholarly formation rather than the volume or polish of scholarly manifestations. The paper proposes that mature scholarship can be studied as an evolving, history-bearing, relationally organized generative capacity. Eight non-exhaustive capacity families organize the inquiry: historical consciousness, relational breadth with systemic understanding, generative attention and problem formation, aesthetic judgment, normative judgment, scholarly translation, generative translation, and epistemic-relational humility. Historical consciousness concerns the reconstruction of concepts through the problems, institutions, material conditions, relations, and prior vocabularies within which they emerged. Relational breadth concerns connections among fields while retaining differences of scale, method, and conceptual language. Generative attention concerns how contingent, ordinary, weak, or unexpected encounters become recognizable as possible origins of inquiry. A comparative analysis of contingency sensitivity then distinguishes problem-formative attention from incipient-change judgment, using the classical *Zhouyi* ideal of knowing minute change as a historically situated interface rather than as validation of divinatory prediction. Aesthetic and normative judgment are separated so that problem formation, intellectual fertility, and research priority remain analytically distinct. Translation is extended from linguistic transfer to movement across conceptual systems, while generative translation concerns the alteration of conditions under which an interlocutor can generate an intelligible counterpart within another language system. Epistemic-relational humility is treated as a capacity for restraining premature projection of one evaluative language system onto another, including where interpretive power is asymmetrically distributed. Human–AI configurations provide a principal stress test without presuming that the identified capacities belong exclusively to human agents. The framework remains preliminary and conceptual. Its capacity architecture requires historical, comparative, ethnographic, educational, and domain-specific empirical investigation before it can support stronger descriptive or normative conclusions.

Keywords: Generative Relational Theory; scholarly formation; problem formation; generative translation; Human–AI scholarship

Preliminary Research Note

This manuscript belongs to the broader Generative Relational (GR) research programme. Its immediate object is scholarly formation: the historically developed configuration of capacities through which scholarship can locate concepts in their generative contexts, relate heterogeneous fields, transform contingent encounters into questions, interpret possible incipient change, judge intellectual and normative significance, translate across language systems, cultivate new understanding in an interlocutor, and exercise restraint in the use of interpretive authority. The paper is motivated partly by recurring observations of mature scholarly practice. Those observations function as heuristic starting points rather than as representative empirical evidence about senior scholars or expertise populations.

The inquiry adopts ontological suspension. The manuscript uses relational, historical, dynamical, and configurational language as analytical representation without inferring an ultimate ontology of knowledge, scholarship, persons, artificial intelligence, or scholarly communities. A Human–AI configuration may therefore be represented as a coupled scholarly system where the representation clarifies dependencies and capacities, while the representation itself does not establish a claim about the ultimate ontological status of the participating agents.

The paper also maintains a distinction between scholarly manifestations and scholarly formation. Texts, proofs, models, lectures, translations, and other outputs can provide evidence concerning scholarly capacities, yet the present framework treats them as partial manifestations whose relation to historical understanding, problem formation, future generativity, judgment, and translational capacity requires separate analysis. This distinction becomes especially salient when AI systems can produce increasingly sophisticated scholarly manifestations under diverse human–AI arrangements.

Formal economy is a governing constraint. The manuscript begins with a minimal representation of a history-bearing scholarly configuration and introduces specialized notation only where an explicit analytical role and inferential scope justify it. External literature is included only after source verification and recording in the manuscript's verification ledger.

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Status. This release-candidate draft contains the complete eighteen-section manuscript after a sixth global revision. The sixth revision adds a bounded educational open problem concerning the cultivation of contingency sensitivity, judgment, and practice in an AI-rich environment. The paper develops scholarly formation as a history-bearing relational generative capacity, integrates eight capacity families through a context-indexed architecture, stress-tests the architecture across Human–AI configurations, and states its principal empirical, normative, disciplinary, cultural, technological, and formal boundaries. The account remains preliminary and requires domain-specific empirical investigation before stronger descriptive, educational, predictive, or normative claims are warranted.

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Statement on the use of language models. The exploratory discussions and preparation of this paper involved OpenAI's ChatGPT. ChatGPT supported exploratory dialogue, literature-oriented source checking, formal reconstruction, argumentative criticism, drafting in LaTeX, and technical checking. The author selected the research questions, supplied the principal conceptual observations concerning scholarly practice, directed and approved the theoretical commitments and epistemic status of the claims, and bears sole responsibility for the manuscript, including its definitions, formal constructions, arguments, conclusions, and errors. Authorship credit remains with the human author.

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1 Introduction

This section establishes the analytical object, motivation, scope, and methodological architecture of the account of scholarly formation developed in this paper. Its role is to distinguish the production of scholarly manifestations from the historically developed capacities through which scholarship becomes intelligible, evaluable, transmissible, and generative across changing relations. The discussion proceeds through six steps. It first defines scholarly formation as the local object of inquiry. It then situates the problem within contemporary AI-mediated changes in scientific and professional knowledge work, introduces a minimal Generative Relational representation of the scholarly configuration, identifies the principal capacity families that organize the manuscript, specifies the status of Human–AI configurations, and closes with the manuscript architecture. The method is conceptual and classificatory, with selective interfaces to empirical research on AI and expertise. The proposed framework is not offered as a universal psychological model of scholars, a psychometric instrument, or a completed theory of expertise. Its immediate purpose is to make several capacities that are often compressed into the broad term *scholarship* available for more precise historical, relational, empirical, and normative investigation.

1.1 Scholarly Formation as an Analytical Object

The contemporary scholarly environment makes it increasingly useful to distinguish the visible products of scholarship from the capacities that support their generation, interpretation, revision, and continuation. A paper, proof, model, lecture, review, translation, dataset, or research proposal can function as a scholarly manifestation. Such manifestations matter because scholarship is communicated, criticized, archived, and institutionally evaluated through them. Their presence, however, provides only partial access to the historical configuration that generated them. Two texts can display similar sophistication while resting on different relations to prior literature, different understandings of the concepts they employ, different abilities to reconstruct the relevant historical problem, and different capacities for extending or revising the argument when circumstances change.

The present paper uses *scholarly formation* to name a broader developmental and relational object. Scholarly formation concerns the evolving configuration through which a person or coupled scholarly system becomes able to locate concepts historically, understand relations among heterogeneous fields, recognize encounters that can generate new problems, discriminate among candidate problems, judge the normative situation of research choices, translate across conceptual systems, facilitate understanding within another system, and regulate the projection of its own categories when encountering different forms of reasoning. The term *formation* emphasizes development through history, practice, relations, institutions, language systems, and repeated encounters with problems. It therefore directs attention toward capacities that can be cultivated, reorganized, weakened, distributed, or partially delegated over time.

This formulation is motivated in part by recurring observations of mature scholarly practice. Experienced scholars can sometimes reconstruct why a concept appeared within a particular historical configuration, identify the limits of earlier conceptual resources, connect apparently distant fields without erasing their differences, notice how a contingent or ordinary phenomenon can become the origin of a research question, distinguish a technically difficult problem from an intellectually fertile one, and reformulate an argument in a language that an interlocutor can inhabit. Some scholars also display a form of restraint in which understanding another conceptual system precedes external evaluation of that system. These observations are analytically suggestive, but they are not treated here as representative empirical findings about senior scholars. Selection effects, disciplinary cultures, institutional prestige, and retrospective idealization can all shape which scholars appear exemplary. The manuscript therefore treats such observations as heuristic prompts whose empirical standing must be examined through relevant literatures and future comparative study.

The paper's central proposal is consequently modest in epistemic status but broad in analytical reach: mature scholarship can be investigated as a history-bearing, relationally organized generative capacity. *History-bearing* indicates that present scholarly capacities depend on accumulated encounters, revisions,

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institutions, conceptual inheritances, and practices. *Relationally organized* indicates that the capacities operate through relations among persons, texts, fields, institutions, tools, languages, and normative structures. *Generative capacity* indicates an ability to produce, reconstruct, extend, translate, and reorganize inquiry rather than merely retain a stock of propositions. The formulation is a research representation. It does not imply that a single invariant essence of scholarship has been identified.

Three distinctions guide the manuscript from the outset. First, information availability and scholarly formation occupy different analytical levels. Access to an archive, database, model, or search system can expand the information available to an inquiry without by itself specifying how the information is historically interpreted, related to other domains, or judged. Second, scholarly manifestations and scholarly capacities require separate analysis. A manifestation can provide evidence of capacity, but the inference depends on provenance, context, interaction, and the task being evaluated. Third, scholarly formation and individual human possession are not identified. Relevant capacities can be distributed across collaborations, institutions, archives, instruments, and AI systems. The paper therefore leaves open the possibility that an analytically useful scholarly unit is a coupled configuration rather than an isolated individual.

These distinctions also limit the manuscript's normative ambitions. The paper does not define a singular ideal scholar to which persons should conform. Different disciplines and historical contexts can privilege different combinations of historical reconstruction, specialization, formal precision, interpretive sensitivity, empirical skill, translational capacity, or practical judgment. The proposed capacity families identify dimensions for inquiry, not a fixed hierarchy of human worth. The normative question of which capacities deserve cultivation, under which institutional conditions, and for which forms of scholarship is treated selectively in the analysis and remains partly outside the paper's scope.

1.2 AI-Mediated Change in Scholarly Manifestations

Artificial intelligence provides an especially revealing context for separating scholarly manifestations from scholarly formation because AI systems can participate in an expanding range of activities that previously functioned as visible indicators of scholarly competence. A major review of AI in scientific discovery documents uses that extend across hypothesis generation, experimental design, data analysis, representation learning, and generative design in scientific domains [1]. In a preregistered experiment involving occupation-specific professional writing tasks, access to ChatGPT reduced completion time and increased assessed output quality within the study's defined task environment [2]. These findings concern distinct domains and should not be generalized into a single measure of scholarly capability. They nevertheless support the narrower claim required here: increasingly capable AI systems can alter the cost and distribution of activities through which scholarly work becomes externally manifested.

The resulting change is wider than automated prose production. Search, retrieval, summarization, coding assistance, mathematical exploration, candidate explanation, translation, literature clustering, and draft generation can all be integrated into research workflows at different stages. The relative ease of producing plausible manifestations can therefore change what a manifestation indicates about the configuration that produced it. A polished literature synthesis may reflect substantial historical understanding, careful AI-assisted retrieval, weak assimilation of generated material, or some combination of these conditions. A technically sophisticated problem may arise from long immersion in a field, automated generation of candidates, cross-domain analogy, or an iterative Human–AI process. The observable artifact alone increasingly underdetermines the developmental route and capacity profile that produced it.

This underdetermination does not by itself establish deterioration in scholarship. AI can extend research capacities, expose scholars to unfamiliar domains, reduce mechanical burdens, support translation, and enlarge the space of candidate problems. The relevant analytical task is therefore to identify which capacities are being redistributed, strengthened, bypassed, or newly coupled under different Human–AI arrangements. The question is relational and developmental rather than reducible to a competition between human and artificial agents.

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Recent large-scale evidence also suggests that individual productivity and collective knowledge development can move in different directions. Hao and colleagues analyzed 41.3 million natural-science papers and reported that AI-augmented scientists were associated with higher publication output, citations, and earlier project leadership, while AI adoption was also associated with contraction in the collective volume of scientific topics studied and reduced engagement among scientists [3]. The study does not establish a universal mechanism for all fields, and its operationalization of AI-augmented research has its own empirical scope. Its relevance to the present paper lies in a more limited point: output expansion, individual advantage, and collective intellectual breadth can diverge. A theory of scholarship organized only around productivity would have difficulty representing this divergence.

The manuscript therefore treats the AI era as a changed condition of scholarly manifestation rather than as evidence for a predetermined conclusion about human superiority, decline, or replacement. AI expands the practical importance of distinctions that were already present in scholarship. Historical information can be retrieved without a corresponding reconstruction of conceptual genesis. Materials from multiple disciplines can be juxtaposed without an adequate account of their relations or incompatibilities. Candidate problems can proliferate faster than a configuration can distinguish encounter-sensitive problem formation from combinatorial question production or apply long-horizon aesthetic judgment to the resulting candidates. Normative recommendations can be generated without resolving the situated conflicts that make them consequential. Linguistic translation can be fluent while leaving the receiving conceptual system structurally unchanged. Simulated perspective-taking can reproduce multiple viewpoints while the distribution of interpretive authority remains unexamined.

These distinctions should not be read as categorical limits on AI systems. The capabilities of AI systems are historically changing, and Human–AI configurations can acquire functions that neither component exhibits in isolation. The manuscript therefore formulates its central contrasts at the level of analytical objects. Retrieval and historical consciousness are different objects even where one system eventually contributes to both. Cross-domain synthesis and systemic understanding are different objects even where an AI-assisted workflow supports both. Candidate-question generation and encounter-sensitive problem formation are different objects even where one system participates in both. Linguistic translation and generative translation are different objects even where future systems participate in both. This object-level distinction enables the framework to remain useful as particular technologies change.

1.3 History-Bearing Relational Generativity

Generative Relational Theory provides a vocabulary for representing scholarly formation without reducing it to an inventory of individual traits. The minimal representation used in this paper treats a scholarly configuration at analytical time t as a history-bearing relational configuration. The provisional schema is stated in Equation 1.

$$\Sigma_t^{\text{sch}} = \big(H_t, \mathcal{R}_t, \mathcal{K}_t, \mathcal{L}_t, \mathcal{N}_t, \mathcal{C}_t\big). \tag{1}$$

In Equation 1, H_t denotes the relevant accumulated history of the scholarly configuration; $\mathcal{R}_t$ denotes its relational organization among persons, communities, institutions, artifacts, instruments, and other participating structures; $\mathcal{K}_t$ denotes knowledge resources currently available to the configuration; $\mathcal{L}_t$ denotes the conceptual and linguistic systems through which problems and claims are articulated; $\mathcal{N}_t$ denotes the normative and institutional environment relevant to scholarly choice; and $\mathcal{C}_t$ denotes the operative capacities available under the configuration at that time. The tuple is deliberately coarse. It is a structural formalization for organizing later distinctions, not an empirically parameterized model and not a claim that scholarship is ontologically composed of six separable substances.

The history term H_t is essential because scholarly competence often depends on relations that are invisible in a static output. A concept can be used accurately at the level of definition while its historical role remains poorly understood. A method can be applied correctly within a familiar class of problems while its boundary conditions remain opaque. A scholar can remember a canonical argument while lacking the sequence of failed approaches, institutional conflicts, technical limitations, or material conditions

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through which the argument acquired significance. The historical component therefore includes more than chronological memory. It represents the paths through which the configuration learned to discriminate relevant problems, reinterpret prior concepts, and identify conditions under which a conceptual move became necessary or productive.

The relational term $\mathcal{R}_t$ similarly extends beyond interpersonal networks. A field of scholarship is structured by relations among disciplines, methods, evidence standards, institutions, archives, funding arrangements, instruments, and conceptual languages. Mature scholarship can involve sensitivity to those relations even when the scholar remains highly specialized in substantive expertise. A physicist need not become a political economist, historian, philosopher, educator, and mathematician simultaneously in order to understand that a scientific problem may interact with mathematical representation, institutional incentives, historical development, educational transmission, and normative consequences. Relational breadth concerns the capacity to recognize such interfaces while maintaining the differences that make the participating fields distinct.

The language-system term $\mathcal{L}_t$ is intentionally broader than natural language. A scholarly language system can include conceptual categories, legitimate forms of evidence, inferential habits, canonical examples, preferred metaphors, disciplinary distinctions, standards of explanation, and historically inherited problem formulations. Two scholars speaking the same natural language can therefore operate within substantially different scholarly language systems. Conversely, scholars using different natural languages can share enough formal, disciplinary, or practical structure to sustain productive translation. Sections 10 and 11 use this broader notion to distinguish translation of manifestations from generative translation, in which the receiving system is supplied with conditions from which an intelligible counterpart can be generated internally.

The normative term $\mathcal{N}_t$ allows the framework to distinguish intellectual evaluation from research priority. A problem can be aesthetically compelling because of its depth, elegance, structural fertility, or ability to reorganize a field. The same problem can occupy a different position within the normative and political-economic conditions of a specific historical situation. Resource constraints, ecological consequences, public risk, distributive effects, institutional responsibilities, and opportunity costs can all affect whether large-scale investment is appropriate. The framework therefore treats aesthetic judgment and normative judgment as related capacities with different analytical roles.

Finally, the term $\mathcal{C}_t$ denotes the operative capacity structure. Capacity is relationally conditioned. A scholar's effective historical reach depends partly on archives and languages; translational capacity depends partly on interlocutors and shared interfaces; judgment can depend on communities of criticism; experimental capability depends on instruments and institutions. Human–AI coupling makes this dependence especially visible because some capacities can be extended through external systems while others may require active assimilation, repeated practice, or institutional support. The later formal development will therefore avoid identifying capacity with an internal property of an isolated individual unless a local analysis justifies that simplification.

Equation 1 also provides the provisional setting for the manuscript's use of generativity. Scholarly generativity refers to the configuration's capacity to produce and reorganize future inquiry under changing conditions. It can include generating problems, reconstructing concepts, establishing relations, revising explanations, translating between systems, identifying limitations, and opening viable continuations for further study. This use of *generativity* concerns the production of structured continuations rather than a simple count of outputs. A prolific configuration can therefore exhibit weak generativity in one dimension, while a less prolific configuration can sustain strong historical, translational, or conceptual continuations. The paper will treat these as empirical possibilities rather than axioms.

1.4 Capacity Architecture of Scholarly Formation

The manuscript develops eight capacity families that emerged from the motivating observations and from their interfaces with scholarship on expertise, judgment, translation, and intellectual practice. Table 1 provides the initial architecture. The categories are provisional and partially overlapping. Their analyti-

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Table 1: Provisional capacity families in the GR account of scholarly formation.

Capacity family	**Analytical role**
Historical consciousness	Reconstructs concepts, methods, and problems through their historical conditions, prior limitations, institutional relations, and downstream transformations.
Relational breadth and systemic understanding	Identifies relations among heterogeneous fields, scales, methods, and conceptual systems while preserving relevant disciplinary differences.
Generative attention and problem formation	Recognizes contingent, ordinary, weak, or unexpected encounters as possible origins of inquiry and articulates candidate problem framings without conflating salience with later intellectual worth.
Aesthetic judgment	Evaluates intellectual fertility, elegance, depth, structural significance, and long-horizon problem worth within a scholarly situation.
Normative judgment	Evaluates research direction and priority in relation to social, ecological, institutional, political-economic, and other normative conditions.
Scholarly translation	Re-expresses a concept through the categories, evidence practices, examples, and inferential conventions of another scholarly language system.
Generative translation	Alters the receiving system's conditions of inquiry so that an intelligible counterpart can be generated within that system rather than supplied only as a finished manifestation.
Epistemic-relational humility	Regulates premature projection of one language system's judgments onto another and supports contextual understanding before external evaluation, including under asymmetric interpretive power.

cal value lies in separating functions that can otherwise be compressed into broad terms such as expertise, intelligence, interdisciplinarity, or wisdom.

Historical consciousness is developed first because concepts become more intelligible when their functions are situated within the problems and relations through which they emerged. The capacity includes the ability to identify why a concept became salient at a particular historical moment, which earlier methods or categories had become insufficient for the relevant problem, and how the concept subsequently altered the available problem space. Historical consciousness therefore differs from possessing many historical facts. Its analytical focus is generative reconstruction of conceptual emergence and transformation.

Relational breadth and systemic understanding concern the organization of knowledge across fields. The relevant distinction is between encyclopedic breadth and relational breadth. Encyclopedic breadth can be approximated by the number of domains, facts, or literatures a scholar can access. Relational breadth concerns the ability to identify dependencies, analogies, historical influences, methodological borrowings, conflicts, shared formal structures, and differences of scale among those domains. The capacity is compatible with disciplinary specialization. Its mature form can support movement across fields while preserving awareness of where translation fails or where concepts change meaning under transfer.

Generative attention and problem formation concern an earlier threshold in inquiry: how something becomes recognizable as a possible question at all. A scholar can encounter an anomaly, an ordinary recurrence, a failed method, a weak signal, a chance exposure, or a conceptual friction and recognize that the encounter can open a new problem space. The same phenomenon can remain background for another configuration. Section 6 therefore treats problem formation as a relational capacity of a history-bearing configuration rather than as an intrinsic property of an event or as a synonym for later aesthetic evaluation.

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Section 7 places this capacity beside a different transformation of contingency: incipient-change judgment. Drawing on selected passages from the *Zhouyi*, it compares the scholarly transformation of an encounter into a problem with the classical sage ideal of detecting minute change as an early manifestation of a developing tendency. The comparison is intentionally non-binary. A proficient scholar can generate questions from contingency while also sensing that the relational conditions surrounding those questions are changing. The resulting higher-order coordination is treated as mediating judgment rather than as a ninth capacity family.

Aesthetic judgment concerns the selection of intellectually worthwhile problems within an expanding candidate space. Scientific and mathematical history contains many cases in which difficulty alone did not determine long-term significance. The present manuscript does not assume a universal definition of intellectual beauty. It treats aesthetic judgment as a historically and disciplinarily situated capacity through which scholars evaluate properties such as elegance, depth, explanatory compression, structural fertility, and the potential of a problem to reorganize further inquiry. AI-assisted problem generation increases the practical importance of examining this capacity because the number of technically plausible or difficult candidate problems can grow faster than the time available for sustained investigation.

Normative judgment is separated from aesthetic judgment because intellectual attractiveness and research priority can diverge. A line of inquiry may be conceptually beautiful while raising substantial questions about resource allocation, ecological cost, social risk, institutional responsibility, or distributive consequence. Conversely, an urgent research programme can carry high normative priority despite limited aesthetic appeal. The distinction permits scholarship to evaluate the worth of a problem within an intellectual language and its priority within a broader relational order without collapsing one evaluation into the other.

Scholarly translation concerns movement between language systems. A conceptual system includes more than terminology, so translation can require reconstruction of examples, evidence standards, inferential habits, disciplinary histories, and the problem that gives a concept its role. A direct verbal substitution can therefore be linguistically accurate while remaining scholastically weak. Mature translation aims at intelligibility within the receiving system while retaining enough of the source structure to make the transformation accountable.

Generative translation extends the translational problem. A scholar can sometimes facilitate understanding by presenting a question, counterexample, analogy, distinction, or problem configuration from which an interlocutor generates the relevant insight within the interlocutor's own language system. The resulting concept need not be a replica of the source manifestation. Its relation to the source can depend on functional, structural, historical, or problem-level correspondences specified through task-indexed criteria in Sections 10 and 11. Generative translation is therefore closely related to non-substitutive teaching: the scholarly act modifies generative conditions rather than merely delivering a completed answer.

Epistemic-relational humility concerns the regulation of interpretation across heterogeneous systems. A scholar operating within a powerful disciplinary, institutional, or linguistic system can possess substantial authority to classify another system from the outside. The present framework treats humility partly as the capacity to restrain premature use of that authority long enough to reconstruct how the other system organizes reasons, evidence, concepts, and problems internally. Such restraint does not preclude later criticism. It changes the sequence and informational basis of criticism. The relation between humility and interpretive power will become important when the paper connects scholarly formation with earlier GR work on relational power.

The eight capacity families are analytically distinct, yet their mature operation is likely to be coupled. Historical consciousness can improve relational comparison by revealing how disciplinary boundaries were generated. Historical consciousness and relational breadth can also prepare the configuration to notice why a weak or ordinary encounter is problem-generating or potentially trajectory-indicative. Generative attention can then enlarge or reorganize the candidate problem space on which aesthetic judgment operates, while incipient-change sensitivity can alter the temporal and practical context in which those problems are evaluated. Relational breadth can enrich aesthetic judgment by exposing structures that remain invisible inside one field. Normative judgment can revise the priority assigned to aesthetically

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attractive projects. Translation depends on historical and relational understanding when a term carries different conceptual genealogies across fields. Generative translation can require humility because the translator must work through the interlocutor's generative conditions rather than impose a finished formulation. These couplings motivate a later section devoted to the relational architecture of the capacities as a system rather than a checklist.

The framework also remains open to additional capacities. Experimental craftsmanship, mathematical intuition, archival skill, empirical design, pedagogical care, collaborative reliability, and institutional navigation can be central to scholarship in particular fields. The eight families in Table 1 were selected because they address the paper's immediate question concerning mature scholarly formation under conditions of abundant informational and generative assistance. They should therefore be understood as a bounded theoretical selection rather than an exhaustive taxonomy of scholarly excellence.

1.5 Human–AI Configurations and Analytical Scope

The paper's use of the term *scholarly formation* does not reserve scholarship to an isolated human individual. Contemporary research already depends on distributed infrastructures: collaborators, editors, archives, databases, instruments, software, laboratories, institutions, and disciplinary communities. AI systems add new forms of participation to this distributed environment. A researcher can use AI for retrieval, candidate generation, coding, translation, critique, simulation, or organizational support; an AI system can in turn depend on human problem formulation, data curation, tool access, evaluation, and institutional context. The analytically relevant unit can therefore vary by research question.

This distributed perspective avoids two premature conclusions. One conclusion would treat any AI contribution as external to scholarly capacity because the human individual did not perform the operation unaided. Such a position would ignore the long history of scholarship as technologically and institutionally mediated practice. Another conclusion would infer scholarly formation directly from the presence of sophisticated AI-generated outputs. Such an inference would ignore differences among access, assimilation, historical understanding, judgment, and capacity for continuation. The GR approach represents these possibilities by asking where a capacity is located, how it is relationally supported, how it persists across time, and what happens when a component is removed or changed.

Naturalistic Decision Making provides one important literature interface for this distributed and situated emphasis. Research in that tradition studies expert practitioners making consequential decisions under conditions such as uncertainty, time pressure, ill-structured problems, shifting goals, and action-feedback loops [4]. The present paper does not equate scholarship with NDM settings, many of which involve operational professions with temporal and practical demands different from academic inquiry. The interface is methodological: expertise can be studied through situated patterns of perception, recognition, action, and experience rather than only through explicit rule possession. Section 2 examines that connection together with adaptive expertise, tacit knowledge, hermeneutics, intellectual history, and intellectual humility.

The Human–AI question is therefore framed as a question about configuration and development. A coupled system can extend historical access without securing historical consciousness; it can also support historical reconstruction through iterative dialogue and source comparison. It can increase cross-domain exposure without creating adequate relational structure; it can also help a scholar discover interfaces that become integrated through further study. It can generate candidate questions without demonstrating that it can preserve unexpected encounters, notice weak signals, or reorganize a problem space around a contingent phenomenon; it can also support those functions through recurrent observation, memory, retrieval, and comparison. It can produce many candidate problems without supplying stable aesthetic judgment; it can also participate in repeated comparison through which a research community's evaluative criteria become more explicit. The framework leaves these pathways open to empirical investigation.

The same openness applies to future AI capacities. The paper does not rely on the claim that generative attention, aesthetic judgment, normative judgment, generative translation, or humility are permanently unavailable to artificial systems. Their current implementation, attribution, and evaluation are

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complex and technology-dependent. The theoretical task is to define the relevant capacities independently enough that changes in implementation do not erase the distinction among them. If an AI system or coupled configuration later satisfies a defensible account of one capacity, the framework should be able to represent that development without conceptual contradiction.

This technology-neutrality also protects the paper from a common analytical compression in AI debates. Discussions framed entirely around replacement can treat scholarship as a bundle of tasks and ask which tasks AI can perform. The present account focuses on the development and organization of capacities across histories and relations. Task performance remains relevant evidence, but the inferential path from task success to scholarly formation requires additional information about historical integration, transfer, judgment, translation, robustness, and continuation. The capacity architecture developed below organizes that additional information.

1.6 Manuscript Architecture

The manuscript develops the account in five analytical movements. Sections 2 and 3 position the proposal relative to existing expertise literatures and establish the minimum GR representation of history-bearing scholarly configurations, relational support, language systems, manifestations, assimilation, and generative continuation. Sections 4–9 then develop historical, relational, problem-formative, aesthetic, and normative capacities. Section 7 interrupts a purely linear sequence by comparing problem formation with incipient-change judgment and by locating mediating judgment at the boundary between scholarly inquiry and wisdom-like practical orientation.

Sections 10–13 develop the cross-system dimension of scholarship. Scholarly translation concerns task-indexed intelligibility across heterogeneous language systems; generative translation concerns interventions that reorganize target-side conditions of inquiry; epistemic-relational humility regulates projection, confidence, and revisability; and interpretive power concerns the conditions under which classifications and translations become consequential for another configuration.

Section 14 integrates these capacities through typed couplings and contextual conditions. Sections 15 and 16 then stress-test the architecture across Human–AI configurations and examine developmental mechanisms including historical study, apprenticeship, interdisciplinary encounter, dialogue, generative teaching, and reflective judgment. Section 17 states the principal descriptive, normative, disciplinary, cultural, technological, and formal boundaries; Section 18 consolidates the resulting research programme.

This structure places AI within a broader theory of scholarly formation. AI changes the practical conditions under which scholarly manifestations are generated, retrieved, translated, and evaluated. The manuscript's deeper object is the evolving capacity architecture through which a scholarly configuration can reconstruct, relate, notice inquiry-generating encounters, discriminate, translate, revise, and continue inquiry across changing historical and relational conditions.

2 Scholarly Expertise and Situated Practice

This section positions the proposed account of scholarly formation relative to established research and philosophical traditions that already explain important features of expert practice. Its role is delimitative as well as constructive: it identifies which parts of the present problem are already supported by work on Naturalistic Decision Making, recognition-based expertise, adaptive expertise, tacit knowledge, historical contextualism, philosophical hermeneutics, and intellectual humility, and it identifies the additional relational architecture developed in the present paper. The discussion is comparative and interpretive. It does not treat these literatures as a single unified theory, because their objects, methods, and evidential bases differ substantially. The common interface is narrower: mature scholarly practice frequently depends on capacities that emerge through situated experience, historical participation, interpretive exposure, and repeated judgment, and these capacities are only partially captured by explicit propositional knowledge.

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Table 2: Literature interfaces for the account of scholarly formation

Literature interface	**Contribution to the present inquiry**	**GR development in the present account**
Naturalistic Decision Making	Situated expert judgment under uncertainty, time pressure, shifting goals, incomplete information, and action–feedback conditions	Extension from operational decision episodes to long-horizon scholarly formation, conceptual history, and relations among heterogeneous knowledge systems
Recognition-primed decision research	Experience-based situation assessment, pattern recognition, and mental simulation in expert action	Analysis of how scholarly recognition itself is historically formed, revised, translated, and normatively evaluated
Adaptive expertise	High-level performance in novel or changing situations; importance of knowledge representation, analogical problem solving, prior experience, and learning orientation	Relational organization among historical, systemic, evaluative, translational, and humility-related capacities
Tacit knowledge	Limits of reducing knowledgeable practice to fully explicit propositions or rules; role of inherited practice and background judgment	Specification of which tacit capacities are relevant to scholarship and how they may be distributed across persons, institutions, archives, and AI-mediated systems
Historical contextualism and hermeneutics	Historical-linguistic situatedness of meaning and the role of historically conditioned horizons in understanding	Formal separation of language systems, interpretive power, generative translation, and history-bearing scholarly configurations
Intellectual humility	Empirically tractable recognition of possible error, openness, ambiguity tolerance, and reduced dogmatism	Extension toward epistemic-relational humility as restraint in projecting one language system's judgment onto another under unequal interpretive power

Table 2 summarizes the principal interfaces used in this section. The table is intentionally asymmetric. The second column records what each literature contributes to the present inquiry; the third states the boundary beyond which the Generative Relational (GR) account still requires additional construction. The boundary claims are analytical judgments of this paper rather than claims made by the cited authors.

2.1 Naturalistic Decision Making

Naturalistic Decision Making (NDM) provides a useful starting interface because it studies competent judgment in environments whose structure differs from simplified laboratory choice tasks. Mosier, Fischer, Hoffman, and Klein characterize NDM research around professional judgment under conditions that can include uncertainty, time pressure, ill-structured problems, shifting goals, and consequential action with feedback [4]. Klein's broader account similarly develops a naturalistic approach from studies of experienced practitioners working under real-world constraints such as high stakes, incomplete information, changing conditions, and personal responsibility [5]. These settings are not equivalent to scholarship. Long-horizon inquiry may permit extended reflection, archival return, formal derivation, peer criticism, and revision over years or decades. The interface lies in the treatment of expertise as situated performance formed through experience rather than as possession of a decontextualized rule set.

This interface matters for the present paper because several observations motivating the account of *scholarly formation* concern capacities visible in practice before they are easily articulated as rules. An experienced scholar may recognize that a proposed analogy crosses incompatible scales, that a concept carries a historical remainder that a contemporary definition suppresses, or that a technically difficult problem lacks sufficient intellectual fertility for sustained investigation. Such judgments can later be

reconstructed in explicit prose, but their initial availability may depend on an accumulated repertoire of cases, failures, disciplinary encounters, and prior conceptual transformations. NDM research supplies a methodological precedent for taking these forms of experienced discrimination seriously as objects of inquiry.

The transfer from NDM to scholarship requires scope discipline. Operational expertise often centers on decisions that culminate in immediate action, whereas scholarship frequently reorganizes the problem representation itself before action becomes well-defined. A scholar may spend substantial effort deciding what the object is, which distinctions matter, which historical comparison is legitimate, and whether the available conceptual language is adequate. The present paper therefore uses NDM as an interface to situated expertise while retaining problem formation, historical reconstruction, cross-system translation, and normative evaluation as separate scholarly objects.

2.2 Recognition and Experienced Situation Assessment

Recognition-based accounts sharpen the role of accumulated experience. Klein's Recognition-Primed Decision model describes experienced decision makers as using situation assessment to recognize a plausible course of action and mental simulation to evaluate how that course may unfold, thereby reducing the need for exhaustive option comparison in familiar but demanding settings [5]. The analytical value for scholarship lies less in importing a decision algorithm than in recognizing that expert performance can depend on structured familiarity with situations, cues, expectations, anomalies, and likely developments.

A scholarly analogue can be stated cautiously. Experienced researchers often encounter a new argument through historically and disciplinarily organized patterns: a proof strategy resembles a known family while violating one of its enabling assumptions; a policy proposal reproduces an older institutional logic under a new vocabulary; a philosophical distinction has analogues in another tradition while serving a different local problem. The relevant expertise therefore includes the capacity to recognize both resemblance and non-equivalence. This dual sensitivity is important for a GR account because relational thinking becomes weak when analogy erases historical or structural difference.

Recognition also helps explain why the visible speed of expert judgment can be misleading. A concise judgment may be the manifested endpoint of a long history of exposure and correction. The temporal economy of the final response can conceal the developmental cost of constructing the repertoire that made the response possible. In scholarly settings, this point cautions against equating rapid answer production with mature formation. A system may generate a plausible classification quickly while lacking the history through which exceptions, counterexamples, and contextual limits became integrated into an expert's repertoire. The manuscript therefore distinguishes the manifestation of a judgment from the history-bearing capacity that supports its reliable revision and transfer.

The recognition interface also provides a bridge to AI without fixing the answer in advance. Contemporary AI systems can identify patterns, retrieve analogues, and generate plausible continuations at high speed. The theoretical question is consequently not whether recognition-like performance is uniquely human. The relevant question is which histories, relations, feedback processes, and correction mechanisms allow recognition to become part of a scholarly configuration whose outputs remain revisable and context-sensitive. That question exceeds the scope of recognition-primed decision theory and becomes part of the GR construction developed in Section 3.

2.3 Adaptive Expertise and Transfer

Adaptive expertise provides a second major interface because scholarly maturity is tested especially strongly when familiar procedures lose adequacy. Bohle Carbonell and colleagues review adaptive expertise as high-level performance in the face of changing tasks and work methods and distinguish it from forms of routine expertise optimized for recurrent conditions [6]. Their review identifies differences associated with knowledge representation, cognitive and analogical problem-solving abilities, prior experience, and environments that support continued learning [6]. The literature is therefore directly rele-

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vant to the paper's concern with capacities that support inquiry beyond stored answers or well-practiced routines.

For scholarly formation, adaptation has at least three analytically distinct forms. A researcher may need to adapt within a discipline when a familiar method meets a new object. A researcher may need to adapt across disciplines when a problem requires translation between different evidential standards or mathematical representations. A researcher may also need to adapt historically when concepts that once organized inquiry cease to fit transformed social, technological, or material conditions. These forms share a requirement for reorganization, yet their mechanisms and constraints can differ substantially.

The GR extension proposed in this paper concerns the relational organization of adaptation. Transfer is rarely a movement of an unchanged competence into an unchanged destination. The target context may alter what counts as an adequate explanation, acceptable evidence, legitimate abstraction, or responsible intervention. A mature scholarly configuration therefore requires sensitivity to transformations in both the object and the evaluative environment. This motivates later separation among historical consciousness, relational breadth, aesthetic judgment, normative judgment, translation, generative translation, and epistemic-relational humility.

Adaptive expertise also places pressure on educational models centered on answer reproduction. Environments that reward efficient repetition can produce strong performance within a stable task family while leaving weaker resources for novelty. Section 16 develops this implication through the paper's account of generative translation and scholarly development. The central educational question becomes how scholarly formation acquires the capacity to reorganize its own problem representation and conceptual resources when the inherited solution space becomes inadequate.

2.4 Tacit Knowledge and Professional Judgment

Polanyi's account of tacit knowing supplies a philosophical interface to the limits of full explicitness. *The Tacit Dimension* develops the thesis that human knowledge includes dimensions that exceed what can be completely stated propositionally and emphasizes the importance of inherited practice, background commitments, and skilled integration in scientific knowing [7]. This tradition is relevant to scholarly formation because many high-level scholarly capacities are expressed through selection, emphasis, timing, comparison, and sensitivity to significance before they are reducible to a complete list of rules.

The present inquiry treats tacitness as a warning against premature formal closure rather than as an exemption from analysis. Aesthetic judgment may contain tacit dimensions, yet examples, comparative cases, training histories, and disagreement patterns can still be studied. Historical consciousness may depend on an acquired feel for anachronism or conceptual displacement, yet historians can articulate methodological constraints that make those judgments more accountable. Translation across language systems may rely on situated sensitivity to audience and conceptual background, yet the relations being translated can still be reconstructed and criticized.

This treatment is especially important in an AI context. Describing a scholarly capacity as tacit does not establish that it is permanently inaccessible to computational systems, nor does successful computational performance establish that the relevant capacity has been exhaustively formalized. Both inferences would exceed the evidence. The safer analytical task is to identify the observable practices, developmental histories, transfer conditions, and correction processes through which a capacity becomes reliable enough to matter for scholarship.

Tacit knowledge also directs attention to social inheritance. Scholarly practice is learned within laboratories, seminars, archives, disciplines, schools of interpretation, professional networks, and informal relations of mentorship. The history-bearing scholarly configuration introduced later therefore includes institutional and relational support rather than locating every relevant capacity inside an isolated individual. Some scholarly capacities may be distributed across people and artifacts; others may depend on repeated participation in communities whose evaluative norms are only partly codified.

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2.5 Hermeneutic and Historical Interfaces

The historical dimension of scholarly formation has two important interfaces in intellectual history and philosophical hermeneutics. Skinner's methodological intervention in the history of ideas criticizes readings that detach texts from the linguistic and historical contexts within which authors could intelligibly act and argues for attention to what authors were doing in making particular utterances in particular contexts [8]. The relevance to this paper is structural: a concept's meaning and intellectual role can depend on the problems, conventions, available vocabularies, and interventions that made its use possible at a given historical moment.

This contextualist interface supports the paper's distinction between historical information and historical consciousness. Knowing that a concept appeared in a particular year, text, or school provides useful information. Historical consciousness demands a richer reconstruction of the local problem field: which alternatives were available, which distinctions carried practical force, which conventions were being preserved or contested, and which subsequent developments altered the concept's function. Section 4 develops this capacity without assuming that a single contextualist methodology exhausts legitimate intellectual history.

Gadamer's philosophical hermeneutics provides a complementary interface. *Truth and Method* treats understanding as historically conditioned and places language, tradition, and historically effected consciousness at the center of hermeneutic experience [9]. Within the present paper, this orientation helps resist the fiction of a view from nowhere in scholarly interpretation. A scholar approaches another text, discipline, or conceptual system through an already formed horizon that shapes which distinctions are initially visible and which questions appear natural.

The GR development begins where historical and hermeneutic situatedness meets explicit relational heterogeneity. Two language systems may organize evidence, analogy, abstraction, normativity, and disciplinary legitimacy differently. Understanding across them therefore involves more than recovering lexical meaning. It can require reconstruction of the generative conditions that make a proposition intelligible within each system. Sections 10–13 distinguish scholarly translation from generative translation and examine how unequal interpretive power affects which system acquires authority to define the other.

Historical contextualism and hermeneutics also introduce a productive tension. Contextual reconstruction protects against anachronistic assimilation, while dialogue with historical or foreign conceptual systems can generate new questions that exceed original intentions. The present framework preserves both possibilities by separating reconstruction from subsequent evaluation and transformation. A scholar can seek faithful contextual understanding first and later use the reconstructed material within a different inquiry, provided the transition remains explicit.

2.6 Intellectual Humility and Epistemic Practice

Empirical research on intellectual humility provides a further interface for the paper's treatment of scholarly restraint. Leary and colleagues operationalize intellectual humility around recognition that one's beliefs may be wrong and report associations with openness, curiosity, tolerance of ambiguity, and reduced dogmatism across their studies [10]. This work supplies an empirically tractable account of fallibility recognition and belief-related openness. It also helps distinguish humility from lack of commitment: a person can hold substantive beliefs while maintaining sensitivity to the possibility of error.

The present paper retains that fallibilist component and extends the object in a relational direction. Scholarly encounters frequently occur across language systems whose categories, evidence rules, historical memories, and institutional authority differ. Epistemic-relational humility therefore concerns the capacity to delay premature projection of one system's evaluative operators onto another long enough to reconstruct the other system's internal relations and historical formation. The delay is methodological rather than absolute. External criticism remains available after contextual understanding, and some cases may require rapid normative response when material harm or safety constraints are present.

This extension also connects humility to power. Interpretive authority is unevenly distributed across languages, journals, universities, funding systems, legal institutions, technical platforms, and globally

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dominant disciplines. A scholar located within a powerful system can possess the practical ability to classify another system before understanding it on its own terms. Humility under these conditions includes restraint in the exercise of interpretive power. Section 13 examines that problem directly.

The distinction between psychological humility and epistemic-relational humility should remain visible. A person can display low interpersonal arrogance while still imposing a dominant conceptual system on another tradition. Conversely, a forceful critic can undertake careful contextual reconstruction before disagreement. The paper therefore treats intellectual-humility research as an important interface rather than a complete model of the scholarly capacity under investigation.

2.7 Positioning of the GR Account

The literature considered in this section supports several elements of the paper's motivation. Expertise can be situated and experience-dependent; expert recognition can compress long histories of exposure into rapid judgments; adaptive expertise concerns competent response to novelty; knowing can contain tacit dimensions; understanding is historically and linguistically conditioned; and fallibility recognition can support more open epistemic practice. These insights significantly reduce the amount of conceptual territory that a GR account needs to claim as novel.

The remaining problem concerns architecture. The present paper asks how eight capacity families can be represented as distinct yet mutually conditioning elements within a history-bearing scholarly configuration: historical consciousness, relational breadth, generative attention and problem formation, aesthetic judgment, normative judgment, translation, generative translation, and epistemic-relational humility. It also asks how those capacities are distributed across persons, institutions, archives, communities, and AI-mediated tools; how power affects translation and interpretation; and how the configuration changes over time. Table 2 records these residual tasks while preserving the heterogeneity of the contributing literatures.

This positioning establishes a methodological constraint for the remainder of the paper. GR formalization should organize relations among the capacities while preserving the differences among psychological evidence, historical interpretation, philosophical argument, educational practice, and computational implementation. An empirical association measured in intellectual-humility research has a different evidential status from a hermeneutic argument about historically conditioned understanding; a field observation in NDM has a different inferential structure from a conceptual claim about translation. The framework gains coherence by relating these objects without collapsing their methods.

Section 3 therefore develops a minimal formal architecture rather than a synthetic theory of expertise. It specifies the history-bearing scholarly configuration, its relational and institutional supports, its knowledge resources and language systems, the distinction between scholarly manifestations and generative capacities, and the temporal status of its development. That construction will provide the common relational vocabulary through which the later capacity-specific sections can communicate while retaining their local disciplinary constraints.

3 Generative Relational Foundations of Scholarly Formation

This section develops the minimum Generative Relational (GR) architecture required for the later analyses of individual scholarly capacities. Its foundational role is to identify the analytical objects through which historical consciousness, relational breadth, judgment, translation, and humility can be discussed within a common vocabulary while preserving their distinct functions. The section proceeds through six steps. It first refines the notion of a history-bearing scholarly configuration introduced in Section 1. It then distinguishes relational and institutional support from internal possession, separates knowledge resources from language systems, formalizes the difference between scholarly manifestations and generative capacity, represents temporal development and assimilation, and states the ontological and empirical limits of the formalism. The method is structural and conceptual. The notation is intended to organize

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relations among objects and possible transformations; it is not an empirically parameterized dynamics and does not establish an ultimate ontology of scholarship.

3.1 History-Bearing Scholarly Configurations

Equation 1 introduced a scholarly configuration at analytical time t as $\Sigma_t^{\text{sch}} = (H_t, \mathcal{R}_t, \mathcal{K}_t, \mathcal{L}_t, \mathcal{N}_t, \mathcal{C}_t)$. The present section treats the components of that tuple as analytical projections of one history-bearing configuration. They are separated because different questions require different projections, yet their empirical realization can overlap. A journal archive, for example, can be represented as part of the accessible knowledge resources $\mathcal{K}_t$, as an institutional relation within $\mathcal{R}_t$, and as a source of disciplinary conventions that participate in $\mathcal{L}_t$. The tuple therefore records six analytical functions whose empirical realizations can overlap.

The history term H_t requires particular care. A history-bearing configuration is not defined merely by attaching a chronological record to an otherwise static state. The analytical claim is stronger and more specific: some present capacities can depend on the path through which the configuration was formed. A scholar who has repeatedly encountered failed analogies between two fields can possess a different sensitivity to scale and domain boundaries from a scholar who has access to the same final literature but has not undergone comparable cycles of comparison and correction. Likewise, a research group can preserve an institutional memory of experimental failures through protocols, notebooks, oral instruction, and review practices even when no single member remembers the complete sequence.

For the purposes of this paper, H_t therefore denotes the relevant prior trajectory of transformations through which the current configuration became available. The word *relevant* prevents the history term from becoming an unrestricted biography of every participating person or institution. Relevance is indexed to the scholarly question under investigation. An analysis of historical consciousness may require intellectual genealogy, archival encounters, and disciplinary training. An analysis of experimental craftsmanship may require laboratory apprenticeship and instrument history. An analysis of Human–AI scholarship may require interaction history, prompting practices, model changes, correction episodes, and provenance records. The contents of H_t are consequently selected by an explicit research question rather than assumed to be exhaustive.

This representation supports a path-dependence distinction without presuming that every scholarly capacity is path-dependent to the same degree. Two configurations can have similar presently accessible resources while differing in the histories through which those resources have been interpreted and incorporated. The resulting difference may matter for transfer, error recognition, explanation, or continuation. In other cases, a resource can be used effectively with little dependence on a prior personal trajectory because the relevant knowledge is stabilized in external procedures, software, institutions, or documentation. The framework leaves both possibilities open and treats a static resource inventory as only one projection of scholarly formation.

Definition 3.1 (History-bearing scholarly configuration)**.** A *history-bearing scholarly configuration* is an analytically specified configuration Σ_t^{sch} whose present capacities and relations are evaluated together with the subset of prior transformations H_t that is relevant to the scholarly function under investigation. The definition permits those transformations to be distributed across persons, communities, artifacts, institutions, and computational systems.

Definition 3.1 makes the unit of analysis intentionally flexible. An individual researcher can be the local unit when the question concerns personal conceptual development. A laboratory can be the unit when experimental competence depends on shared instruments, routines, and records. A Human–AI workflow can be the unit when a capacity emerges through repeated interaction and tool use. A scholarly tradition can be the unit when the object is the historical persistence and transformation of a conceptual language. The choice of unit should therefore follow the scholarly function being explained rather than an a priori commitment to methodological individualism or technological holism.

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3.2 Relational and Institutional Support

The relational component $\mathcal{R}_t$ records how scholarly capacities are supported, constrained, and distributed. The term includes interpersonal relations, yet its intended scope is wider. Access to archives, laboratory instruments, editorial institutions, funding, disciplinary communities, computational infrastructure, legal permissions, educational systems, and communication platforms can alter what a scholarly configuration is able to do. A capacity attributed to a person can consequently depend on relations that are external to the person's body while remaining stable enough to function as part of ordinary scholarly practice.

This point motivates a distinction between *local possession* and *relational availability*. Local possession concerns capacities that remain available under a specified reduction of external support. Relational availability concerns capacities that can be reliably realized within a recurring configuration of supports. The distinction serves a diagnostic function and carries no intrinsic evaluative ordering. Relationally available capacity is not thereby inferior to locally possessed capacity. Contemporary scholarship routinely depends on libraries, notation systems, instruments, peer criticism, and software. The distinction becomes analytically important when support conditions change or when a scholarly output is used as evidence about an individual actor.

A minimal support representation can be introduced without specifying a complete network model. Let $S_t(c)$ denote the set of supports treated as materially relevant to the realization of capacity $c \in \mathcal{C}_t$ under the local task definition. The word *relevant* is deliberate: the representation does not claim that every listed support is causally necessary, jointly sufficient, or minimal. Those stronger dependency claims require domain-specific evidence. The support representation is stated in Equation 2.

$$S_t(c) \subseteq \{\text{persons, communities, artifacts, institutions, instruments, computational systems}\}_t. \quad (2)$$

Equation 2 is a typing device rather than a numerical model. It allows an investigator to ask which supports are constitutive for a particular realization of a capacity, which are substitutable, and which failures materially change the capacity profile. Historical consciousness can depend on access to archives and secondary scholarship; normative judgment can depend on communities capable of articulating affected interests; experimental competence can depend on instruments and technicians; generative translation can depend on an interlocutor whose responses expose whether a proposed conceptual bridge is actually generative.

The support relation also clarifies why institutional conditions belong inside the analysis of scholarly formation. Institutions do more than provide resources. They stabilize categories, authorize evidence practices, allocate time, create incentives, define legitimate outputs, and distribute interpretive authority. A researcher trained within one disciplinary institution can therefore inherit a language system and evaluative repertoire through relations that are only partly explicit. Institutional support can enlarge generativity by preserving archives, sustaining criticism, and funding long-horizon inquiry. It can also narrow generativity by rewarding standardized manifestations, constraining admissible questions, or excluding alternative conceptual systems. The GR representation keeps these possibilities visible without assuming a single normative direction.

Power enters the support relation whenever actors or institutions can alter another configuration's options, classifications, resources, or interpretive standing. The present section uses one bounded implication of the paper series' broader theory of relational power. Scholarly capacities are exercised within support structures whose accessibility and authority can be asymmetrically distributed. Section 13 develops this implication through language systems and interpretive authority.

3.3 Knowledge Resources and Language Systems

The distinction between $\mathcal{K}_t$ and $\mathcal{L}_t$ is necessary because access to information and the organization of intelligibility perform different analytical functions. The knowledge-resource component $\mathcal{K}_t$ contains materials currently available for use: texts, datasets, remembered propositions, proofs, examples, models, empirical observations, databases, generated candidates, and other resources that can enter inquiry.

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Table 3: Foundational objects in the GR representation of scholarly formation

Object	Analytical role	Illustrative diagnostic question
H_t	Relevant prior transformations through which the present configuration was formed	Which encounters, revisions, failures, inheritances, or interactions materially affect the present scholarly function?
$\mathcal{R}_t$	Relations and supports among persons, institutions, artifacts, instruments, communities, and computational systems	Which relations enable, constrain, stabilize, or distribute the capacity being attributed?
$\mathcal{K}_t$	Knowledge and informational resources currently accessible to the configuration	Which materials can the configuration retrieve, recall, inspect, or manipulate for the task?
$\mathcal{L}_t$	Conceptual, linguistic, evidential, and inferential structures through which resources become intelligible	Which distinctions, evidence rules, problem framings, and standards of explanation organize interpretation?
$\mathcal{N}_t$	Normative and institutional conditions relevant to scholarly choice and priority	Which obligations, risks, resource constraints, responsibilities, and affected relations condition research direction?
$\mathcal{C}_t$	Operative scholarly capacities available within the configuration	Which scholarly functions can be reliably realized, revised, transferred, or reconstructed under specified conditions?

The language-system component $\mathcal{L}_t$ concerns the structures through which those resources become interpretable and actionable: concepts, distinctions, admissible inferential moves, evidence conventions, problem framings, metaphors, standards of explanation, and historically stabilized categories.

The distinction can be illustrated by a simple case. Two configurations can access the same archive while asking different questions of it because their conceptual distinctions differ. Conversely, two configurations can share a conceptual language while possessing unequal archives, linguistic access, or computational retrieval. The first difference is primarily represented through $\mathcal{L}_t$; the second through $\mathcal{K}_t$ and the relevant support relations in $\mathcal{R}_t$. In practice, the components interact. New resources can induce changes in a language system, and a changed language system can make previously available resources newly salient.

Table 3 summarizes the analytical roles of the principal objects used in this section. The table also states a diagnostic question for each object so that later empirical or historical work can operationalize the formalism without treating the notation as self-validating.

Two further separations prevent circularity in the tuple. The normative-condition component $\mathcal{N}_t$ records the obligations, risks, institutional rules, affected relations, and other normative circumstances represented as relevant to the inquiry; it does not itself perform normative judgment. Normative judgment is an operative capacity within $\mathcal{C}_t$ that interprets and evaluates research choices in relation to such conditions together with evidence, alternatives, uncertainty, and responsibility. Likewise, $\mathcal{C}_t$ is a container for task-relevant scholarly capacities rather than a duplicate of the other five components: a capacity can depend on history, relations, resources, language systems, and normative conditions without being reducible to any one of them.

The distinction between knowledge resources and language systems is particularly important in AI-mediated scholarship. A model can enlarge $\mathcal{K}_t$ by retrieving literature, proposing examples, summarizing debates, or generating candidate derivations. The same interaction may or may not modify $\mathcal{L}_t$. A researcher can copy a generated explanation without incorporating its conceptual distinctions, or can use repeated dialogue to reorganize how a problem is represented. The framework therefore keeps increased access analytically separate from equivalent formation. The relevant empirical question is how resources become assimilated into the configuration and how that assimilation changes subsequent interpretation and generation.

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Language systems can themselves be plural within one scholarly configuration. A researcher can move among mathematical, legal, historical, philosophical, and policy vocabularies without reducing them to a common metalanguage. The framework therefore permits $\mathcal{L}_t$ to contain partially overlapping systems whose translations are incomplete. This plurality matters because one function of mature scholarship can be the preservation of difference while building enough relational structure for comparison or dialogue. Sections 10 and 11 develop this problem through scholarly translation and generative translation.

3.4 Scholarly Manifestation and Generative Capacity

The central analytical distinction of the paper concerns the relation between what a scholarly configuration produces and what it is able to continue generating. A *scholarly manifestation* is an observable or recordable product through which some part of scholarly activity becomes available to others: a paper, proof, explanation, model, translation, review, lecture, dataset, design, or documented judgment. A manifestation is important evidence. It can be compared, criticized, archived, cited, and evaluated. It nevertheless provides only a projection of the configuration that produced it.

Let q denote a specified scholarly task and ξ the local conditions under which the task is performed. The set of manifestations that a configuration can produce for that task is represented in Equation 3.

$$\mathfrak{M}_{q,\xi}(\Sigma_t^{\text{sch}}) = \{m : \ m \text{ is an admissible scholarly manifestation produced under } (q, \xi)\}. \tag{3}$$

Equation 3 does not require manifestations to be deterministic. Multiple outputs can be compatible with the same configuration and task, and stochastic or collaborative systems can generate different manifestations across repetitions. The representation is useful because it distinguishes performance at a specified interface from the broader capacity structure that supports future inquiry.

Generative capacity is represented at a different level. Let $\mathfrak{G}(\Sigma_t^{\text{sch}})$ denote the set of scholarly transformations or continuations that the configuration can sustain under a stated domain and support condition. Examples include reconstructing the origin of a concept, revising an argument after criticism, transferring a method to a new domain, identifying a failed analogy, generating a new problem from a contradiction, translating a concept across language systems, or reorganizing research priorities after normative conditions change. The continuation representation is stated in Equation 4.

$$\mathfrak{G}(\Sigma_t^{\text{sch}}) = \{\gamma : \ \gamma \text{ is a viable scholarly continuation from } \Sigma_t^{\text{sch}}\}. \tag{4}$$

The term *viable* is intentionally local. A continuation can be viable relative to a field, task family, timescale, institutional setting, support envelope, or evidential standard. These scope indices are suppressed in the notation because the continuation object is meant to contain multiple possible next scholarly tasks rather than one fixed interface task of the kind indexed in $\mathfrak{M}_{q,\xi}$. Any empirical use of $\mathfrak{G}$ must therefore declare the domain and support conditions under which viability is being assessed. Equation 4 does not define a universal scalar quantity of generativity. Its purpose is to make continuation space available as an object of comparison. Future empirical work could operationalize parts of this set through transfer tasks, longitudinal problem development, error correction, explanation under perturbation, or demonstrated capacity to regenerate an argument after support is removed.

The distinction between Equations 3 and 4 yields a central claim of the paper.

Claim 3.2 (Manifestation equivalence and generative non-equivalence)**.** Similarity or equivalence between scholarly manifestations under a specified task does not, by itself, establish similarity or equivalence between the history-bearing generative capacities of the configurations that produced them.

Claim 3.2 states an epistemic constraint on inference; its status is not a theorem about every pair of scholarly systems. Equivalent manifestations can sometimes be strong evidence of equivalent capacity, especially when the task probes transfer, explanation, revision, and robustness across varied conditions.

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The claim concerns the insufficiency of output similarity alone. Two configurations can produce the same answer through different histories, supports, language systems, or degrees of assimilation. Their future continuation spaces can therefore differ even when one local manifestation is indistinguishable.

The converse relation also requires caution. Different manifestations need not imply different scholarly capacities. Two scholars can express the same underlying distinction through different disciplinary vocabularies; two language systems can generate different surface formulations that preserve relevant structure; a Human–AI configuration can produce a manifestation unlike that of an unaided human while sustaining comparable continuation functions. The preservation and equivalence questions developed elsewhere in the broader GR programme therefore remain typed: the relevant level, relation, task, and retained characteristic must be specified before equivalence is inferred.

This manifestation–generativity distinction also clarifies why authorship, provenance, and explanation matter without reducing scholarship to any one of them. Provenance can reveal which supports and transformations participated in an output. Explanation can probe whether a configuration can reconstruct relations that the output compresses. Revision after perturbation can test whether the underlying capacity survives changes in wording or task structure. None of these procedures provides a complete measure of scholarly formation, yet each can supply evidence about the configuration behind the manifestation.

3.5 Temporal Development and Assimilation

Scholarly formation is developmental because the configuration changes through encounters, study, criticism, tool use, institutional transitions, successful and failed inquiries, and transformations in the surrounding language and normative environment. The paper therefore represents development as an update of the whole configuration, with accumulation inside $\mathcal{K}_t$ as one possible component of that update. A minimal update rule is stated in Equation 5.

$$\Sigma^{\text{sch}}_{t+1} = \mathcal{F}_t\big(\Sigma^{\text{sch}}_t, \Delta_t\big), \tag{5}$$

where Δ_t denotes the bundle of task-relevant encounters and changes occurring between the two analytical times. Depending on the inquiry, Δ_t can include reading, experiment, dialogue, criticism, institutional change, migration across disciplines, AI interaction, archival discovery, failure, or a change in material and normative conditions. The map $\mathcal{F}_t$ is not specified as a deterministic learning law. It indicates that formation can alter several components simultaneously and that the transformation rule itself may vary historically.

This update representation allows the paper to distinguish *acquisition* from *assimilation*. Acquisition occurs when a new resource becomes accessible within $\mathcal{K}_{t+1}$. Assimilation concerns a broader transformation in which the new resource changes how the configuration can interpret, relate, judge, translate, reconstruct, or continue inquiry. Assimilation can therefore involve changes in H_t, $\mathcal{R}_t$, $\mathcal{L}_t$, $\mathcal{N}_t$, or $\mathcal{C}_t$ as well as changes in $\mathcal{K}_t$.

Definition 3.3 (Scholarly assimilation)**.** A newly acquired resource is *scholarly assimilated* relative to a specified inquiry when its incorporation produces a relevant and sufficiently stable change in the configuration's interpretive, relational, evaluative, translational, or generative organization. Mere external retrievability of a manifestation or record is insufficient for this attribution.

Definition 3.3 is deliberately graded. Assimilation need not be complete, permanent, or internally located. A mathematical technique can be assimilated well enough to support transfer within one problem class while remaining weakly understood historically. A historical narrative can reorganize conceptual interpretation without changing experimental skill. An AI system can function as part of an assimilated workflow when repeated interaction, provenance practices, correction routines, and task decomposition become stable features of the scholarly configuration. Conversely, generated text can remain weakly assimilated when the user cannot reconstruct, revise, or appropriately transfer its central distinctions.

The distinction between acquisition and assimilation provides a precise way to formulate one challenge of AI-mediated scholarship while keeping the evaluative status of AI use open. Generative systems

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can accelerate acquisition by expanding the volume and speed of accessible material. They can also support assimilation through dialogue, comparison, simulation, critique, and repeated reformulation. The developmental question is which transformations actually occur in Σ_t^{sch} and whether the resulting changes persist across tasks and contexts. That question is empirical and can produce different answers for different scholars, systems, disciplines, and stages of training.

Temporal development also permits loss, narrowing, and reorganization. A configuration can gain one capacity while weakening another; institutional specialization can deepen local competence while reducing cross-domain translation; automation can preserve output quality while eroding a skill that was previously maintained through repeated practice; new conceptual languages can reveal possibilities while making older distinctions less salient. Equation 5 therefore represents formation as transformation whose direction can include growth, loss, narrowing, and reorganization. This openness is retained in the later analyses of scholarly development and Human–AI coupling.

3.6 Representation Status and Ontological Suspension

The formalism in this section is intentionally modest. The tuple Σ_t^{sch}, the task-relative support set $S_t(c)$, the manifestation set $\mathfrak{M}_{q,\xi}$, the locally scoped continuation set $\mathfrak{G}$, and the update map $\mathcal{F}_t$ are analytical representations. They identify distinctions that later historical, interpretive, educational, computational, or empirical studies can investigate. They do not establish that scholarship possesses a unique state space, that the listed components are ontologically fundamental, or that scholarly development follows a Markovian or deterministic dynamics.

Several limitations follow from this status. First, the decomposition can be refined differently for different domains. Laboratory science may require explicit representation of instruments, experimental organisms, and material infrastructures. Mathematics may require greater attention to proof practices, notation, and problem traditions. Historical scholarship may require richer treatment of archives, source criticism, and historiographical languages. Second, the present formalism does not provide numerical measures of the eight capacity families. Any operationalization would require domain-specific tasks, validity arguments, and evidence that the measurement procedure captures the intended scholarly function rather than a convenient proxy.

Third, the representation maintains ontological suspension. GR language about configurations, relations, histories, capacities, and transformations is used because it supports analysis of how scholarly functions are generated and sustained. The framework does not infer an ultimate metaphysics of mind, agency, knowledge, or artificial systems from the usefulness of that representation. A capacity can be attributed at the level of a coupled configuration without deciding whether the relevant causal or phenomenal properties belong ultimately to a person, an institution, an AI system, or some deeper ontological substrate.

Fourth, formal separation does not imply causal independence. Historical consciousness can alter aesthetic judgment; institutional power can shape language systems; translation can reorganize knowledge resources; normative conflict can transform research priorities; AI-assisted retrieval can change the relational organization of a project. The manuscript analyzes these couplings selectively. The present section supplies the shared vocabulary required to state these couplings while preserving distinctions among forms of scholarly maturity.

The resulting foundation can be summarized as a sequence of analytical commitments. Scholarly formation is represented through a history-bearing configuration rather than a static inventory. Capacity can be relationally available and institutionally supported. Knowledge resources and language systems are distinguished because access and intelligibility perform different functions. Manifestations provide evidence of scholarship while leaving generative capacity partially underdetermined. Development concerns transformation and assimilation across time rather than accumulation alone. Formal notation remains a revisable representation under ontological suspension. These commitments provide the common structure for Section 4, which examines the first capacity family in detail: historical consciousness and the reconstruction of conceptual genesis.

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4 Historical Consciousness and Conceptual Genesis

This section develops historical consciousness as the first substantive capacity in the proposed architecture of scholarly formation. Its role is to specify what exceeds historical retrieval when a scholar explains how a concept, method, or problem became intelligible within a particular historical and relational configuration. The objective is therefore narrower than a general philosophy of history and broader than factual recall. The discussion proceeds through the historical locus of a concept, the problem constellation and conceptual repertoire available within that locus, the intervention performed by a new formulation, its subsequent uptake and transformation, and the implications of AI-mediated historical retrieval. The method is interpretive and structural. Historical contextualism and conceptual history provide important methodological interfaces, while the Generative Relational (GR) contribution lies in representing historical consciousness as a capacity of a history-bearing scholarly configuration rather than as possession of historical information alone.

4.1 Historical Consciousness as Generative Reconstruction

Historical information and historical consciousness perform different functions within the framework established in Section 3. Dates, quotations, bibliographic records, archival documents, biographies, and chronologies can enter the accessible resource set $\mathcal{K}_t$. Historical consciousness concerns what a scholarly configuration can do with such resources. It includes the capacity to reconstruct how an object of inquiry became possible, salient, contestable, or authoritative within a particular historical field and how that object's meaning and function changed through subsequent relations.

The distinction matters because a concept can be known propositionally while remaining historically flattened. A contemporary definition may state how a term is used in a present discipline while suppressing the problem situation within which earlier formulations acquired their force. Conversely, a historian can accumulate many facts about a concept while leaving unclear why those facts belong to one explanatory sequence. Historical consciousness therefore requires organization of evidence into a revisable account of conceptual genesis, intervention, uptake, and transformation.

Skinner's methodological intervention in intellectual history supplies one important interface. His critique of decontextualized histories of ideas emphasizes the danger of attributing timeless questions or later conceptual categories to historical actors whose linguistic conventions and available descriptions differed from those of the interpreter [8]. Koselleck's conceptual history provides a complementary interface by examining semantic change, historical temporality, and the relations between conceptual vocabularies and changing social-historical conditions [11]. The present paper does not combine these approaches into a single historiographical method. It uses them to support a narrower scholarly requirement: mature historical understanding attends to the conditions under which concepts were usable and to the transformations through which their later meanings became possible.

Definition 4.1 (Historical consciousness in scholarly formation)**.** Within the present framework, *historical consciousness* is the capacity of a scholarly configuration to construct, criticize, and revise evidence-sensitive accounts of how a concept, problem, method, or practice emerged within a historically situated relational field, how it intervened in an available repertoire, and how its subsequent uptake altered later possibilities of inquiry.

Definition 4.1 treats historical consciousness as generative because the reconstruction changes the present space of intelligibility. Recovering why an earlier distinction mattered can reveal assumptions hidden by contemporary usage, reopen alternatives that later standardization suppressed, and clarify which parts of a concept can travel into a new domain without carrying its original function unchanged. Historical inquiry therefore contributes to present scholarly generativity when it enlarges or reorganizes the set of questions, comparisons, and conceptual continuations that a configuration can responsibly entertain.

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Table 4: Provisional dimensions of generative historical reconstruction

Dimension	Analytical object	Scholarly function
Historical locus	Relevant temporal, spatial, linguistic, institutional, material, and relational conditions	Locates the concept within the field in which it became intelligible and usable
Problem constellation	Questions, conflicts, anomalies, practical pressures, or newly salient distinctions identified in the historical record	Clarifies what the formulation was responsive to without assuming that one problem had one necessary solution
Available repertoire	Concepts, methods, metaphors, classifications, evidence practices, and inherited alternatives available to relevant actors	Establishes the historically available space of formulation and comparison
Tensions and limits	Documented difficulties, contested assumptions, failed applications, exclusions, or perceived inadequacies in the available repertoire	Identifies pressures for revision while preserving the difference between contemporaneous evidence and retrospective judgment
Conceptual intervention	New distinctions, redescriptions, methods, recombinations, or problem formulations introduced by the object under study	Specifies what changed in the local language or practice
Historical uptake	Adoption, rejection, institutionalization, translation, controversy, or selective reuse	Tracks how relational environments conditioned the intervention's practical and intellectual effects
Conceptual afterlife	Later reinterpretations, descendants, abandoned branches, and changes in problem space	Connects genesis to subsequent transformation without treating later outcomes as predetermined

4.2 Historical Locus and Relational Conditions

A concept's historical locus is more than a date and geographic coordinate. The relevant locus can include linguistic conventions, institutions, material infrastructures, political conflicts, disciplinary boundaries, technologies of inscription, educational arrangements, and relations of authority. Which elements matter depends on the object and the historical question. A mathematical notation may require attention to proof practices and communication networks; a political concept may require legal institutions, rhetorical conventions, and conflicts over authority; a scientific method may require instruments, laboratories, measurement practices, and prior theoretical commitments.

This relational specification prevents historical context from becoming an unlimited background category. Context is analytically useful when the historian can state how a selected relation bears on the interpretation or genesis under investigation. The GR representation therefore treats historical reconstruction as question-indexed in the same sense that Section 3 treats the history component H_t as relevant rather than exhaustive. A historical account need not reconstruct an entire society in order to explain one conceptual transformation; it should identify the relations whose inclusion materially changes the interpretation.

Table 4 provides a provisional profile for such reconstruction. The dimensions are analytical prompts rather than mandatory stages. Their ordering is also non-causal: several can develop recursively, and evidence discovered at a later stage can require revision of the proposed historical locus or problem constellation.

The table makes historical consciousness structurally different from a chronology. Chronology is indispensable evidence, yet temporal ordering alone does not identify the relations among a problem, an available repertoire, a conceptual intervention, and later uptake. The historian must justify those relations through sources and remain open to alternative reconstructions. In this sense, historical consciousness contains both a synthetic capacity and a discipline of evidential restraint.

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4.3 Problem Constellations and Available Repertoires

The motivating observation for this paper concerns scholars who can explain why a concept emerged in a particular historical situation, which problems it addressed, and why preceding resources did not settle those problems. This description captures an important scholarly capacity, yet the phrase "preceding resources were insufficient" requires methodological qualification. Historical actors may experience a conceptual repertoire as inadequate, inconsistent, politically constrained, or unable to address newly salient phenomena. Later interpreters may identify additional limitations that were unavailable or unimportant to the actors themselves. These two forms of judgment have different evidential status.

Historical consciousness therefore reconstructs a *problem constellation* rather than assuming an objective problem waiting for a uniquely correct concept. A problem constellation can contain practical pressures, intellectual anomalies, normative conflicts, institutional changes, new measurements, new populations of cases, or tensions among inherited commitments. The historical question asks which of these were actually salient to relevant actors and which are retrospective analytical categories introduced by the present scholar.

The corresponding *available repertoire* is the set of concepts, methods, classifications, metaphors, and inferential practices that can be shown to have been available within the selected historical field. Skinner's contextualist argument is particularly important here because it directs attention to historically available linguistic conventions and guards against making an earlier author answer a question formulated only by later vocabularies [8]. The GR vocabulary adds a relational emphasis: availability itself can be uneven. A concept may exist somewhere in the archive while remaining inaccessible across linguistic, institutional, class, geographic, or disciplinary boundaries. What matters for a local historical reconstruction is therefore relational availability within the configuration being studied, not bare existence in the total historical record.

Caution 4.2 (Retrospective necessity)**.** A successful later concept should not be treated as the historically necessary answer to an earlier problem merely because later scholarship organizes the sequence around that concept. Historical reconstruction should distinguish contemporaneously documented tensions and perceived inadequacies from retrospective judgments about what earlier actors *should* have recognized.

Caution 4.2 protects the generative character of history from teleology. If a later formulation is presented as the inevitable solution latent in an earlier problem, alternative historical branches disappear from view. A more generative reconstruction can preserve unrealized alternatives, rejected proposals, competing vocabularies, and paths that became unavailable through institutional or political change. These branches matter because they reveal that present conceptual order is one historically stabilized configuration among several possibilities that may once have been live.

This point also affects interdisciplinary learning. When a contemporary scholar imports a concept from another field, knowing the original problem constellation can indicate which features were functional responses to that field and which may survive translation. Historical consciousness thereby supports relational breadth without licensing superficial analogy. It supplies information about the conditions under which a concept's internal relations were generated.

4.4 Conceptual Intervention and Historical Uptake

A concept becomes historically significant through more than its first articulation. Historical consciousness also asks what the formulation did within its local field and what relations enabled or constrained its uptake. A conceptual intervention may create a distinction, redescribe an existing object, unify previously separate cases, reorganize evidence, establish a new problem, or make an older question less salient. These functions should be inferred from historical evidence rather than from the later fame of the concept.

The same formulation can also have different functions across communities. Institutional adoption can standardize one meaning while controversy preserves another. Translation into a new language or discipline can change the concept's extension, normative force, or evidential requirements. Educational

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systems can detach a concept from the controversy that generated it and transmit a compressed textbook manifestation. Such stabilization can be useful for cumulative work, yet it can also conceal historical alternatives and produce the impression that present categories were always available in their current form.

Koselleck's conceptual history is useful at this point because it treats concepts as historically changing semantic structures embedded in transformations of social and temporal experience rather than as fixed labels attached to unchanged objects [11]. The present GR account extends this insight into the architecture of scholarly formation. A scholar with historical consciousness can track a concept through multiple relational configurations and ask which properties were preserved, which were reinterpreted, and which new functions emerged. The resulting analysis interfaces directly with the equivalence and preservation problems developed elsewhere in the broader GR programme, although the present paper does not require a formal equivalence classification for each historical case.

Historical uptake also introduces power. Institutions differ in their ability to stabilize terminology, authorize archives, define curricula, fund research programmes, and determine which interpretations become canonical. Consequently, the historical afterlife of a concept can reflect both intellectual fertility and asymmetries of dissemination or interpretive authority. A mature reconstruction therefore avoids inferring intrinsic intellectual superiority directly from historical dominance. Section 4 treats this point as an epistemic requirement; Section 13 returns to interpretive power as a distinct scholarly and normative problem.

4.5 Conceptual Afterlives and Path-Dependent Understanding

The historical consciousness proposed here extends in both temporal directions. Reconstruction moves backward from a present concept toward its conditions of emergence and forward from its early articulation toward later descendants, reinterpretations, and abandoned branches. These directions are linked because later use often changes what earlier formulations appear to mean. Gadamer's account of historically effected understanding provides a philosophical interface for this point: interpretation occurs from within historically conditioned horizons, and the interpreter's own historical position participates in the encounter with a text or tradition [9]. The present paper treats this as a reminder that historical reconstruction is itself situated rather than a view from outside history.

Path dependence enters scholarly formation when the route through a concept's history changes present discrimination. A scholar who has encountered only a current textbook definition may possess a useful local resource. A scholar who has also studied competing earlier formulations, failed applications, later appropriations, and disciplinary translations may be able to distinguish cases that the compressed definition merges. The two configurations can therefore contain overlapping propositional knowledge while supporting different continuation spaces.

This difference should not be romanticized. Historical depth can become ornamental erudition when it does not alter interpretation, comparison, judgment, or inquiry. The relevant criterion within the present framework is assimilation. Historical material becomes part of scholarly formation when its incorporation changes the configuration's capacity to reconstruct, discriminate, revise, translate, or generate questions. Section 3 defined this process as scholarly assimilation. Historical consciousness is one domain in which the distinction between acquisition and assimilation becomes especially visible.

The relation to generativity is consequently conditional. Historical reconstruction can increase generativity by reopening suppressed alternatives, exposing contingent assumptions, and identifying relations that a contemporary abstraction hides. It can also constrain irresponsible novelty by showing that a supposedly new proposal repeats an older structure whose limitations are already documented. Both functions enlarge the quality of the continuation space even when one expands possibilities and the other removes poorly supported ones. Generativity in this paper therefore concerns viable continuation rather than sheer proliferation of candidate ideas.

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4.6 AI-Mediated Historical Retrieval and Scholarly Assimilation

AI systems alter the practical environment of historical scholarship by making retrieval, summarization, comparison, translation, and candidate narrative generation increasingly accessible. The present framework does not infer from this change that historical consciousness remains exclusively human. It instead separates several functions that can be distributed differently across Human–AI configurations.

A system can retrieve a date, locate references, summarize a debate, or generate a plausible genealogy. These manifestations can materially improve inquiry. Historical consciousness, however, is attributed at the level of a scholarly configuration only when the relevant configuration can also maintain evidential provenance, distinguish contemporary evidence from retrospective synthesis, compare competing reconstructions, expose uncertainty, revise the historical locus when new evidence appears, and connect the reconstruction to later conceptual judgment or inquiry. The distinction is functional rather than species-based.

This formulation yields an AI-era asymmetry between access and assimilation. AI can greatly lower the cost of accessing historical manifestations while leaving open whether the resulting material changes the scholar's operative language system and generative capacities. A researcher can receive a fluent historical narrative without being able to identify which claims rest on primary evidence, which are interpretive synthesis, which alternatives were excluded, or which present categories have been projected backward. Conversely, iterative Human–AI work can support historical assimilation when it enables source comparison, counterexample search, alternative periodization, multilingual access, and repeated correction within a provenance-aware workflow.

The practical consequence is that historical retrieval should be evaluated through continuation rather than fluency alone. A historically informed scholarly configuration should be able to use the reconstruction to answer further questions: which part of a concept depended on its original institution; which distinction survived later translation; which apparent predecessor was named retrospectively; which alternative branch remained possible; and what evidence would force the current genealogy to change. These tasks probe the generative organization behind a historical manifestation.

4.7 Methodological Boundaries and Interface with Relational Breadth

Historical consciousness is not a single transferable method that can be applied identically across disciplines. Intellectual history, history of science, legal history, economic history, mathematical history, and histories grounded in oral or material traditions employ different sources and standards of inference. The present framework therefore specifies a capacity architecture rather than a universal historiographical protocol. Domain-specific historians remain necessary for determining what counts as adequate evidence and responsible contextualization in each field.

The archive itself also has a relational history. Preservation, destruction, classification, translation, colonial extraction, institutional privilege, and unequal literacy can shape which voices remain available for reconstruction. Absence from an archive does not by itself establish historical absence, while surviving documentation does not guarantee representative importance. Historical consciousness consequently includes sensitivity to the conditions under which evidence became preservable and retrievable. This problem will later connect historical understanding to interpretive power and epistemic-relational humility.

The capacity developed in this section can now be stated in compact form. Historical consciousness reconstructs conceptual genesis through a selected historical locus, identifies problem constellations and relationally available repertoires, distinguishes contemporaneous tensions from retrospective judgments, traces intervention and uptake, follows later transformation, and keeps the reconstruction revisable under new evidence. Its value for scholarly formation lies in how these operations reorganize present understanding and future inquiry.

Historical consciousness and relational breadth are coupled but distinct. Historical reconstruction can clarify why contemporary fields stand in particular conceptual, methodological, or institutional relations; relational breadth adds the capacity to work with those structured relations while preserving differences

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of scale, method, and language.

5 Relational Breadth and Systemic Understanding

This section develops relational breadth and systemic understanding as the second substantive capacity in the proposed architecture of scholarly formation. Its role is to specify what distinguishes mature cross-domain understanding from the accumulation of information drawn from many fields. The objective is to identify the operations through which a scholarly configuration can preserve disciplinary differences, recognize warranted relations among heterogeneous domains, and use those relations to reorganize inquiry without flattening local methods or concepts. The discussion proceeds through knowledge domains as relationally situated structures, typed cross-domain relations, methodological and scale differences, historical borrowing and transformation, analogical correspondence, and practical criteria for relational breadth. The method is conceptual and comparative. Research on interdisciplinarity supplies an important interface because it emphasizes integration across bodies of specialized knowledge, while the Generative Relational (GR) contribution lies in representing breadth as a capacity to construct and revise typed relations whose validity remains conditional on domain, scale, language, and evidential warrant.

5.1 Knowledge Domains as Relational Structures

The motivating observation for this paper concerns scholars whose intellectual movement across fields appears unusually fluid. A conversation may pass from physics to political economy, mathematics, philosophy, or education without treating those fields as isolated repositories. Such movement does not by itself establish mature breadth. Rapid switching can remain superficial when a speaker transfers vocabulary without understanding the evidential standards, objects, scales, or historical conditions that give the vocabulary local meaning. Relational breadth therefore concerns the organization of relations among domains rather than the number of domains from which terms can be retrieved.

Interdisciplinary research provides a useful established interface. The National Academies defined interdisciplinary research in terms of integrating information, data, techniques, tools, perspectives, concepts, or theories from multiple disciplines or bodies of specialized knowledge in order to advance understanding or address problems whose solutions exceed one field [12]. A later instructional synthesis similarly treats integration of disciplinary insights as a defining feature of interdisciplinarity and emphasizes the difficulty created by different disciplinary modes of thinking and research practice [13]. These accounts already move beyond juxtaposition. The present framework addresses a related but somewhat different analytical object: the formation of a scholar or scholarly configuration capable of recognizing what kinds of relations can responsibly connect domains before, during, and after any particular interdisciplinary project.

Within the GR representation introduced in Section 3, a knowledge domain can be treated provisionally as a structured scholarly region rather than as a fixed natural kind. A domain may contain characteristic objects, questions, methods, evidence practices, vocabularies, institutions, historical lineages, and normative commitments. Its boundaries can be porous, contested, and historically changing. The representation therefore avoids assuming that disciplines are timeless or mutually exclusive compartments.

For a question q at time t, the relevant cross-domain configuration is represented in Equation 6.

$$\mathfrak{D}_t^{(q)} = \big(\mathcal{D}_t^{(q)}, \mathcal{E}_t^{(q)}, \tau_t, \omega_t\big), \tag{6}$$

where $\mathcal{D}_t^{(q)}$ is the set of domains made relevant by the inquiry, $\mathcal{E}_t^{(q)}$ is the set of proposed relations among them, τ_t assigns each relation a type, and ω_t records the evidential or interpretive warrant presently available for that relation. Equation 6 is a structural representation rather than an empirical model. Its purpose is to make explicit that cross-domain understanding requires more than the declaration that two fields are connected.

The question index q matters. The same pair of domains may be related differently under different inquiries. Mathematics and physics may be connected through formal modeling in one problem, through

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the history of instrumentation in another, and through philosophy of explanation in a third. A relation that is useful for one problem should therefore not be generalized automatically into a global identity between disciplines.

Definition 5.1 (Relational breadth)**.** Within the present framework, *relational breadth* is the capacity of a scholarly configuration to identify, type, justify, compare, and revise relations among heterogeneous domains while preserving the domain-specific distinctions required for responsible interpretation and inquiry.

Definition 5.1 makes breadth a relational capacity. It includes the ability to move across domains, yet it also includes the discipline to stop a transfer when the relevant relation is weak, unverified, scale-inappropriate, or dependent on a metaphor that has ceased to preserve the source structure.

5.2 Disciplinary Difference and Cross-Domain Relation

Cross-domain understanding requires simultaneous attention to relation and difference. A field boundary can be institutionally contingent while still marking real differences in method, evidence, scale, or object of inquiry. Conversely, two fields with distinct institutional identities may share mathematical structures, historical sources, measurement practices, or normative problems. Relational breadth therefore treats disciplinary identity as neither absolute separation nor automatic commensurability.

A useful scholarly operation is to ask what is being related. The relation may concern objects, methods, formal structures, explanatory aims, data, institutions, values, or historical inheritance. Two domains can be closely related along one dimension and distant along another. For example, an optimization method may transfer from operations research to public policy while the normative meaning of an objective function changes substantially. A dynamical-system metaphor may illuminate path dependence in a social process while leaving the interpretation of state variables and causal mechanisms unresolved. A historical analogy may organize comparison while remaining too weak to support prediction.

Table 5 gives a provisional taxonomy of cross-domain relations relevant to scholarly formation. The categories can overlap, and their purpose is diagnostic rather than exhaustive.

The table helps distinguish relational breadth from undifferentiated interdisciplinarity. A scholar who says that economics and ecology are connected has specified little. A more mature account might identify a material constraint relation between ecological processes and production, a measurement interface between environmental and economic indicators, a normative tension concerning intergenerational distribution, and a historical relation through the evolution of industrial institutions. Each relation can then be evaluated on its own evidence and assumptions.

This typed approach also preserves negative results. A proposed relation may fail. A concept imported from one field may prove incommensurate with the receiving field's measurement practice; a formal analogy may break at the point where interpretation becomes essential; an apparent historical influence may lack documentary support. Relational breadth includes the ability to retain such failed translations as information about domain boundaries rather than treating them as obstacles to be rhetorically erased.

5.3 Methodological and Scale Relations

Systemic understanding frequently requires movement among methods and scales. Such movement is especially vulnerable to category errors because the same word can refer to different analytical objects at different levels. A "state" in a dynamical model, a "state" in political theory, and a "state" in ordinary language do not acquire equivalence through lexical identity. Likewise, a statistical association at a population level does not automatically specify a mechanism at an individual level, and a microscopic physical model does not automatically provide a normative account of institutions that depend on interpretation and law.

Relational breadth therefore requires explicit bridge conditions. When a scholar transfers a method, the relevant questions include what inputs the method presupposes, what output it licenses, what error

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Table 5: Provisional types of cross-domain relation in relational scholarly breadth

Relation type	Analytical content	Primary caution
Historical influence	Documented transmission, inheritance, reaction, or institutional co-development across domains	Later similarity does not establish historical influence
Method transfer	Movement of a technique, instrument, protocol, or inferential procedure into a new domain	Performance and validity conditions can change after transfer
Formal correspondence	Shared mathematical, logical, computational, or structural representation	Formal similarity does not establish equivalence of interpretation or mechanism
Scale relation	Connection among phenomena investigated at different temporal, spatial, organizational, or analytical scales	Micro–macro or local–global transitions require explicit bridge assumptions
Conceptual translation	Reconstruction of a concept in another disciplinary language or problem space	Terminological similarity can conceal different inferential roles
Analogical relation	Partial correspondence used to generate hypotheses, explanations, or questions	Analogy supports exploration only to the extent that relevant relations are preserved
Constraint or dependence	One domain supplies boundary conditions, feasibility constraints, or explanatory dependencies for another	Dependence can be asymmetric and need not imply reduction
Normative tension	Different domains encode competing values, priorities, responsibilities, or standards of acceptable action	Technical integration does not resolve normative disagreement

model accompanies it, and whether the receiving domain supplies objects that satisfy those assumptions. When a scholar connects scales, the questions include which variables are preserved, aggregated, emergent, or lost and whether the relation is explanatory, predictive, constitutive, or merely heuristic.

This requirement is consistent with the methodological pluralism established in the writing principles of the broader GR programme. Historical, interpretive, qualitative, quantitative, formal, and computational methods provide partially irreducible forms of access. Relational breadth does not assign one method universal priority. It asks how methods can constrain or inform one another under a particular inquiry while preserving the limits of each mode of access.

A compact criterion can be stated without introducing a universal metric. A cross-domain relation becomes stronger when the scholarly configuration can specify the source object, target object, relation type, preserved structure, lost structure, bridge assumptions, and available evidence. The relation remains weaker when these elements are left implicit. This criterion is deliberately procedural: the present paper does not propose a scalar score for interdisciplinarity or breadth.

5.4 Historical Influence and Conceptual Borrowing

The historical consciousness developed in Section 4 is one enabling condition for relational breadth because many contemporary relations among fields were generated through earlier episodes of borrowing, institutional reorganization, or shared problem formation. The National Academies report notes that techniques can migrate across fields and become sufficiently assimilated that their foreign origin is no longer salient [12]. This observation is important for the present framework because it shows that cross-domain relations can become historical components of a receiving discipline rather than remaining external bridges.

Borrowing, however, can transform both the imported object and the receiving domain. A technique can be reparameterized, a concept can change inferential role, and a metaphor can become formalized.

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Historical influence is therefore better represented as a generative relation than as transport of an unchanged object. The relevant scholarly question is not only where an idea came from but what was altered through uptake and what new continuations became possible after assimilation.

This historical perspective also restrains retrospective simplification. Contemporary disciplinary maps can make earlier relations appear obvious even when the relevant boundaries were organized differently. Conversely, a field that appears autonomous today may depend on concepts, instruments, or institutions inherited from multiple predecessors. Relational breadth benefits from reconstructing these genealogies because doing so reveals that disciplinary identity itself can be a historical outcome of earlier cross-domain relations.

5.5 Analogy, Structural Correspondence, and Limits

Analogy is one of the most productive and most hazardous mechanisms of cross-domain thought. It can expose a relation that would remain invisible within a single vocabulary, generate a new question, or suggest a formal representation. Adaptive-expertise research identifies analogical and cognitive problem-solving processes among the resources through which experts respond to novel situations [6]. For scholarly formation, the important issue is how analogy is disciplined after it has generated attention.

A useful analogy preserves selected relations while leaving other relations unmatched. The receiving scholar should therefore be able to state which correspondence is intended. If an economic process is compared with an attractor, for example, the analogy becomes analytically stronger only when the relevant state space, evolution rule, basin structure, and interpretation of stability are specified. If these elements remain unavailable, "attractor" may still function as a heuristic metaphor, but its epistemic status should remain visibly heuristic.

Caution 5.2 (Analogy and cross-domain equivalence)**.** A productive analogy can justify further comparison or model construction without establishing equivalence between the source and target domains. Formal correspondence, historical influence, causal dependence, and conceptual identity are distinct relations and require distinct warrants.

Caution 5.2 connects relational breadth with the equivalence taxonomy developed earlier in the GR programme. Similar manifestations or shared structures can support a locally useful comparison while leaving substantial domain-specific remainders. Mature breadth therefore depends partly on the ability to preserve those remainders rather than forcing them into a common vocabulary.

The same principle applies to systems language. Calling a set of interacting objects a "system" can direct attention toward relations, feedback, constraints, and multiple scales, but the label does not itself identify those relations. In this paper, *systemic understanding* refers to the capacity to organize mutually relevant relations and their higher-order consequences for a question. It does not require commitment to one universal systems theory.

Definition 5.3 (Systemic understanding)**.** Within the present framework, *systemic understanding* is the capacity to reconstruct how multiple typed relations jointly condition an object, problem, or inquiry, including interactions among domains, scales, methods, institutions, histories, and normative structures where those relations are evidentially or interpretively warranted.

Definition 5.3 makes systemic understanding a question-relative achievement. In the eight-family architecture used later in the paper, systemic understanding is treated as an integrative mode of relational breadth rather than as a ninth independent capacity family: it becomes relevant when several typed relations must be considered jointly for the inquiry. Some inquiries can be responsibly answered within one specialized field; others require a broader relational configuration. Breadth is therefore not automatically superior to depth. Mature scholarly formation includes judgment about when a wider relation set improves the inquiry and when it introduces noise, unsupported analogy, or unnecessary coupling.

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5.6 Relational Breadth in Scholarly Practice

Relational breadth becomes visible in practice through a sequence of operations. A scholarly configuration first identifies which domains are materially relevant to a problem. It then reconstructs the local standards and language systems of those domains sufficiently to avoid superficial transfer. Proposed relations are typed and supported; mismatches in scale, method, or interpretation are retained; and the resulting relation structure is used to generate further questions, comparisons, or constraints. The process is recursive because a newly identified relation can change which domains or historical pathways appear relevant.

The distinction between encyclopedic and relational breadth can now be stated precisely. Encyclopedic breadth expands the quantity and diversity of accessible material in $\mathcal{K}_t$. Relational breadth changes the organization of $\mathcal{R}_t$, $\mathcal{L}_t$, and $\mathcal{C}_t$ by creating or revising warranted relations among previously separate resources and practices. A scholar can therefore possess extensive cross-domain information while retaining weak relational breadth, just as a scholar with narrower factual coverage can sometimes display strong relational breadth within a well-defined problem space.

AI systems sharpen this distinction. Retrieval and synthesis tools can rapidly place materials from distant disciplines next to one another, lowering the practical cost of cross-domain search. Such juxtaposition can increase the candidate edge set $\mathcal{E}_t^{(q)}$ in Equation 6. The scholarly challenge then shifts toward relation typing, warrant assessment, preservation of domain-specific assumptions, and discrimination between generative analogy and spurious similarity. This is another instance of the acquisition–assimilation distinction developed in Section 3: access to cross-domain material becomes scholarly formation when it reorganizes future inquiry in ways that remain answerable to the relevant domains.

Human–AI collaboration may support this capacity rather than merely threaten it. An AI system can assist with finding distant literatures, generating candidate analogies, comparing terminologies, or exposing possible scale connections. A human or distributed scholarly configuration can contribute historical placement, local disciplinary judgment, source criticism, tacit familiarity, and responsibility for deciding which relations should guide action. The allocation is contingent rather than essential. What matters analytically is whether the coupled configuration can construct, test, revise, and sometimes reject cross-domain relations with adequate warrant.

The capacity developed in this section therefore has two complementary dimensions. *Breadth* concerns the reach of a scholarly configuration across heterogeneous domains. *Systemic understanding* concerns the organization of relations among those domains and the consequences of their interaction. Mature scholarly formation joins these dimensions while preserving local depth, methodological plurality, and the possibility that some translations fail.

Relational breadth can inform aesthetic judgment because intellectual fertility often depends on recognizing a problem's structural position across fields, historical lineages, and possible continuations. Aesthetic judgment remains distinct: it concerns selection among possible inquiries according to qualities such as depth, elegance, explanatory compression, and generative potential.

6 Generative Attention and Problem Formation

This section develops generative attention and problem formation as the third capacity family in the proposed account of scholarly formation. Its role is to explain how a phenomenon, encounter, weak signal, anomaly, failure, ordinary recurrence, or accidental exposure becomes available as a possible object of inquiry before aesthetic or normative judgment can evaluate it. The objective is narrower than a complete psychology of creativity and broader than an account of anomaly-driven discovery. The discussion distinguishes problem recognition from problem evaluation, relates the proposal to work on problem formulation and serendipity, introduces a GR representation of encounter-sensitive problem formation, and examines the relation between prepared scholarly configurations and contingent phenomena. The method is conceptual and relational. Existing research on problem recognition and discovery supplies empirical and philosophical interfaces, while the GR contribution concerns the relational conditions un-

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der which an encounter becomes generative for a history-bearing scholarly configuration.

6.1 Encounter, Salience, and the Genesis of Inquiry

Scholarly inquiry does not begin only after a well-formed problem has been supplied. Many research trajectories begin earlier, when a configuration encounters something that becomes salient enough to deserve articulation as a question. The encounter can involve an unexpected experimental result, a recurrent natural phenomenon, an apparently ordinary institutional practice, a difficult textual passage, a mismatch between theories, an anomalous data point, a failed translation, a social interaction, or a chance exposure to an unfamiliar body of work. In such cases, the relevant scholarly capacity concerns whether the encounter becomes a generative occasion for inquiry.

Psychological work on problem solving has long distinguished problem recognition, definition, and representation from later solution procedures. Pretz, Naples, and Sternberg emphasize that many problems must first be recognized in the environment and then defined and represented before they can be solved [42]. Earlier work by Csikszentmihalyi and Getzels similarly examined discovery-oriented behavior during problem formulation and reported a positive relation between such behavior and the originality of the resulting creative products in their art-school study [41]. These literatures establish useful interfaces for the present argument: problem formation is analytically distinguishable from solving a problem that is already given.

The capacity developed here extends that distinction in a relational direction. The same phenomenon can be present to several scholarly configurations while becoming generative for only some of them. A recurring observation can remain background noise for one configuration, become a technical nuisance for another, and become the origin of a research programme for a third. The difference does not need to reside solely in the intrinsic properties of the phenomenon. It can arise from the relation between the encounter and the configuration's accumulated history, unresolved problems, disciplinary repertoire, cross-domain relations, tacit experience, and evaluative dispositions.

For present purposes, let e_t denote a task-relevant encounter available to a scholarly configuration Σ_t^{sch} at analytical time t, and let $\mathscr{Q}_{t,\xi}$ denote the context-relative space of candidate problem framings that the configuration could in principle articulate in context ξ. The generative-attention correspondence is stated in Equation 7.

$$\mathfrak{Y}_{t,\xi}\big(e_t; \Sigma_t^{\mathrm{sch}}\big) \subseteq \mathscr{Q}_{t,\xi}. \tag{7}$$

In Equation 7, membership means that the encounter makes a candidate problem framing sufficiently salient to become available for articulation, investigation, or preservation as an inquiry seed. The correspondence can be empty. It need not produce one unique question, and it does not imply that any generated question is valuable, feasible, or normatively appropriate. The notation therefore represents a pre-evaluative stage of scholarly formation: it concerns what can become a question before the later capacities of aesthetic and normative judgment determine whether the question merits sustained commitment.

Definition 6.1 (Generative attention)**.** Within the present framework, *generative attention* is the revisable capacity of a scholarly configuration to recognize an encounter as potentially inquiry-generating, articulate one or more problem framings from that encounter, and preserve enough of the encounter's relational structure for subsequent investigation rather than reducing it prematurely to an already familiar category.

Definition 6.1 separates generative attention from generalized curiosity. Curiosity can motivate exploration without yielding a tractable or conceptually structured problem. Generative attention concerns the transformation of an encounter into a scholarly problem space that can later be reconstructed, compared, tested, translated, or judged.

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Table 6: Encounter types relevant to generative attention and problem formation.

Encounter type	Potential scholarly function	Primary caution
Unexpected anomaly	Reveals mismatch between expectation and observation and can motivate explanatory reconstruction.	Surprise alone does not establish explanatory importance.
Ordinary recurrence	Makes a stable but neglected relation available for conceptualization or comparative inquiry.	Familiarity can be mistaken for universality or depth.
Failure or resistance	Exposes a boundary condition, hidden assumption, or limitation in a method or concept.	Local failure does not establish failure of the broader framework.
Cross-domain coincidence	Suggests a possible structural, historical, or methodological relation across fields.	Co-occurrence or resemblance can generate analogy without warranting equivalence.
Conceptual friction	Reveals that a term, distinction, or inferential move does not travel smoothly across language systems.	Translation difficulty can arise from missing background rather than deep incommensurability.
Chance exposure	Introduces an unsought source, phenomenon, or relation that redirects inquiry.	Retrospective success can exaggerate the role of chance and obscure prior preparation.
Weak or peripheral signal	Preserves observations that dominant classifications would normally discard or aggregate away.	Noise, measurement error, and selective attention remain alternative explanations.

6.2 Problem Finding, Serendipity, and Adjacent Discovery Accounts

The proposed capacity has important neighbors in the literatures on problem finding, scientific discovery, and serendipity. The problem-recognition literature emphasizes that creative problem solving often depends on how a problem is identified and represented before a solution is sought [42]. Csikszentmihalyi and Getzels provide an empirical precedent for studying behavior during the problem-formulation stage rather than treating the supplied problem statement as fixed [41]. These interfaces support a distinction between the generation of a problem and the evaluation or solution of an already specified one.

Serendipity introduces a different emphasis. Copeland characterizes serendipity in science through the intersection of chance and wisdom and treats recognition of the unexpected as part of a discovery process whose outcome stands in an oblique relation to the investigator's prior intentions [43]. This is relevant because scholarly formation can depend on the ability to notice significance in events that were not sought for the purpose they eventually serve. The role of chance, however, does not exhaust the present concept. Generative attention also includes cases in which the initiating phenomenon is ordinary, recurrent, or deliberately observed rather than accidental.

The distinction matters because a phenomenon need not be anomalous to become generative. A scholar can notice a relation that is visible to many observers yet rarely treated as a research object. A routine bureaucratic practice can become a question about institutional power. A common weather pattern can become a question about measurement, scale, or urban adaptation. A recurring difficulty in explaining a concept can become a question about the conceptual architecture of a field. A familiar mathematical object can become newly generative when placed in relation to a different structure. In such cases, the scholarly act lies partly in making a previously backgrounded relation available for inquiry.

The present framework therefore treats problem finding, serendipity, and anomaly recognition as partially overlapping interfaces rather than synonyms for generative attention. Table 6 summarizes several encounter types and the analytical caution associated with each.

Table 6 is not a taxonomy of discovery mechanisms. Its role is to show that generative attention can be triggered by heterogeneous encounters and that each trigger requires a different form of epistemic discipline. The capacity is therefore not equivalent to a standing preference for novelty or anomaly. Mature

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operation includes knowing when an apparently interesting deviation should remain a low-priority trace rather than being promoted prematurely into a major research claim.

6.3 Yuanqi-Sensitive Problem Formation

The motivating observation for this section can be expressed through the Chinese term *yuanqi* (缘起) in a limited scholarly sense: the contingent or relational occasion through which an inquiry begins to take form. The term is used here heuristically and does not import a complete Buddhist doctrine of dependent origination. Its analytical purpose is to emphasize that the origin of inquiry can lie in the relation between a phenomenon and a prepared scholarly configuration, rather than in a pre-existing problem statement waiting to be solved.

Yuanqi sensitivity therefore names a particular orientation within generative attention. A scholar can encounter an event and ask not only whether it is surprising, but whether it reveals a relation, distinction, tension, or generative condition that deserves further articulation. The encounter becomes a scholarly origin when it alters the problem space available to the configuration. This can involve creating a new problem, reformulating an inherited one, identifying a hidden boundary condition, or connecting a local observation to a wider relational structure.

This formulation avoids treating the initiating phenomenon as though it contained a research question intrinsically. The same encounter can have different scholarly consequences for different histories. Formally, two configurations Σ_t^{sch} and $\Sigma_t'^{\text{sch}}$ can encounter the same e_t while generating different problem sets. The relational dependence is stated in Equation 8.

$$\mathfrak{Y}_{t,\xi}\big(e_t; \Sigma_t^{\text{sch}}\big) \neq \mathfrak{Y}_{t,\xi}\big(e_t; \Sigma_t'^{\text{sch}}\big) \quad \text{can hold even for the same encounter } e_t. \tag{8}$$

Equation 8 is a possibility statement, not a universal law. Its purpose is to encode the claim that scholarly salience can be path-dependent and configuration-relative. Different histories can make different differences perceptible.

This point also clarifies why expert scholars can sometimes appear able to derive questions from phenomena that others regard as trivial. The difference need not be mystical intuition. Years of conceptual work can create a dense set of unresolved relations, failed analogies, historical contrasts, methodological sensitivities, and tacit expectations. A small perturbation can then intersect with that structure and become generative. Expertise changes not only what a scholar knows, but potentially what can become noticeable as a problem.

Claim 6.2 (Relational realization of inquiry origins)**.** Within the present framework, the scholarly generativity of an encounter is realized through the relation between the encounter and a history-bearing configuration. An event can therefore become inquiry-generating without being intrinsically anomalous, important, or theoretically loaded independently of the configuration that encounters it.

Claim 6.2 leaves room for strongly structured external phenomena. Some events are objectively unusual relative to a defined model or measurement regime. The claim concerns the transition from occurrence to scholarly problem formation: whether and how the occurrence becomes a research object depends on additional historical, conceptual, relational, and methodological conditions.

6.4 Prepared Relational Configurations

Serendipity is often associated with the idea of the prepared mind. The GR framework reframes that intuition as a *prepared relational configuration*. Preparation can be distributed across a scholar's prior study, collaborators, archives, instruments, disciplinary languages, datasets, institutions, and unresolved research histories. The relevant capacity can therefore be relationally supported even when no isolated individual contains the complete background needed to recognize the encounter's significance.

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Historical consciousness and relational breadth play especially important roles in this preparation. Historical consciousness can make a present phenomenon salient because it resembles a previously unresolved transformation, failed category, or abandoned alternative. Relational breadth can make an encounter generative because it activates a relation to another field, scale, method, or institutional structure. Tacit expertise can contribute by making a deviation perceptually salient before the scholar can fully articulate why it matters. The generative-attention capacity is therefore upstream of aesthetic judgment while simultaneously depending on capacities developed elsewhere in the architecture.

This coupling also explains why narrow expertise can have both advantages and risks. Deep specialization can sharpen sensitivity to small deviations that a generalist would miss. The same specialization can stabilize a salience structure that filters out phenomena defined as external to the field. Relational breadth can widen the interfaces through which such phenomena become intelligible, while historical consciousness can reveal that current disciplinary boundaries were themselves generated and can therefore be questioned.

Preparedness should not be romanticized. Retrospective narratives of discovery can make successful observations look inevitable once the later theory is known. Selection bias favors memorable cases in which an unusual encounter produced an important result, while innumerable noticed anomalies lead nowhere. Mature generative attention therefore includes preservation and triage as well as enthusiasm. A scholar may record a weak signal without escalating it, retain an unresolved question for later comparison, or deliberately seek disconfirming explanations before treating the encounter as fertile.

Caution 6.3 (Retrospective inflation of inquiry origins)**.** Accounts of discovery should avoid reconstructing a successful research trajectory as though the initiating encounter already contained the later problem, theory, or significance. The evidential record may support only that an encounter became salient and was subsequently elaborated through additional historical, relational, experimental, or interpretive work.

Caution 6.3 aligns the section with the historical restraint developed in Section 4. The point of identifying an inquiry origin is to reconstruct how a trajectory became possible, not to turn contingency into inevitability after the fact.

6.5 Problem Formation and Aesthetic Selection

Generative attention and aesthetic judgment answer different questions. Generative attention concerns which possible questions become visible enough to enter inquiry. Aesthetic judgment concerns how already recognizable candidates are evaluated for depth, elegance, structural fertility, explanatory compression, or long-horizon promise. The distinction can be represented by restricting the domain of aesthetic judgment to candidate problems made available through one or more inquiry-generating processes.

For an encounter e_t, a candidate p can enter later aesthetic evaluation when it belongs to $\mathfrak{Y}_{t,\xi}(e_t; \Sigma_t^{\text{sch}})$. The relation is stated in Equation 9.

$$p \in \mathfrak{Y}_{t,\xi}\big(e_t; \Sigma_t^{\text{sch}}\big) \quad \Longrightarrow \quad p \text{ is available for evaluation by } J_{t,\xi}^{\text{aest}}. \tag{9}$$

Equation 9 does not assert that every aesthetically evaluated problem originated from one identifiable encounter. Some problems are inherited from a field, assigned institutionally, or generated through explicit combinatorial search. The equation specifies the interface for encounter-generated candidates. It also prevents one common compression in AI-era discussion: producing many candidate questions and discriminating which of them deserve long-term inquiry are distinct operations.

The distinction creates two different failure modes. A configuration can possess strong aesthetic judgment over a narrow supplied problem set while missing important phenomena that never enter that set. Conversely, a configuration can generate questions from almost every encounter while lacking discrimination about which questions are deep, tractable, or worth sustained attention. Mature scholarly formation requires some coordination between problem formation and problem selection without requiring either capacity to be maximized independently.

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This coordination also makes generative attention relevant to the continuation-space framework. An encounter can matter because it opens a new branch of inquiry, but it can also matter because it reorganizes the existing problem space. A seemingly minor phenomenon can reveal that two previously separate questions share a hidden relation, that an accepted distinction is unstable, or that an ignored variable changes the interpretation of a larger literature. Generativity therefore concerns transformation of the inquiry structure, not the raw number of new questions produced.

6.6 Human–AI Configurations and Weak-Signal Preservation

AI systems intensify the distinction between candidate generation and generative attention. Large models and automated research systems can generate large numbers of questions, hypotheses, analogies, and research directions. Such throughput can be valuable, yet it does not by itself establish encounter-sensitive problem formation. The stronger question is whether a Human–AI configuration can preserve and learn from weak, unexpected, or ordinary phenomena whose significance is not already encoded in the prompt or dominant classification scheme.

A Human–AI configuration can support generative attention in several ways. Sensors and computational pipelines can preserve observations that exceed unaided human attention. Retrieval systems can connect a local anomaly to distant literatures. Long interaction histories can make recurring difficulties visible across projects. Models can generate alternative framings of an observation and help test whether a weak signal survives changes in representation. Conversely, summarization, ranking, denoising, benchmark optimization, and dominant training categories can suppress precisely the peripheral observations from which new questions might emerge.

The relevant evaluation therefore concerns the whole configuration. Useful evidence would include whether unexpected observations are retained with provenance; whether the system can distinguish measurement error from theoretically relevant deviation; whether alternative explanations are generated before escalation; whether a previously neglected signal changes later problem formulation; and whether the configuration learns which kinds of earlier overlooked phenomena later proved generative. These are longitudinal properties. A single surprising output provides weak evidence for the capacity.

The AI case also clarifies that generative attention should not be defined as intrinsically human. A recurrent Human–AI–sensor–archive configuration can in principle satisfy the functional and relational conditions of Definition 6.1. The attribution should follow the evidence about the configuration's retained history, salience structure, correction procedures, and later problem formation rather than species membership.

6.7 Evidential Boundaries of Generative Attention

The present proposal is deliberately preliminary. Problem recognition, problem formulation, serendipity, curiosity, creativity, anomaly detection, and exploratory observation each have established literatures with partially overlapping objects. The term *generative attention* is introduced to organize a GR-specific relation among encounter, history-bearing configuration, problem formation, and continuation; it does not replace those traditions.

The capacity also resists direct measurement through output counts. A high number of questions can reflect indiscriminate generation. A low number can reflect deep selectivity. Retrospective interviews can overstate the clarity of an initiating insight, while archival traces can underrecord tacit noticing or abandoned possibilities. Empirical investigation would therefore benefit from longitudinal designs that preserve notebooks, prompts, failed experiments, conversational records, weak signals, delayed reinterpretations, and subsequent changes in problem formulation.

The most important boundary concerns value. Recognizing that an encounter can generate a question does not establish that the question is intellectually beautiful, normatively important, empirically tractable, or socially desirable. Those evaluations belong to later or differently coupled capacities. Generative attention therefore expands the architecture upstream of aesthetic judgment while preserving the distinction between *making a question available* and *deciding what the question is worth*.

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The resulting addition changes the paper's account of mature scholarship in one important respect. A proficient scholar is not characterized only by the capacity to reconstruct, relate, judge, translate, and revise. Scholarly formation can also include a capacity to allow the world, an archive, an experiment, an interlocutor, or an apparently minor contingency to become the origin of a new inquiry trajectory. Within a GR account, the origin is neither located wholly in the phenomenon nor wholly in the observer. It is realized through their history-bearing relation. Section 7 extends this upstream sensitivity comparatively by asking how the same kind of weak or contingent encounter can also be interpreted as an early manifestation of a developing trajectory, without collapsing problem formation into prognosis.

7 Comparative Structures of Contingency Sensitivity

This section develops a comparative analysis of two ways in which a history-bearing configuration can transform a minor, contingent, or weakly salient encounter into an intellectually or practically significant object. The first is the problem-formative orientation developed in Section 6: an encounter becomes the origin of one or more questions that can organize subsequent inquiry. The second is an incipient-change orientation exemplified by the classical sage ideal associated with the *Zhouyi*: a small change is interpreted as an early manifestation of a developing tendency whose significance lies partly in what it may become. The objective is comparative rather than genealogical. The section does not identify modern scholarship with classical sagehood, validate divinatory prediction, or treat either orientation as a universal cognitive type. It asks instead which attentional and judgmental transformations are structurally shared, where they differ, and how mature scholarship can sometimes coordinate both without reducing one to the other.

7.1 A Shared Upstream Sensitivity to Contingency

Generative attention begins from the possibility that an encounter becomes more than background. A failed experiment, an ordinary recurrence, a slight institutional change, an unexpected phrase, a weak signal in a dataset, or an accidental observation can become sufficiently salient to reorganize inquiry. The defining operation in Section 6 is problem formation: the encounter expands the set of questions that the scholarly configuration can articulate and preserve.

A different but neighboring transformation is possible. The same encounter can be treated as a possible early indication of a process that is already unfolding. The observer does not primarily ask which research question the encounter generates. The observer asks what developing relation, tendency, or trajectory the encounter may disclose. This orientation is particularly visible in classical Chinese discussions of *ji* (幾), commonly associated with minute or incipient movement. In the *Xici II*, the *Zhouyi* states, "幾者，動之微，吉之先見者也" and then "君子見幾而作，不俟終日" [44]. The first phrase identifies *ji* with the minute beginning of movement and an early manifestation relevant to later fortune or misfortune; the second connects recognition of such incipience with timely action.

The comparison therefore begins from a shared upstream capacity: sensitivity to differences whose significance is not exhausted by their immediate magnitude. The two orientations diverge in what is generated from that sensitivity. Problem-formative attention makes a question available. Incipient-change attention makes a provisional trajectory interpretation available. Both can fail. A weak signal can be noise; an apparent anomaly can reflect measurement error; an inferred tendency can disappear; a generated problem can prove trivial. The shared capacity is consequently better described as *contingency sensitivity* than as privileged access to hidden truth.

Definition 7.1 (Contingency sensitivity)**.** Within the present comparative analysis, *contingency sensitivity* is the revisable capacity of a history-bearing configuration to preserve and differentiate minor, unexpected, weak, ordinary, or initially peripheral encounters when they may alter problem formation, trajectory interpretation, or practical judgment.

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Definition 7.1 is intentionally broader than the third scholarly capacity family. Generative attention is one scholarly transformation of contingency sensitivity. Incipient-change judgment is another possible transformation. The broader term therefore identifies a shared upstream structure without implying that the downstream interpretations have the same epistemic status.

7.2 The Classical Sage Ideal of Knowing Incipient Change

The *Zhouyi* provides a particularly clear classical vocabulary for sensitivity to the early stages of change. The *Xici II* links *ji* to minute movement and timely response, while the same passage associates the exemplary person with knowing what is still subtle and what has become manifest [44]. The ideal is consequently not limited to passive observation. Minute change matters because the observer seeks to understand its place within a developing configuration and to respond before the trajectory becomes difficult to alter.

The initial line of *Kun* supplies a compact image of such trajectory sensitivity: "履霜，堅冰至" [45]. The associated *Xiang* commentary describes frost as the beginning of freezing and hard ice as the result of gradual development [45]. Structurally, the passage moves from a small present manifestation to a later condition by treating the present observation as part of a process rather than as an isolated point. The present paper uses this image comparatively. It does not assume that every small sign reliably determines its later outcome. Its relevance lies in the attentional form: an apparently modest condition can become significant when interpreted as an early phase of a trajectory.

A related passage in the *Bi Tuan* states, "觀乎天文，以察時變；觀乎人文，以化成天下" [46]. The passage links observation of patterned phenomena with discernment of temporal change and relates human patterning to social transformation. Tze-Ki Hon's account of the *Yijing* emphasizes the text's long development into a philosophy of change concerned with human finitude, ceaseless transformation, pattern discernment, and decision under uncertainty [47]. The present comparison draws on that philosophical structure while keeping the historical diversity of *Yijing* interpretation visible. The classical text and its later traditions include divinatory, cosmological, moral, political, and reflective uses; a single modern formalization should not collapse those uses into one homogeneous doctrine.

The sage ideal therefore contributes a different attentional question from the research creator's initial question. A problem-formative orientation asks what inquiry becomes possible because of an encounter. An incipient-change orientation asks what developing configuration the encounter may belong to. The first expands a problem space; the second attempts to situate the encounter within a temporal structure.

7.3 Problem Formation and Incipient-Change Judgment

The distinction can be stated through two outputs of the same encounter. Section 6 already represents the candidate problem framings made salient by an encounter through $\mathfrak{Y}_{t,\xi}(e_t; \Sigma_t^{\text{sch}})$. For the present comparison, let the provisional trajectory interpretations made salient by the same encounter be written as a family $\{\widehat{\gamma}_k\}_{k \in K(e_t)}$, where each $\widehat{\gamma}_k$ is a revisable trajectory hypothesis rather than a prediction guaranteed by the encounter. The comparative pair is stated in Equation 10.

$$\mathfrak{A}_{t,\xi}^{\text{cont}}\big(e_t; \Sigma_t^{\text{sch}}\big) = \Big(\mathfrak{Y}_{t,\xi}\big(e_t; \Sigma_t^{\text{sch}}\big), \{\widehat{\gamma}_k\}_{k \in K(e_t)}\Big). \tag{10}$$

Equation 10 is a diagnostic representation rather than a claim that the two outputs are always present or generated by one psychological mechanism. Either component can be empty. A scholar can generate a worthwhile question without possessing a credible trajectory judgment. A practitioner can recognize a developing tendency without converting it into a research programme. The representation only makes explicit that the same encounter can support distinct forms of salience.

The difference also changes how uncertainty is handled. Problem formation can rationally preserve uncertainty by proliferating hypotheses, comparisons, and research designs. A trajectory judgment often has a more immediate practical horizon: whether to wait, investigate, allocate attention, intervene,

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Table 7: Two transformations of contingency and their possible coordination.

Analytical feature	Problem-formative orientation	Incipient-change orientation	Coordinated mature practice
Primary transformation	Encounter becomes a question or problem family.	Encounter becomes a provisional sign of a developing trajectory.	Encounter can generate both inquiry and trajectory hypotheses.
Temporal emphasis	Future investigation and conceptual development.	Early-stage change and possible later configuration.	Inquiry is selected with attention to historical timing and changing conditions.
Typical uncertainty treatment	Preserves or expands alternatives for investigation.	Compresses some uncertainty for orientation or timely response.	Keeps trajectory judgments revisable while protecting inquiry options.
Relation to evaluation	Aesthetic and normative judgment evaluate generated problems.	Practical and normative judgment evaluate responses to possible change.	Multiple judgment modes constrain one another.
Characteristic risk	Trivial problem proliferation or novelty-seeking.	Pattern over-detection, retrospective fitting, or premature prognosis.	Overconfidence can arise when problem quality and trajectory confidence reinforce each other.

preserve optionality, or prepare for a possible transition. The latter can therefore require some compression of uncertainty even when the available evidence remains incomplete. This helps explain why incipient-change judgment can resemble the time-sensitive pattern recognition studied in naturalistic decision making while extending the relevant object from immediate operational situations to longer historical, institutional, disciplinary, or political trajectories.

Table 7 summarizes the comparison without turning the two orientations into mutually exclusive types of person.

The third column of Table 7 should therefore be read as an idealized orientation, not as a claim that classical sage traditions operate through one uniform method. Likewise, the first column does not characterize every scholar. The comparison concerns transformations of encounters, not fixed social identities.

7.4 Scholarship, Sagehood, and the Avoidance of a Binary Typology

The comparison becomes most useful when the scholar and the sage are not treated as opposite types. A proficient scholar can detect that an apparently minor event is both question-generating and trajectory-indicative. A change in citation behavior can become a research problem about scholarly communication while also suggesting that a disciplinary centre of gravity is moving. A subtle institutional rule change can motivate inquiry into governance while simultaneously indicating that the practical option space of a field is narrowing. An unexpected AI behavior can generate a technical or philosophical problem while also revealing that the evidential meaning of scholarly manifestations is changing.

This combined sensitivity can be especially important for senior scholars because long participation can supply a larger archive of partially comparable trajectories. The relevant advantage is not age or prestige by itself. It is the possibility that the configuration has retained histories of how earlier weak signals developed, disappeared, reversed, or became structurally consequential. Such histories can make some present differences salient that would otherwise appear negligible. The same mechanism can also create bias: a scholar can over-project familiar past trajectories onto a genuinely novel situation. Historical depth therefore supports trajectory sensitivity only when coupled to humility and revision.

The classical sage ideal and scholarly creation can consequently be treated as overlapping orienta-

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tions within a larger space of contingency-sensitive judgment. The comparison suggests at least three operations: a generative orientation that converts an encounter into questions, an incipient-change orientation that converts it into provisional trajectory interpretations, and a coordinating orientation that considers how those questions and trajectories should shape commitment. These operations can coexist within one history-bearing configuration.

Claim 7.2 (Non-binary contingency orientations)**.** Within the present framework, problem-formative and incipient-change orientations should be treated as potentially co-occurring transformations of contingency sensitivity rather than as mutually exclusive types of scholar or sage.

Claim 7.2 prevents the comparison from becoming a civilizational or disciplinary dichotomy. Classical Chinese sources can illuminate one historically important articulation of incipient-change sensitivity without implying that such sensitivity belongs only to classical Chinese thought. Modern researchers, political practitioners, physicians, engineers, diplomats, and organizational leaders can also form trajectory judgments from weak change. Conversely, classical thinkers also generated questions, concepts, and arguments rather than merely reading omens. The comparison concerns emphasis and structure, not exclusive cultural ownership.

7.5 Mediating Judgment under Changing Conditions

Once problem formation and trajectory sensing are both available, the relation between aesthetic and normative judgment becomes more complex. A problem can be intellectually beautiful and structurally fertile while the developing situation makes immediate large-scale investment unwise. Another problem can appear aesthetically modest yet become normatively urgent because a trajectory is approaching a difficult-to-reverse transition. A mature scholarly configuration can therefore require coordination among problem quality, normative priority, historical timing, trajectory uncertainty, and the available action space.

The present paper uses *mediating judgment* for this higher-order coordination. It is not added as a ninth capacity family. Its operation depends on the capacities already developed: historical consciousness supplies temporal comparison; relational breadth reconstructs interacting structures; generative attention supplies problem candidates; aesthetic judgment evaluates intellectual fertility; normative judgment evaluates priority and consequences; humility calibrates confidence; and translation capacities make the judgment discussable across language systems. Incipient-change sensitivity contributes a provisional account of how the relevant configuration may be changing.

Definition 7.3 (Mediating judgment)**.** *Mediating judgment* coordinates problem formation, trajectory interpretation, aesthetic evaluation, normative evaluation, historical context, relational structure, and revisability when a scholarly configuration must decide what deserves inquiry, commitment, delay, preservation, or practical response under changing conditions.

Definition 7.3 keeps mediation distinct from compromise. The objective is not to average incompatible judgments. Aesthetic judgment and normative judgment can remain genuinely in tension. A trajectory hypothesis can remain too uncertain to guide intervention. A normatively urgent condition can justify attention to a problem that is not aesthetically preferred. Mediation concerns making these differences jointly available to action without erasing their distinct evaluative roles.

This higher-order coordination also clarifies the relation between scholarship and wisdom. The present paper does not define wisdom comprehensively. It identifies one boundary condition: scholarly maturity begins to approach a wisdom-like mode when the configuration can generate worthwhile questions while also locating them within changing historical relations and calibrating commitment to the situation's normative and practical structure. The relation is gradual and revisable rather than categorical.

7.6 Epistemic Boundaries of Sign, Pattern, and Prognosis

The comparison requires a strict epistemic boundary. The attentional value of a classical passage does not establish the empirical truth of any cosmological, divinatory, or omen-based theory historically asso-

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ciated with it. A configuration can be exceptionally sensitive to weak changes while interpreting them through an unreliable causal model. Conversely, a modern researcher can possess sophisticated statistical tools while discarding a weak but important phenomenon because a dominant classification system treats it as noise. Attention and interpretation therefore require separate evaluation.

The same caution applies to modern trajectory sensing. Weak-signal interpretation is vulnerable to confirmation bias, selective memory, retrospective fitting, narrative compression, and excessive analogy with past trajectories. A successful outcome can make its early indicators appear more obvious than they were prospectively. The *Zhouyi* image of frost and hard ice is analytically valuable as a representation of gradual development, yet real social, scientific, and political processes can branch, reverse, accelerate, or dissolve. The inference from an early manifestation to a later state must therefore remain a trajectory hypothesis rather than a deterministic law.

Hon's discussion of the *Yijing* is useful precisely because it presents the text as historically layered and philosophically concerned with change, human finitude, pattern discernment, uncertainty, and practical response rather than reducing it to one simple predictive doctrine [47]. This provides an appropriate boundary for the comparison: the present section studies a mode of attention and judgment that can be reconstructed from the text while suspending stronger claims about supernatural prediction or universal cosmological correspondence.

Caution 7.4 (Attentional sensitivity and predictive validity)**.** Sensitivity to subtle change does not by itself establish the validity of the interpretive system through which that change is explained or predicted. The capacity to preserve weak signals and the warrant for a particular trajectory inference should be assessed separately.

Caution 7.4 applies symmetrically. It protects classical material from being dismissed merely because some historical uses were divinatory, while also preventing classical symbolism from being treated as empirical validation. It protects modern scholarship from assuming that methodological sophistication eliminates pattern over-detection. Both forms of inquiry require provenance, alternative explanations, revision, and retrospective checking of which weak signals were ignored, overinterpreted, or correctly preserved.

7.7 Implications for the Architecture of Scholarly Formation

The comparative result modifies the interpretation of the eight-capacity architecture without adding another checklist item. Generative attention remains the third scholarly capacity family because the paper's central object is scholarly formation. Incipient-change sensitivity is treated as a possible higher-order use of historical consciousness, relational breadth, generative attention, and situated pattern recognition. Mediating judgment is likewise treated as coordination among existing capacities rather than an independent score.

The resulting architecture is therefore recursive. Historical consciousness and relational breadth can prepare a configuration to notice a small difference. The encounter can generate a question, a trajectory hypothesis, or both. Aesthetic judgment can evaluate the question's intellectual fertility. Normative judgment can evaluate whether commitment is appropriate under current relations. Humility regulates confidence in both the question and the trajectory interpretation. Later evidence then feeds back into the configuration's historical archive, changing what future encounters can become salient.

This comparative structure strengthens the paper's account of mature scholarship. A proficient scholar can do more than produce and evaluate questions. In some contexts, the scholar can also perceive that the relational environment in which those questions matter is itself changing. Scholarly formation then includes the possibility of coordinating inquiry with temporal sensitivity without converting scholarship into prognosis and without treating every contingent event as a sign. The boundary between scholarship and wisdom becomes a problem of relational coordination: how a configuration remains capable of asking what deserves to be known while also discerning when the conditions of knowing, acting, and prioritizing are themselves in motion.

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8 Aesthetic Judgment and Intellectual Worth

This section develops aesthetic judgment as the fourth substantive capacity in the proposed architecture of scholarly formation. Section 6 distinguished how encounters become candidate problems; the present section specifies how a scholarly configuration discriminates among recognizable questions, theories, proofs, explanations, and research programmes when logical admissibility, factual correctness, or technical difficulty alone leave many candidates available. The objective is not to provide a universal definition of intellectual beauty. The discussion instead identifies a family of historically and disciplinarily variable evaluative operations through which scholars recognize elegance, depth, compression, structural fertility, unexpected connection, and long-horizon generative promise. The method is conceptual and comparative. Existing work on aesthetic evaluation in science and mathematics provides an important interface, while the Generative Relational (GR) contribution lies in treating aesthetic judgment as a situated capacity of a history-bearing scholarly configuration whose criteria can be learned, revised, and transformed through disciplinary and historical relations.

8.1 Candidate Problem Spaces and Scholarly Selection

Scholarly inquiry rarely proceeds by solving every problem that can be formulated. A field can contain far more mathematically consistent questions, empirically testable hypotheses, formally definable objects, or textually generable interpretations than a scholarly community can pursue. Artificial intelligence can enlarge this excess by accelerating recombination, conjecture production, literature retrieval, simulation, coding, proof search, and linguistic formulation. The resulting condition increases the importance of selection without implying that selection is uniquely human or that earlier scholarship lacked abundant possibility.

For a scholarly configuration Σ_t^{sch} and inquiry context ξ, let $\mathcal{P}_{t,\xi}$ denote a task-relative set of candidate problems or lines of inquiry that are presently recognizable to the configuration, including but not limited to encounter-generated candidates from Equation 7. The notation is stated in Equation 11.

$$\mathcal{P}_{t,\xi} = \{p_1, p_2, \ldots, p_n, \ldots\}, \tag{11}$$

where membership records recognizability rather than intrinsic worth. Equation 11 is deliberately permissive: a candidate can be trivial, malformed, inaccessible with available methods, aesthetically unpromising, normatively undesirable, or extraordinarily fertile. The capacity at issue in this section concerns how some candidates acquire greater intellectual salience within a scholarly configuration.

The history of science provides substantial evidence that aesthetic evaluation participates in scientific practice. McAllister's analysis treats scientists' aesthetic evaluations of theories as historically consequential and examines properties such as symmetry and simplicity as components of changing aesthetic canons in theory assessment [14]. Chandrasekhar's lectures likewise document the place of beauty and aesthetic motivation in scientific inquiry, including explicit discussion of the quest for beauty and the aesthetic basis attributed to general relativity [15]. These sources do not establish a universal aesthetic criterion. They support the narrower claim that scientific actors themselves have repeatedly used aesthetic language and aesthetic considerations in describing research motivation and evaluation.

Mathematical practice makes the selective function particularly visible because formal correctness leaves open many choices concerning which objects to define, which lemmas to pursue, which proof strategy to prefer, which representation to adopt, and which problem deserves sustained attention. Fiori and Selling characterize aesthetically guided choice as a form of discernment in mathematical work and distinguish acts of nominating, combining, and balancing ideas [16]. Their educational argument is not adopted here as a general theory of scholarly aesthetics. It supplies a useful example of selection occurring within mathematical activity rather than only after a finished theorem has been produced.

Within the present framework, aesthetic judgment therefore operates before, during, and after manifestation production. It can guide problem nomination, method choice, representational preference, proof architecture, explanatory organization, and decisions about whether a line of inquiry warrants continued

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attention. Aesthetic judgment is consequently related to scholarly generativity because it shapes which branches of the continuation space $\mathfrak{G}(\Sigma_t^{\mathrm{sch}})$ receive attention and resources.

8.2 Difficulty, Novelty, and Intellectual Fertility

Difficulty is one source of scholarly challenge, yet difficulty alone provides weak guidance about intellectual worth. A problem can be difficult because it exposes a deep structural obstruction, because the available notation is poor, because computation is expensive, because the problem is badly posed, or because it has been deliberately constructed to resist solution. These forms of difficulty have different scholarly implications. The capacity to generate difficult problems therefore does not by itself generate a mature research agenda.

Novelty has a similar ambiguity. A candidate can be unprecedented while remaining weakly connected to important structures, existing problems, or future lines of inquiry. Conversely, an old problem can become newly generative when a changed language, method, instrument, or historical situation reveals relations that were previously inaccessible. The evaluative task is therefore richer than a binary distinction between new and known objects.

The paper uses *intellectual fertility* as a provisional term for the capacity of a problem, concept, method, or result to support further worthwhile inquiry relative to a scholarly configuration and context. Fertility can arise through several mechanisms: exposing a hidden structure, linking previously separated domains, generating new techniques, clarifying a family of cases, reorganizing an existing problem space, or creating questions whose investigation changes what later scholars can recognize. The term remains relational because the same object can be fertile for one configuration and comparatively inert for another whose language, methods, or historical situation differs.

Definition 8.1 (Aesthetic judgment in scholarly formation)**.** Within the present framework, *aesthetic judgment* is the situated capacity of a scholarly configuration to discriminate among candidate scholarly objects according to perceived forms of intellectual worth, including such qualities as elegance, depth, compression, structural fertility, unexpected connection, and generative promise, while remaining open to revision through historical experience, disciplinary transformation, and criticism.

Definition 8.1 is intentionally plural. It does not assert that the listed qualities are exhaustive, commensurable, or universally shared. A field may prize constructive explicitness where another prizes abstraction; a research school may value symmetry while a later generation treats the same preference as restrictive; a scholar may prefer a concept because it opens an unexpected bridge even when it is formally less economical than an alternative. Aesthetic judgment is thus represented as historically formed discrimination rather than a timeless metric.

This framing also distinguishes aesthetic judgment from raw preference. A mature judgment is ordinarily accountable to some combination of disciplinary exemplars, historical experience, technical understanding, comparative alternatives, and anticipated consequences for future inquiry. Its warrant can remain partly tacit, as the discussion of Polanyi in Section 2 suggests, while still being open to articulation, criticism, and revision. The possibility of tacit components does not exempt aesthetic judgment from scholarly responsibility.

8.3 Elegance, Compression, and Explanatory Organization

Elegance is among the most recurrent aesthetic terms in mathematics and theoretical science, yet the term can refer to several different structures. A proof can be elegant because it is short, because it uses a surprising invariant, because one idea resolves many cases, because the argument exposes why a result holds, or because its notation makes a hidden relation visible. A theory can appear elegant because it unifies phenomena, displays symmetry, reduces free parameters, or organizes heterogeneous observations through a compact structure. Treating elegance as mere brevity would therefore erase much of its scholarly function.

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McAllister's historical analysis is useful precisely because it treats aesthetic properties as historically variable components of scientific evaluation rather than as self-evident signs of truth [14]. His account of changing aesthetic canons also cautions against projecting current preferences backward as universal standards. Chandrasekhar's reflections provide a complementary practitioner perspective in which beauty operates as a motivation and evaluative orientation in scientific work [15]. The present paper uses these sources as evidence that aesthetic evaluation can be epistemically and motivationally significant without inferring that beauty guarantees empirical adequacy.

For the GR framework, explanatory compression is relevant when a representation allows a configuration to preserve or recover a larger relational structure with fewer independent commitments. Compression in this sense need not be syntactic minimality. A longer argument can be more intellectually economical when it reveals dependencies that a short calculation leaves opaque. Similarly, a diagram, theorem, historical reconstruction, or conceptual distinction can be aesthetically powerful because it reorganizes many observations into a smaller number of intelligible relations.

The relation between compression and generativity is contingent. Excessive compression can hide assumptions, erase historical difference, or make a framework difficult to adapt outside its original domain. A highly unified theory can also become aesthetically dominant in ways that discourage attention to anomalies or heterogeneous cases. Mature aesthetic judgment therefore includes sensitivity to the cost of an elegant representation as well as to its organizing power.

Caution 8.2 (Aesthetic attraction and epistemic warrant)**.** Aesthetic attraction can guide attention, comparison, and research commitment, but it does not by itself establish truth, empirical adequacy, explanatory superiority, or historical inevitability. Within this paper, aesthetic evaluation remains one scholarly judgment family whose evidential and normative consequences require separate argument.

Caution 8.2 preserves a boundary needed throughout the framework. A beautiful explanation can be false; an awkward model can be empirically indispensable; an aesthetically compelling research programme can impose unacceptable social costs. Normative priority therefore remains analytically separate from intellectual attractiveness.

8.4 Depth and Structural Generativity

Scholars often use *deep* to distinguish an inquiry that reorganizes understanding from one that merely resolves a local task. The term is difficult to formalize because depth can refer to different relations: dependence on fundamental structures, breadth of consequences, distance from surface formulation, explanatory reach, resistance to local techniques, or capacity to alter the vocabulary in which later problems are posed. The paper therefore does not identify depth with one measurable property.

A GR interpretation emphasizes *structural generativity*. A scholarly object has structural generativity when engagement with it can reorganize the relations through which a configuration produces later questions, comparisons, methods, or explanations. This notion connects aesthetic judgment to the continuation-space formalism introduced in Section 3. Let $\mathfrak{G}(\Sigma_t^{\mathrm{sch}})$ denote the set of viable continuations before sustained engagement with candidate p, and let $\Sigma_{t+1}^{\mathrm{sch}}(p)$ denote a later configuration in which relevant consequences of that engagement have been assimilated. The comparison of continuation spaces is represented schematically in Equation 12.

$$\mathfrak{G}(\Sigma_t^{\mathrm{sch}}) \quad \text{and} \quad \mathfrak{G}\Big(\Sigma_{t+1}^{\mathrm{sch}}(p)\Big) \tag{12}$$

Equation 12 does not prescribe a cardinality comparison. A deep problem need not increase the number of conceivable future questions. It can narrow a confused problem space, eliminate unproductive branches, reveal a stronger invariant, or transform the language in which later questions become formulable. Structural generativity therefore concerns qualitative reorganization as well as expansion.

Aesthetic judgment and structural generativity should nevertheless remain distinct. $J_{t,\xi}^{\mathrm{aest}}$ is a situated evaluative practice that can prospectively attribute generative promise to a candidate before its consequences are known. A later comparison of continuation spaces supplies different, retrospective or

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Table 8: Provisional distinctions in aesthetic evaluation of scholarly inquiry

Evaluative term	Primary analytical question	Relevant caution
Difficulty	What makes the object resistant to available methods or understanding?	Difficulty may result from poor formulation, computational burden, or artificial complication.
Novelty	Which aspects are historically or locally unprecedented?	Novelty can be weakly connected to significant structures or future inquiry.
Elegance	Which relations are organized with economy, coherence, or illuminating form?	Elegance is multidimensional and historically variable.
Compression	How much structure becomes recoverable through a reduced set of relations or commitments?	Compression can conceal assumptions, exclusions, or domain-specific remainder.
Depth	How extensively does the inquiry alter explanatory, conceptual, or methodological organization?	Depth has multiple disciplinary meanings and lacks a universal metric.
Structural generativity	How does engagement reorganize viable future inquiry and the relations among possible continuations?	Generativity can involve pruning, redirection, or re-description as well as expansion.

longitudinal evidence about what engagement with the candidate actually reorganized. An aesthetically compelling judgment can therefore overestimate future generativity, while an initially unremarkable object can later prove structurally generative. The framework uses generativity as one possible object of aesthetic appraisal without defining aesthetic warrant by eventual success.

This distinction is especially important in an AI-mediated environment. A generative system can produce many variations around a prompt, and those variations can be useful for exploration. Yet an increase in the number of candidates does not establish an increase in structural generativity. A configuration may face more options while gaining little ability to discriminate among them, connect them to historical problems, or identify which branch would transform subsequent inquiry. The aesthetically mature function lies partly in recognizing which candidate has the potential to reorganize a problem space and which merely adds another manifestation.

Table 8 summarizes several distinctions used in this section. The table does not rank the properties or imply that one candidate should maximize them simultaneously.

The distinctions in Table 8 also explain why aesthetic expertise can improve with history and breadth. Historical consciousness supplies exemplars whose significance became visible through later transformations. Relational breadth reveals structural correspondences and tensions that can make a candidate fertile across several domains. The aesthetic capacity developed here is therefore coupled to earlier capacities rather than functioning as an isolated taste faculty.

8.5 Long-Horizon Research Commitment

Some scholarly problems demand years or decades of sustained attention. The decision to enter such a trajectory cannot be fully justified by immediate output metrics because many of the relevant consequences are unknown at the point of commitment. Aesthetic judgment can therefore have a prospective function: it supports commitment under uncertainty by identifying problems whose structure appears sufficiently rich, coherent, or generative to warrant prolonged engagement.

This prospective role should be described with epistemic humility. Aesthetic conviction can be mistaken, and historical survivorship can exaggerate the apparent reliability of celebrated scholars' intuitions. Famous examples are disproportionately drawn from programmes that later became consequential, whereas abandoned beautiful ideas, failed research schools, and aesthetically motivated dead ends are less visible. The present framework therefore treats long-horizon aesthetic commitment as a fallible scholarly practice rather than an oracle of future significance.

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The role of formation becomes visible precisely in this uncertainty. A mature scholar can draw on historical cases, disciplinary exemplars, relational breadth, tacit experience, and ongoing dialogue to decide that one difficult problem possesses a kind of intellectual fertility absent from many equally difficult alternatives. Such judgments may be difficult to reduce to explicit rules, yet they can be examined retrospectively through reasons, comparisons, trajectories of revision, and the consequences of sustained inquiry. This makes aesthetic judgment compatible with the paper's broader commitment to accountable but partially tacit expertise.

AI changes the environment of this commitment in at least two ways. First, systems that cheaply generate candidate questions, conjectures, formulations, or connections can enlarge $\mathcal{P}_{t,\xi}$. Second, AI can participate in aesthetic discrimination by comparing structures, surfacing precedents, simulating consequences, proposing unifications, or learning preference patterns from expert feedback. Neither change settles whether a given Human–AI configuration possesses mature aesthetic judgment. The relevant evidence concerns whether the coupled configuration can make stable, revisable, context-sensitive discriminations whose consequences improve the organization of inquiry over time.

This framing avoids making aesthetic judgment a protected human essence. A future AI system might acquire capabilities that support some or many of the functions described here. Conversely, a human researcher can exhibit weak aesthetic judgment despite extensive factual knowledge. The analytical unit remains the scholarly configuration and its demonstrated capacity across histories, tasks, and contexts.

8.6 Limits of Formalizing Aesthetic Judgment

Aesthetic judgment is especially vulnerable to premature formalization. It is tempting to write a scalar function that maps a candidate problem to a numerical value and then treat scholarly selection as optimization. Such a representation could be useful in a tightly specified empirical study, but the present paper does not assume that elegance, depth, fertility, surprise, and explanatory organization share a stable common scale. Their relative importance can change across disciplines, research schools, historical moments, and problem types.

A limited notation can nevertheless clarify the analytical role of judgment. Let $J^{\text{aest}}_{t,\xi}$ denote the aesthetic-evaluative practice available to scholarly configuration Σ^{sch}_t in context ξ. Its application to candidate p can produce a structured evaluation profile rather than a scalar score. Equation 13 states this representation.

$$J^{\text{aest}}_{t,\xi}(p) = \mathbf{a}_{t,\xi}(p), \tag{13}$$

where $\mathbf{a}_{t,\xi}(p)$ denotes a context-sensitive profile whose components can include locally relevant judgments of elegance, depth, compression, fertility, coherence, or other aesthetic properties. Equation 13 is a formal representation of differentiated judgment, not a claim that the components can be objectively measured or aggregated.

This representation preserves three properties important to the GR account. First, aesthetic judgment is *situated*: the index t, ξ records historical and contextual dependence. Second, it is *relational*: the evaluation depends on the language, exemplars, methods, and problem structures available to the configuration. Third, it is *revisable*: later inquiry can alter both the profile assigned to p and the evaluative practice $J^{\text{aest}}_{t,\xi}$ itself. McAllister's historical treatment of changing aesthetic canons in science is especially relevant to this revisability [14].

Aesthetic judgment therefore occupies a specific place within scholarly formation. It mediates between an expanding candidate space and selective research commitment; it can identify elegance, depth, and prospective generative promise without reducing them to difficulty or novelty; and it can guide long-horizon inquiry while remaining fallible and historically formed. Normative judgment remains a distinct evaluative capacity because an intellectually beautiful and structurally fertile problem can still receive low priority under particular social, ecological, political, or resource conditions. Preserving this distinction is necessary for the broader account of scholarly maturity developed here.

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9 Normative Judgment and Research Priority

This section develops normative judgment as the fifth substantive capacity in the proposed architecture of scholarly formation. Its role is to distinguish the intellectual evaluation of a research direction from the practical judgment concerning whether, when, at what scale, and under which conditions that direction should receive attention, resources, institutional support, or accelerated development. The objective is to specify the relational information that enters research-priority judgment without reducing heterogeneous normative considerations to a single metric. The discussion is conceptual and comparative. Work in philosophy of science, research-priority setting, and the economics of scientific practice provides external interfaces, while the Generative Relational (GR) contribution lies in treating normative priority as a situated judgment formed within a history-bearing configuration whose available resources, institutions, affected relations, and future continuation possibilities can change through the research process itself.

9.1 Normative Situation of Research Choice

Scientific and scholarly inquiry is selective. Even where many questions are answerable in principle, communities and institutions face finite time, attention, equipment, labor, funding, ecological capacity, and opportunities for implementation. Kitcher develops this selectivity as a central problem of scientific significance and argues that the importance assigned to research questions cannot be settled by truth-seeking alone; his ideal of well-ordered science relates scientific significance to informed deliberation about human interests [17]. The present framework does not adopt Kitcher's democratic ideal as the unique procedure for priority setting. It uses the underlying selectivity problem as evidence that research significance and research organization contain an evaluative dimension beyond epistemic correctness.

Douglas provides a complementary interface by arguing that values can legitimately enter scientific reasoning in conditions where choices under uncertainty have morally significant consequences, while also distinguishing roles for values that preserve standards of evidential integrity [18]. Her account is particularly useful for the present paper because it prevents two simplifications: treating science as wholly insulated from values, and treating the presence of values as permission for unrestricted political or moral substitution for evidence. Normative judgment in scholarly formation requires attention to both evidential adequacy and the consequences of research choices.

The relevant unit of analysis is therefore a research choice situated within a relational context. The normative conditions recorded in $\mathcal{N}_t$ supply part of that context; they do not determine the judgment by themselves. Normative judgment belongs to the operative capacity component $\mathcal{C}_t$ and evaluates a choice through an evidentially and historically situated interpretation of those conditions, alternatives, uncertainties, and responsibilities. Let p denote a candidate research direction, t the historical time of judgment, and ξ the local inquiry context. The paper represents the normative evaluation of p through the profile in Equation 14.

$$J^{\text{norm}}_{t,\xi}(p) = \mathbf{n}_{t,\xi}(p), \tag{14}$$

where $\mathbf{n}_{t,\xi}(p)$ is a structured profile of normatively relevant considerations rather than a scalar score. The profile can include expected social consequences, ecological effects, resource requirements, distributional effects, risk and reversibility, institutional obligations, opportunity costs, and the effects of research on future inquiry conditions. The components need not be mutually commensurable, and their relevance can vary across research domains and historical situations.

Definition 9.1 (Normative judgment in scholarly formation)**.** Within the present framework, *normative judgment* is the situated capacity of a scholarly configuration to evaluate the practical priority, permissible scale, timing, conditions, and responsibilities associated with a research direction in relation to affected beings, institutions, resources, environments, alternative uses, and future possibilities of inquiry.

Definition 9.1 makes priority action-relative. A judgment that a problem deserves intellectual attention is different from a judgment that it should receive a major laboratory, a national programme, rapid

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Table 9: Provisional dimensions of normative research-priority judgment.

Dimension	Analytical question	Priority relevance
Social consequence	Which persons, communities, institutions, or practices may be affected, and through which pathways?	Connects research choice to foreseeable benefits, burdens, vulnerabilities, and forms of dependence.
Ecological consequence	Which material, energetic, biological, or environmental conditions may be altered?	Makes ecological cost and persistence relevant to research scale and implementation.
Resource demand	Which scarce forms of funding, labor, time, infrastructure, data, land, energy, or attention are required?	Relates a research programme to alternative uses of finite capacities.
Distribution	Who is positioned to receive benefits, bear risks, supply labor, or lose options?	Makes unequal allocation of consequences visible within the priority judgment.
Risk and reversibility	Which adverse outcomes are plausible, how uncertain are they, and how readily can the intervention be revised or withdrawn?	Relates uncertainty to pacing, safeguards, monitoring, and permissible commitment.
Institutional responsibility	Which duties arise from the role, authority, mandate, expertise, or public position of the relevant institution or researcher?	Connects research freedom to role-specific responsibility and accountability.
Future inquiry conditions	How might present investment expand, narrow, lock in, or destroy later research possibilities?	Extends priority judgment to the generative consequences of present allocation.

deployment, unrestricted dissemination, or decades of concentrated public investment. The same research object can therefore receive different priority judgments at different action scales. A preliminary theoretical investigation may be normatively acceptable under conditions where large-scale implementation would require further evidence, institutional safeguards, or public deliberation.

Table 9 summarizes a provisional set of dimensions that can enter the normative profile. The table is a scaffolding device rather than a universal checklist. Domain-specific inquiry can add, remove, or refine dimensions when justified by the relevant normative and empirical setting.

The dimensions in Table 9 do not produce an automatic decision. They identify relations that a mature judgment may need to reconstruct. Priority can remain underdetermined after the relevant considerations have been identified because different normative frameworks can weight them differently and because empirical uncertainty can remain substantial. Scholarly formation therefore includes the capacity to expose the structure of a normative disagreement rather than prematurely converting it into apparent consensus.

9.2 Social and Ecological Consequences

Research choices can transform relations beyond the immediate community producing the research. A new technique can alter labor organization, informational asymmetries, access to services, environmental burdens, security conditions, or the distribution of decision authority. A theoretical development can also acquire practical consequences after a delay or through applications that were not central to the original inquiry. Normative judgment therefore requires a temporal and relational horizon broad enough to consider plausible pathways from inquiry to use while preserving uncertainty about effects that cannot yet be known.

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The present framework distinguishes consequence awareness from deterministic impact prediction. Scholars rarely possess complete causal knowledge of downstream applications. Mature normative judgment can nevertheless identify classes of foreseeable consequence, specify relevant uncertainties, distinguish reversible from difficult-to-reverse commitments, and revise priority as evidence changes. This orientation fits the broader GR commitment to history-bearing judgment: the normative profile at time t can be updated as the relational configuration changes.

Ecological considerations make the scale dependence of research priority especially visible. Computational research can require energy-intensive infrastructure; field research can place pressure on vulnerable sites or populations; experimental programmes can consume scarce materials; engineering programmes can create long-lived physical commitments. These effects do not supply a universal reason to reject resource-intensive inquiry. They become part of the relational situation within which scale, timing, alternatives, and expected contribution are judged.

The same reasoning applies to socially beneficial research. A programme expected to produce substantial public benefit can acquire high normative priority even when its aesthetic profile is modest. Conversely, an intellectually elegant programme can receive lower practical priority under conditions where its resource demands crowd out urgent obligations or where foreseeable harms are inadequately governed. The framework therefore preserves the independence of the aesthetic and normative profiles while allowing them to interact in actual research choice.

Caution 9.2 (Forecasting discipline)**.** Normative priority should not be justified by speculative consequence narratives presented with greater confidence than the available evidence supports. Where downstream effects remain uncertain, the judgment should record the uncertainty, the causal assumptions, the reversibility of present commitments, and the conditions under which the priority assessment should be revised.

Caution 9.2 is especially important in emerging technological domains, where both optimistic and catastrophic narratives can outrun empirical support. Scholarly maturity includes the ability to treat uncertainty as part of the normative structure rather than as an inconvenience to be hidden by rhetorical confidence.

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9.3 Resource Allocation and Opportunity Cost

Research priority acquires practical meaning when attention, time, infrastructure, labor, and funding are allocated among competing possibilities. Opportunity cost therefore belongs to the structure of normative judgment. Allocating a scarce telescope, supercomputer, archive budget, laboratory, field site, or cohort of trained researchers to one programme changes the continuation spaces available to other programmes. The relevant comparison is consequently wider than the expected value of the focal project considered in isolation.

Research-priority literature in health provides a useful domain-specific example. Viergever and colleagues, drawing on a literature review and World Health Organization-related priority-setting exercises, emphasize context, available resources, stakeholder participation, information gathering, explicit criteria, implementation, evaluation, and transparency as recurring elements of good-practice priority setting [19]. Their checklist is designed for health research and cannot be transferred wholesale to every scholarly domain. Its relevance here lies in showing that mature priority setting is commonly treated as a structured process involving context, affected parties, criteria, and implementation rather than as a ranking derived from scientific merit alone.

Within GR, opportunity cost can be represented through changes in continuation space. Let $\mathfrak{G}(\Sigma_t^{\mathrm{sch}})$ denote the viable scholarly continuation space introduced in Section 3. A large commitment to p can expand some future trajectories while reducing the viability of others. The allocation effect is represented schematically in Equation 15.

$$\mathfrak{G}(\Sigma_t^{\mathrm{sch}}) \xrightarrow{A_t(p)} \mathfrak{G}(\Sigma_{t+1}^{\mathrm{sch}}), \tag{15}$$

where $A_t(p)$ denotes a concrete allocation associated with the research direction p. Equation 15 does not specify whether the resulting continuation space is larger or smaller. An allocation can create new instruments, datasets, communities, and methods; it can also concentrate resources, create infrastructure lock-in, or weaken alternative traditions. The normative question concerns the structure and distribution of these changes.

This perspective also makes preservation relevant. A research community may sometimes have reason to preserve a low-throughput, minority, or temporarily unfashionable line of inquiry because maintaining the capacity for future regeneration has value even when current output is limited. Conversely, indefinite preservation of every research trajectory would itself consume resources and can obstruct new inquiry. Normative judgment therefore concerns selective maintenance of plural continuation possibilities rather than maximal preservation.

9.4 Political-Economic Conditions

Research priorities are formed within institutions whose incentives, funding structures, labor arrangements, prestige systems, and markets shape which questions become practically available. Stephan's economic analysis of science documents how costs, funding mechanisms, employment structures, reputational incentives, and competition for resources can influence topic choice, risk-taking, collaboration, and the organization of public research [20]. The present paper uses this work as an empirical and institutional interface rather than as a complete theory of scholarly motivation.

A GR analysis distinguishes the intellectual attractiveness of a research direction from its institutional legibility. Some projects fit established funding categories, publication genres, datasets, evaluation metrics, or commercial pathways more readily than others. This difference can alter the probability that a project acquires laboratories, trainees, visibility, and follow-on resources. Repeated allocation can then change the research landscape itself, producing a feedback relation between institutional recognition and future scholarly availability.

The same feedback can affect normative judgment. A field with abundant funding and institutional prestige can appear socially inevitable or intrinsically important because its manifestations are numerous and visible. A field with weak institutional support can appear marginal partly because the relations required for its development were never built. Mature scholarly judgment therefore asks whether observed prominence reflects intellectual and normative priority, institutional path dependence, accumulated power, or some combination of these factors.

This analysis also applies to AI-mediated research. Systems that reduce the cost of producing proposals, code, literature syntheses, or manuscript drafts can alter the competitive environment without equalizing access to compute, proprietary data, laboratory infrastructure, expert communities, or institutional legitimacy. Generative abundance at the manifestation layer can coexist with concentrated control over enabling conditions. Normative judgment about AI-enabled research should therefore consider the distribution of generative conditions alongside the volume of produced outputs.

The political-economic perspective remains analytically distinct from a claim that institutional incentives fully determine research content. Scholars can resist incentives, communities can maintain unfashionable programmes, and new concepts can reorganize institutions. The GR interest lies in mutual conditioning: scholarly trajectories act within funding and prestige relations, while successful trajectories can subsequently transform those relations.

9.5 Institutional Responsibility

Normative judgment changes with institutional role. A private researcher deciding how to spend personal study time occupies a different responsibility structure from a public funding agency allocating a national research budget, a university governing human-subject research, a laboratory controlling hazardous infrastructure, or a journal deciding which kinds of evidence receive disciplinary visibility. Authority, resources, expertise, and capacity to impose consequences can generate role-specific obligations.

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Douglas's analysis of scientific responsibility is relevant here because it treats moral responsibility as compatible with rigorous attention to evidence and distinguishes appropriate roles for values within scientific reasoning [18]. Kitcher's account likewise connects the organization of inquiry to questions of significance and the responsibilities of scientific communities within society [17]. These works differ in their philosophical architecture. The present framework draws from their shared recognition that research organization involves responsibility without treating either account as the final normative foundation for GR.

Institutional responsibility can be analyzed through at least four relations. First, an institution can owe duties to those exposed to risks created by its research. Second, it can owe stewardship duties concerning public, charitable, or collectively maintained resources. Third, it can hold epistemic responsibilities concerning transparency, methodological quality, and communication of uncertainty. Fourth, it can have generative responsibilities concerning the maintenance of research capacities, training structures, archives, and plural intellectual traditions on which future inquiry depends.

The fourth relation extends the usual discussion of immediate harms and benefits. A funding or educational institution can alter the composition of future scholarship by deciding which methods are taught, which languages are preserved, which archives remain accessible, which young researchers receive stable development time, and which long-horizon programmes survive periods of low immediate return. These decisions affect future continuation space even where their short-term outputs are difficult to quantify.

Remark 9.3 (Role-sensitive responsibility)**.** The framework does not infer one universal duty from the existence of scholarly capacity. Responsibility is indexed to relational position, authority, foreseeable effect, available alternatives, and institutional mandate. Greater capacity or power can enlarge some responsibilities without implying that every capable actor bears identical obligations.

Remark 9.3 also protects the account from converting scholarly maturity into unlimited moral burden. Normative judgment includes recognition of the boundaries of one's role, competence, and authority as well as recognition of obligations.

9.6 Intellectual Worth and Normative Priority

The relation between aesthetic judgment and normative judgment can now be stated more precisely. Section 8 introduced an aesthetic profile $\mathbf{a}_{t,\xi}(p)$ that records forms of perceived intellectual worth. Equation 14 introduced a normative profile $\mathbf{n}_{t,\xi}(p)$ concerning the situated consequences and responsibilities associated with pursuit. A mature research decision can require both profiles while preserving their distinct analytical functions.

The joint evaluative representation is stated in Equation 16.

$$\mathcal{J}_{t,\xi}(p) = \big(\mathbf{a}_{t,\xi}(p), \mathbf{n}_{t,\xi}(p)\big). \tag{16}$$

Equation 16 does not define a ranking function. It records that intellectual worth and normative priority can supply different information about the same research direction. A project can be aesthetically compelling and normatively low-priority at a particular historical moment; another can be aesthetically ordinary yet normatively urgent because it addresses a severe practical need with available methods. A third can be strong on both dimensions, while a fourth can warrant little commitment on either. The framework preserves these possibilities without requiring a universal conversion rate between them.

The distinction is especially important in an AI-rich research environment. As candidate generation becomes cheaper, communities can encounter a larger supply of technically interesting and aesthetically attractive directions. Normative capacity concerns the additional question of which trajectories should receive scarce collective commitment. AI can assist consequence modelling, literature synthesis, scenario generation, stakeholder mapping, and resource estimation, but increased analytical throughput does not by itself settle conflicts among values, distributions, institutional roles, or acceptable risk. Human–AI

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scholarly configurations should therefore be evaluated by the quality and revisability of their normative reasoning rather than by whether the final priority judgment originated from an unaided human process.

Normative judgment also feeds back into scholarly formation. Repeated priority decisions shape which histories are accumulated, which relations are built, which methods become routine, which communities survive, and which future candidates become recognizable. A normative judgment is therefore not only a response to an existing research landscape. At institutional scale, it can participate in generating the landscape within which later scholarly judgment occurs.

The capacity developed in this section can be summarized as disciplined research-priority judgment under relational constraint. Mature scholarship can recognize intellectual beauty without treating beauty as sufficient priority, acknowledge social need without permitting urgency to erase evidential standards, identify economic and institutional conditioning without reducing inquiry to incentives, and make provisional commitments while preserving the possibility of revision. This evaluative capacity remains distinct from scholarly translation, which concerns movement among heterogeneous conceptual and linguistic systems whose standards of evidence, inference, and intelligibility can themselves differ.

10 Language Systems and Scholarly Translation

This section develops scholarly translation as the sixth capacity family in the proposed account of scholarly formation. Its role is to specify what is required when a concept, problem, argument, method, or evidential claim must become intelligible within a language system whose distinctions and inferential practices differ from those in which the scholarly object was initially formulated. The objective is narrower than a general theory of translation. The section focuses on translation across scholarly, disciplinary, intercultural, and institutional settings in which meaning depends on more than lexical substitution. The discussion proceeds through six steps. It first refines the concept of a scholarly language system, then identifies the evidential and inferential organization that makes such systems operative, develops a task-indexed relation of cross-system intelligibility, examines interdisciplinary and intercultural translation, and closes by specifying partiality, remainder, and failure as analytically important features of translation. The method is conceptual and comparative. Existing work on hermeneutics, incommensurability, trading zones, and boundary objects provides interfaces for the analysis, while the GR contribution concerns the relation among language systems, retained scholarly functions, history-bearing configurations, and future generative capacity.

10.1 Conceptual Language Systems

Section 3.3 introduced $\mathcal{L}_t$ as the component of a scholarly configuration through which available resources become interpretable and actionable. The present section gives that object a more explicit internal structure. A scholarly language system contains natural-language expressions, yet it also includes concepts, distinctions, examples, notational practices, inferential permissions, evidence conventions, standards of explanation, problem framings, and historically stabilized expectations concerning what counts as a relevant question or a satisfactory answer. The term *language system* is therefore analytical rather than purely linguistic.

For a specified scholarly question q and local context ξ, the relevant projection of a language system is represented in Equation 17.

$$\mathcal{L}^{(q,\xi)} = \left(\mathsf{Con}^{(q,\xi)}, \mathsf{Inf}^{(q,\xi)}, \mathsf{Evd}^{(q,\xi)}, \mathsf{Prb}^{(q,\xi)}, \mathsf{Exm}^{(q,\xi)}, \mathsf{Std}^{(q,\xi)}\right). \tag{17}$$

In Equation 17, Con denotes the relevant conceptual distinctions, Inf the locally admissible inferential moves, Evd the evidential conventions, Prb the problem framings, Exm the exemplary and representational resources through which the system is learned or used, and Std the standards by which explanations, arguments, or solutions are assessed. These components are analytical projections and can overlap empirically. A canonical example can function simultaneously as an exemplar, an evidential precedent, and a source of disciplinary vocabulary. A mathematical notation can encode both a conceptual distinction

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Table 10: Components of a scholarly language system and translation diagnostics

Component	Local scholarly function	Translation diagnostic
Conceptual distinctions Con	Organize categories, contrasts, and objects of attention	Which distinctions remain necessary in the target system, and which distinctions would be collapsed by a fluent paraphrase?
Inferential practices Inf	Specify locally licensed transitions among claims or representations	Does the translated formulation preserve the inferences that the source argument actually licenses?
Evidence conventions Evd	Organize what can count as support, counterevidence, or warrant	What kind of evidence would make the claim intelligible and assessable within the target practice?
Problem framings Prb	Determine what is treated as the problem, boundary condition, or relevant unknown	Has the target formulation preserved the problem being addressed, or silently substituted another problem?
Exemplary resources Exm	Supply cases, metaphors, models, diagrams, precedents, and notational anchors	Which examples or representations carry the operative intuition, and do they travel across the boundary?
Assessment standards Std	Organize adequacy, rigor, explanation, elegance, relevance, or legitimacy	Under which target-side standards can the translated object be evaluated without disguising a change of criterion?

and a permitted transformation. A legal category can carry an evidential rule, an institutional history, and a normative consequence.

The question index prevents the representation from expanding into a complete theory of an entire discipline or culture. A physicist and a political theorist can share ordinary language while relying on sharply different local systems for a particular problem. Two subfields within physics can likewise differ in accepted idealizations, evidential practices, or preferred representations. Conversely, two scholars working in different natural languages can share a technical mathematical system sufficiently well to coordinate inquiry. The relevant translation problem is therefore determined by the differences that matter for the scholarly task rather than by linguistic identity alone.

The historical dimension developed in Section 4 remains active inside $\mathcal{L}^{(q,\xi)}$. Concepts and inferential practices carry histories of use, correction, institutionalization, and contest. Gadamer's philosophical hermeneutics provides one important interface because understanding is situated within historically formed horizons and language rather than treated as access to a context-free semantic object [9]. Kuhn's later work on communicability and incommensurability likewise emphasizes that scientific comparison can involve lexically and conceptually structured differences without making communication impossible [21]. The present framework uses these interfaces cautiously. It does not infer that disciplines are internally homogeneous paradigms or that translation across them requires total conceptual conversion.

Table 10 summarizes the components used in Equation 17 and the corresponding translation questions. The table is diagnostic: it indicates where a surface-level paraphrase can remain inadequate even when the words appear fluent.

The representation makes one feature of mature scholarship visible. Entering another language system requires more than learning its vocabulary. A scholar must often reconstruct how distinctions, evidence, inference, exemplars, and standards work together. This reconstruction can remain partial. The capacity at issue is the ability to identify the parts that matter for the local inquiry and to revise one's translation when target-side use reveals that a supposedly equivalent expression performs a different scholarly function.

10.2 Evidence, Inference, and Disciplinary Convention

Scholarly translation becomes difficult when two systems assign different functions to apparently similar claims. A statement that operates as a model assumption in one field can be read as an empirical

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assertion in another. A stylized example in economics can be interpreted as a historical description by a reader who does not share the modeling convention. A legal proposition can depend on institutional authority and precedent in ways that differ from the evidential structure of an empirical social-science claim. Mathematical similarity can therefore coexist with evidential or inferential non-equivalence.

The distinction can be expressed through the relation between a proposition and the local practices that surround it. Let $\mathscr{O}_A^{(q,\xi)}$ and $\mathscr{O}_B^{(q,\xi)}$ denote the scholarly-object spaces made available by the source and target language systems for the local inquiry. Let $x_A \in \mathscr{O}_A^{(q,\xi)}$ denote a source-side scholarly object and $x_B \in \mathscr{O}_B^{(q,\xi)}$ a proposed target-side rendering. Let β denote a task-specified retention specification: the characteristics whose preservation matters for the translation. A provisional translation relation is stated in Equation 18.

$$\mathcal{T}_{A\to B}^{(q,\xi,\beta)} \subseteq \mathscr{O}_A^{(q,\xi)} \times \mathscr{O}_B^{(q,\xi)}, \tag{18}$$

where $(x_A, x_B) \in \mathcal{T}_{A\to B}^{(q,\xi,\beta)}$ records a proposed translation relation under the stated task, context, and retained characteristics. Equation 18 is deliberately relational rather than functional. One source object can admit several adequate target renderings, and one target rendering can integrate materials from several source expressions. The relation can also remain undefined for parts of the source object when the target system lacks an adequate local counterpart.

The parameter β requires explicit specification. In one task, preservation of inferential role can be central. In another, historical connotation, legal effect, operational definition, or mathematical structure can matter more. Translation quality therefore cannot be inferred from lexical closeness alone. A formally similar expression can fail when it alters evidential status, while a visibly different expression can preserve the function relevant to the inquiry.

Definition 10.1 (Scholarly translation)**.** A *scholarly translation* from $\mathcal{L}_A$ to $\mathcal{L}_B$ is a task-indexed construction that makes a source scholarly object intelligible and assessable within $\mathcal{L}_B$. The construction states which characteristics it intends to retain and records materially relevant remainder.

Definition 10.1 makes translation a scholarly activity because the translator must exercise judgment about what the source object is doing. The task can require source-side competence, target-side competence, and sensitivity to the relation between them. An interpreter who understands the source concept but lacks familiarity with target-side evidence rules may produce an accurate paraphrase that remains unusable in the target field. An interpreter fluent in the target vocabulary can also produce a locally elegant rendering that changes the source problem or inferential commitment. Scholarly translation therefore depends on relational breadth from Section 5, while adding the stronger requirement that an object become usable inside another language system.

Disciplinary conventions matter because they often remain only partly explicit. Polanyi's account of tacit knowing is relevant here: competent participation in a scholarly practice can depend on background judgment and inherited practice that exceeds a list of formal rules [7]. Translation consequently benefits from interaction with practitioners, examples, corrections, and situated use. A glossary can support entry into a field, yet it rarely supplies the full pattern of evidential and inferential expectations through which the terms acquire scholarly force.

10.3 Cross-System Intelligibility

Cross-system intelligibility is the practical condition under which a target configuration can recognize what scholarly work a source object is intended to perform. The relevant achievement is stronger than surface comprehensibility and weaker than full conceptual identity. The target configuration needs enough structure to identify the source problem, follow the important distinctions, understand the evidential status, reconstruct relevant inferences, and recognize where the target formulation changes or leaves open part of the source object.

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This intermediate status is important because complete unification is often unnecessary for scholarly cooperation. Kuhn's discussions of comparability and communicability are useful precisely because conceptual difference need not entail the absence of rational comparison or communication [21]. Galison's historical analysis of experimental microphysics develops a complementary case: heterogeneous subcultures can coordinate in local "trading zones" through partial languages and shared practices even when their broader conceptual commitments remain different [22]. Star and Griesemer's analysis of boundary objects similarly shows how heterogeneous actors can cooperate through objects that remain adaptable to different viewpoints while preserving enough common structure for coordinated work [23].

These literatures suggest several modes of cross-system coordination that should remain analytically distinct. One mode seeks a relatively direct conceptual translation. A second constructs a local interaction language sufficient for a bounded task. A third relies on shared objects, standardized forms, datasets, diagrams, or procedures whose use can be coordinated despite differing interpretations. A fourth preserves disagreement while making the disagreement sufficiently explicit for criticism or joint decision. Mature scholarship can move among these modes without treating one as the universal solution.

The present framework therefore treats cross-system intelligibility as a relation with degrees and dimensions rather than as a binary property. A translation can preserve terminology while weakening inferential fidelity; another can preserve causal structure while changing metaphor and notation; a boundary object can enable coordination without generating strong semantic convergence. The investigator should identify which type of intelligibility is relevant to the task and which residual differences remain consequential.

This point also clarifies the relation between translation and assimilation. A target configuration can understand a translated manifestation for one task without incorporating the source distinctions into its own language system. Stronger assimilation occurs when the encounter changes later interpretation, comparison, or problem formation within Σ_t^{sch}. Translation can therefore be episodic, while scholarly formation concerns whether the translated material becomes part of a stable or revisable continuation capacity.

10.4 Interdisciplinary Translation

Interdisciplinary translation provides a particularly visible case because the participating systems can share ordinary language while assigning different technical roles to the same terms. Section 5 treated interdisciplinary competence as the construction of typed and warranted relations among domains. Scholarly translation adds a complementary task: a concept or method must be reformulated so that participants in another domain can use, criticize, or appropriately limit it within their own evidential and inferential practice.

Three translation operations are especially important. The first is *role reconstruction*: identifying whether a source item functions as an empirical claim, a mathematical representation, a heuristic, a normative principle, a legal category, an analogy, or another kind of scholarly object. The second is *target-side anchoring*: locating examples, distinctions, or practices in the target field that can carry the relevant structure. The third is *remainder marking*: identifying assumptions, scales, background knowledge, or evaluative criteria that do not travel with the translation.

These operations help explain why mature interdisciplinary scholars can move rapidly among fields without treating the boundaries as meaningless. Their mobility can depend on stronger boundary awareness. A physicist borrowing a concept from information theory, a political economist using a dynamical-systems analogy, or an education researcher drawing on cognitive science needs to know which relations are structural, which are heuristic, and which remain unsupported. The translation succeeds when it increases target-side intelligibility while preserving the ability to identify where the source and target systems diverge.

The existing interdisciplinarity literature reviewed in Section 5 already emphasizes integration rather than juxtaposition [12, 13]. Galison and Star–Griesemer add a useful qualification: productive collaboration can also proceed through local coordination mechanisms that fall short of comprehensive integration

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[22, 23]. The GR account therefore permits several successful endpoints, including conceptual translation, local trading languages, boundary objects, and explicit preservation of unresolved difference. The appropriate endpoint depends on the scholarly task.

AI systems can accelerate interdisciplinary translation by proposing definitions, analogies, equivalent terminology, examples, and explanatory variants. The same capability can increase the rate of unsupported transfer. Generated fluency can hide a change in evidential status, scale, or inferential role. For this reason, AI-assisted translation should be evaluated through target-side use and correction rather than by linguistic smoothness alone. A Human–AI configuration demonstrates stronger scholarly translation when it can expose assumptions, preserve domain labels, identify uncertainty, recover source provenance, and revise the translation after target-field criticism.

10.5 Intercultural and Institutional Translation

Scholarly language systems also differ across cultural and institutional settings. A concept can move among academic traditions, legal systems, policy organizations, professional communities, public institutions, and local knowledge practices. In such cases, translation can involve different histories of classification, legitimacy, evidence, authority, and normative salience. Natural-language translation remains important, yet the harder problem often concerns the institutional or conceptual work performed by a term.

A policy category, for example, can carry administrative consequences that are absent from its closest academic analogue. A legal concept can depend on jurisdiction-specific doctrine and procedure. A philosophical term can be embedded in an intellectual genealogy that gives it a different range of contrasts from a superficially similar term in another tradition. Historical consciousness from Section 4 therefore becomes part of translation: the translator needs to know which historical relations are constitutive for the present use and which can be bracketed for the local task.

Gadamer's account of historically situated understanding supports caution toward a purely transport model of meaning [9]. The present framework adds a GR emphasis on configuration and relation. Translation occurs between history-bearing scholarly configurations whose language systems are supported by institutions, archives, communities, and differential authority. The translator's task includes reconstructing enough of those relations for the target formulation to remain responsible to the source while becoming intelligible locally.

The institutional dimension also connects to the power analysis in Section 13. A dominant institution can possess greater capacity to standardize terminology, certify translations, or impose classifications on another system. The present section does not yet evaluate those asymmetries normatively. It records a narrower analytical requirement: translation should identify when a target-side rendering acquires institutional consequences or interpretive authority that were absent from the source context. This requirement helps prevent apparently neutral translation from concealing a change in the social function of the concept.

Intercultural translation also reveals why humility and translation are connected but distinct capacities. Translation requires target-side reconstruction. Humility concerns the regulation of one's own evaluative projection while performing that reconstruction. A scholar can possess substantial translational technique while remaining overly confident that the target system is fully captured. Section 12 treats epistemic-relational humility as a separate constraint on how translation, judgment, and criticism are exercised.

10.6 Translation Boundaries and Remainders

Scholarly translation becomes more reliable when its limits are represented explicitly. A translation can preserve some characteristics while losing others; a local coordination language can work for one task and fail for another; an apparently equivalent concept can depend on a historical distinction that has no stable target counterpart. These outcomes are not merely defects. They provide information about the relation between language systems.

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Let $\rho^{(q,\xi)}(x_A)$ denote the source-side characteristics judged relevant to x_A under the current inquiry, and let $\mathrm{Ret}_{\beta}^{(q,\xi)}(x_A, x_B)$ denote the characteristics actually retained by the proposed translation under retention specification β. The translation remainder is represented in Equation 19.

$$\mathfrak{R}_{A\to B}^{(q,\xi)}(x_A, x_B) = \rho^{(q,\xi)}(x_A) \setminus \mathrm{Ret}_{\beta}^{(q,\xi)}(x_A, x_B). \tag{19}$$

Equation 19 is schematic. It does not assume that conceptual characteristics form a simple set in every empirical application. Its analytical role is to require a place for what the translation leaves behind: historical connotation, inferential permission, evidential status, normative force, scale, ambiguity, or another feature relevant to the source object. A translation with a small remainder for one task can have a large remainder for another.

Caution 10.2 (Translation without forced equivalence)**.** Cross-system intelligibility, coordinated use, or successful local translation provides evidence of a workable relation between language systems. These achievements do not by themselves establish identity, full equivalence, or universal commensurability between the systems.

Caution 10.2 extends the manuscript's earlier discipline concerning analogy and equivalence. Failed translation can be analytically productive when it identifies a distinction that the target language cannot currently express without substantial reconstruction. Partial translation can reveal which functions travel and which depend on local history. Competing translations can expose ambiguity in the source itself. Translation therefore becomes a method for studying boundaries as well as crossing them.

The distinction is especially important in an AI environment. Contemporary language models can produce rapid, fluent renderings across natural languages and disciplinary registers. Fluency supplies evidence of manifestation-level competence, while scholarly translation requires additional evidence concerning inferential role, evidential status, provenance, target-side uptake, and remainder recognition. A model or Human–AI configuration that can say "there is no exact counterpart" and explain the consequential difference can, for some tasks, demonstrate stronger translation capacity than a system that produces seamless lexical substitution.

These results establish the transition to Section 11. Scholarly translation concerns responsible target-side intelligibility under explicitly stated retention criteria and remainder. Generative translation asks a further question: whether an intervention changes the target configuration's later capacity to reconstruct, test, extend, or independently regenerate the relevant scholarly object.

11 Generative Translation

This section develops generative translation as the seventh capacity family in the proposed account of scholarly formation. Its role is to distinguish the provision of a target-side scholarly manifestation from an intervention that changes the conditions under which an interlocutor can generate, reconstruct, test, or extend a corresponding concept within the interlocutor's own language system. The objective is to specify this distinction without presuming that mature understanding requires solitary discovery or that direct explanation is educationally inferior. The discussion proceeds through six steps. It first identifies the manifestation-oriented structure of ordinary scholarly translation, then represents generative translation as a configuration update, classifies several forms of generative intervention, examines evidence of target-side concept generation, relates the proposal to tutoring and conceptual-change research, and closes with heterogeneous-system cases and limits. The method is structural and comparative. Section 10 supplies the translation relation and remainder; Section 3 supplies the history-bearing configuration, update map, assimilation criterion, and continuation space used here.

11.1 Translation of Manifestations

Scholarly translation commonly aims to produce a target-side manifestation that makes a source object intelligible in another language system. Let x_A denote a source-side scholarly object and let x_B denote

Table 11: Manifestation-oriented translation and generative translation as distinct scholarly functions

Analytical dimension	**Manifestation-oriented translation**	**Generative translation**
Primary object	Target-side rendering of a source concept, claim, method, or problem	Conditions under which the target configuration can generate, reconstruct, test, or extend a corresponding object
Immediate evidence	Accuracy, intelligibility, preservation of task-relevant function, and explicit remainder	Change in later interpretation, reconstruction, transfer, criticism, or continuation
Typical means	Definition, paraphrase, notation, example, diagram, comparative explanation	Sequenced questions, examples, contrasts, counterexamples, partial representations, structured encounters, and direct explanation used within a developmental sequence
Temporal horizon	Can be evaluated at the moment of reception	Requires evidence from subsequent target-side activity
Relation to assimilation	Can supply a resource for later assimilation	Aims directly at a configuration change that supports assimilation
Characteristic risk	Fluent rendering can conceal lost inferential or historical structure	Intervention can over-steer the target system, create dependence, or mistake temporary performance for formation

a target-side rendering. Section 10 represented the relation between them through $\mathcal{T}_{A\to B}^{(q,\xi,\beta)}$, where the task q, context ξ, and retained characteristics β specify what the translation is intended to preserve. This representation already exceeds lexical substitution because the relevant object can include inferential role, evidential status, historical connotation, problem framing, or institutional function.

A manifestation-oriented translation can be highly sophisticated. It can reconstruct examples, introduce a new notation, explain background assumptions, or provide several target formulations for different audiences. Its immediate product nevertheless remains a target-side object supplied to the receiving configuration. The receiving scholar can then use, criticize, assimilate, or ignore that object. Translation quality at this level is therefore evaluated primarily through the adequacy of the supplied rendering and the explicit treatment of its remainder.

Generative translation shifts the analytical focus from the supplied rendering to the subsequent organization of the receiving configuration. The translator can still provide words, examples, diagrams, partial formulations, and explicit claims. The distinctive feature is that these manifestations are selected for their capacity to reorganize the target-side conditions of inquiry. A question can make a previously unnoticed distinction salient. A counterexample can destabilize an inherited classification. A sequence of examples can allow an interlocutor to infer a relation before a formal definition is supplied. A partial formalism can expose which part of a concept is structurally important and which part belongs to the source tradition's local vocabulary.

The distinction therefore concerns scholarly function rather than surface form. The same sentence can operate as an ordinary translation in one interaction and as part of a generative translation in another. A direct definition can become generative when the receiving scholar integrates it into a larger pattern, reconstructs its limits, and begins producing target-side consequences that were unavailable before. Conversely, a deliberately indirect prompt can remain weakly generative if it produces only transient guessing. Generative translation is consequently identified through the relation between an intervention and a change in subsequent scholarly capacity.

Table 11 summarizes the distinction. The table treats the two modes as analytically separable functions that can coexist within one episode.

The distinction in Table 11 also clarifies why generative translation should not be equated with indirectness. A scholar can state the source concept explicitly and still organize the interaction so that the interlocutor must connect it to local evidence, reformulate it through local distinctions, and test its

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limits. The generative function resides in the transformation of the target-side configuration rather than in withholding information.

11.2 Generative Conditions of Understanding

The formal architecture introduced in Section 3 permits generative translation to be represented without introducing a separate ontology of "generative meaning." Let $\Sigma_{B,t}^{\text{sch}}$ denote the target scholarly configuration at analytical time t, and let $\Delta_{A\to B,t}^{\text{gen}}$ denote an intervention bundle selected in relation to source object x_A and target language system $\mathcal{L}_{B,t}$. The target-side update is represented in Equation 20.

$$\Sigma_{B,t+1}^{\text{sch}} = \mathcal{F}_{B,t}\big(\Sigma_{B,t}^{\text{sch}}, \Delta_{A\to B,t}^{\text{gen}}\big). \tag{20}$$

Equation 20 reuses the general scholarly update map $\mathcal{F}_t$ from Equation 5. The intervention bundle can include questions, examples, conceptual contrasts, source fragments, diagrams, partial derivations, criticism, prompts for reconstruction, or access to relevant experiences and records. The superscript gen marks the intended scholarly function of the intervention; it does not guarantee successful generation.

The target configuration can count as having generated a target-side counterpart when a manifestation produced after the update stands in the task-relevant translation relation to the source. A minimal manifestation condition is stated in Equation 21.

$$x'_B \in \mathfrak{M}_{q,\xi}\big(\Sigma_{B,t+1}^{\text{sch}}\big), \qquad (x_A, x'_B) \in \mathcal{T}_{A\to B}^{(q,\xi,\beta)}. \tag{21}$$

Equation 21 supplies only a minimal condition. A single successful restatement can result from imitation, short-term memory, or strong local cueing. Stronger evidence concerns the configuration's subsequent capacity to reconstruct the concept after support changes, identify where the translation ceases to hold, vary examples, respond to counterexamples, transfer the distinction to an adjacent problem, or generate a novel consequence within the target language system. These behaviors link generative translation to the assimilation criterion in Definition 3.3 and to the continuation space $\mathfrak{G}(\Sigma_t^{\text{sch}})$.

Definition 11.1 (Generative translation)**.** A translation episode is *generative* relative to a specified source object, target configuration, task, and context when its intervention contributes to a sufficiently stable target-side reorganization that supports the generation, reconstruction, testing, transfer, or extension of a corresponding scholarly object within the target language system. The attribution is stronger when the resulting capacity persists across variation in wording, examples, support, or local problem conditions.

Definition 11.1 is intentionally relational. It also imposes a boundary on the concept. A target-side capacity change counts here as generative translation only when the intervention is organized in relation to a source scholarly object and a source–target language-system relation, and when the later target-side capacity concerns a corresponding object under stated translation criteria. Generic learning, maturation, or conceptual change caused by an unrelated intervention remains scholarly development but is not thereby translation. Because the present formalism is not a causal identification model, empirical applications must state what evidence supports attributing the observed reorganization to the translation episode rather than to concurrent influences.

The same intervention can be generative for one configuration and unproductive for another because histories, examples, prior distinctions, and available supports differ. A highly explicit explanation can be generative for a scholar whose language system already contains the relevant neighboring concepts. A carefully designed analogy can fail when the target field lacks the background distinction that gives the analogy its intended role. The object of assessment is therefore the relation among source object, intervention, target history, target language system, and subsequent activity.

This formulation also preserves the paper's distinction between relational availability and local possession. A target configuration can develop target-side scholarly capacity through recurrent generative-translation episodes involving collaborators, archives, instruments, or AI systems. The capacity can remain distributed across the coupled configuration. The relevant question is whether the configuration

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can reliably reproduce the scholarly function under the support conditions being attributed, not whether every component can do so independently.

11.3 Questions, Examples, and Conceptual Perturbations

Generative translation often works through interventions that alter what the target configuration notices, contrasts, or attempts to explain. The term *conceptual perturbation* is used here for a deliberately introduced difference that makes an existing organization of the problem locally unstable or incomplete. The term is a structural metaphor rather than a claim that conceptual change follows a physical perturbation law. Its analytical value lies in identifying interventions that modify the problem conditions without supplying a complete target-side solution.

Several intervention forms can perform this function. A *question* can expose a missing distinction or require the interlocutor to make an implicit assumption explicit. An *example sequence* can vary one relation while holding others sufficiently stable for a pattern to become visible. A *counterexample* can show that an apparently general concept depends on a hidden condition. A *contrast pair* can clarify which differences the source system treats as consequential. An *analogy* can transfer a provisional relational structure while leaving the target configuration responsible for identifying the remainder. A *partial representation* can provide enough formal or diagrammatic structure to organize inquiry while leaving a consequential component open for target-side reconstruction.

These interventions differ from random difficulty. Productive perturbation is calibrated to the target configuration's available distinctions and continuation space. An example that is too close to existing practice can produce no reorganization; an example that depends on unavailable background knowledge can appear arbitrary. Mature generative translation therefore requires a model of what the interlocutor can currently distinguish and which neighboring resources are relationally available. This requirement connects generative translation to historical consciousness and relational breadth: the translator needs some reconstruction of how the target system arrived at its present organization and what adjacent conceptual resources it can plausibly assimilate.

The ordering of interventions also matters. Generative translation can be sequential. An initial question can reveal how the target system frames a problem. A second intervention can then be selected in response to that framing. The translator can alternate between elicitation, explicit explanation, comparison, and reconstruction. This adaptive sequence resembles Naturalistic Decision Making in one limited respect: the translator acts in an evolving situation where target-side responses provide feedback for the next move. The analogy remains methodological; the section does not equate tutoring or scholarly dialogue with operational decision making.

A further implication concerns meta-level translation. The translator need not begin from the source concept's most local terminology. In some cases, a more abstract relation can travel more effectively. If the source concept depends on a distinction between state and transition, for example, the translator can first establish why the target problem requires separating persistence from change, then allow the local vocabulary to emerge within the target field. The resulting manifestation can differ substantially from the source expression while retaining the function specified by β. This is the central sense in which generative translation can precede direct conceptual equivalence.

Caution 11.2 (Perturbation and steering)**.** Changing another configuration's generative conditions can support understanding, yet the same structural capacity can also be used to steer attention, suppress alternatives, or engineer agreement. Generative success therefore does not by itself establish epistemic or normative legitimacy. Sections 12 and 13 provide the corresponding constraints of humility and interpretive power.

Caution 11.2 is important because generative translation has greater formative reach than a single paraphrase. A translator who controls examples, problem framings, and admissible distinctions can influence which concepts become available to the interlocutor. The capacity is therefore analytically separable from the normative evaluation of its use.

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11.4 Interlocutor-Internal Concept Generation

The phrase *interlocutor-internal* refers here to generation within the selected target scholarly configuration rather than to a claim about private mental location. A target configuration can include a person, group, institution, archive, or recurrent Human–AI workflow. The defining feature is that the resulting concept becomes organized through the target configuration's own distinctions, examples, evidence practices, and inferential relations.

This target-side generation can be observed through several forms of evidence. The interlocutor can reformulate the concept using locally meaningful examples without losing the source-side function relevant to the task. The interlocutor can identify a case where the concept should not apply. The interlocutor can derive a consequence that the translator did not explicitly provide. The interlocutor can compare the concept with a neighboring target-side distinction and explain the difference. The interlocutor can reconstruct the concept after the original phrasing is unavailable. These performances probe assimilation more strongly than verbatim repetition.

Generative translation can therefore produce a target manifestation that is less lexically similar to the source while being more deeply integrated into the target system. This possibility is especially important across disciplinary or cultural boundaries. A source concept whose force depends on one field's canonical examples can become more usable when the receiving field reconstructs an analogue from its own practice. Section 10 already allows several target-side renderings. The present section adds a developmental criterion: the target configuration should be able to participate in the production and revision of that rendering.

The relation to translation remainder remains essential. Target-side generation can transform the concept as it is assimilated. Some source characteristics can be lost; new target-side consequences can appear; the target system can expose ambiguity or hidden assumptions in the source. Generative translation therefore need not reproduce the source object's entire historical trajectory. Responsible practice records which functions were retained, which remainders remain, and which target-side transformations arose during assimilation.

This feature makes generative translation potentially reciprocal. Once the target configuration generates x'_B, the source-side scholar can encounter a formulation that reveals new distinctions or weaknesses in x_A. The interaction can then update both configurations. A mature scholarly dialogue can consequently alternate the roles of source and target. The language of translation remains useful because the systems differ, while the generative process becomes co-formative rather than unidirectional.

The reciprocal case also provides a bridge to later analyses of humility. A translator who expects the target system merely to reproduce the source concept treats the source language as the fixed criterion of success. Generative translation allows the target response to modify the translator's own understanding. This does not eliminate standards of accuracy or evidence. It changes the interaction from one-way delivery toward a revisable relation in which both systems can acquire new distinctions.

11.5 Non-Substitutive Education

Education provides a particularly clear application because teaching can either supply a solution at the level of manifestation or reorganize the learner's capacity to produce and test solutions. The present account uses the term *non-substitutive education* for educational activity whose success includes the learner's later capacity to perform relevant scholarly operations without reproducing the teacher's intervention in the same form. The term identifies a functional objective and does not imply that teachers should avoid direct instruction.

Wood, Bruner, and Ross's study of tutoring in problem solving provides an important educational interface because it analyzes how tutoring can structure a learner's activity during problem solving rather than treating instruction as simple transmission [24]. Research on conceptual change provides a second interface. Posner and colleagues analyze learning situations in which existing conceptions are reorganized in response to problems, alternatives, and intelligibility conditions [25]. These literatures are not equivalent to the GR concept of generative translation. They are narrower empirical and theoretical tra-

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ditions concerned with learning and conceptual change. Their relevance lies in showing that educational support can operate through the organization of problem conditions and conceptual reconstruction rather than through answer delivery alone.

The GR extension concerns translation across heterogeneous language systems. A teacher can understand a concept in $\mathcal{L}_A$ while the learner organizes the problem through $\mathcal{L}_B$. Directly supplying the mature source formulation can leave the learner with a manifestation whose inferential role remains weakly assimilated. A generative sequence can instead begin from distinctions and examples already available in $\mathcal{L}_B$, introduce a problem that makes a missing distinction consequential, and then coordinate the learner's emerging formulation with the source concept. The educational objective is target-side generativity under preserved scholarly constraints.

Several diagnostics follow. First, success should be tested across variation: new examples, altered wording, changed surface features, and neighboring problems. Second, the learner should be able to explain why a tempting alternative fails under the relevant conditions. Third, the learner should be able to reconnect the generated concept to formal definitions, historical provenance, and disciplinary standards after local understanding has emerged. Fourth, the learner should eventually distinguish the support structure from the concept itself. A scaffold that remains permanently necessary can represent relationally available capacity, yet claims about independent mastery require additional evidence.

This framework is especially relevant in AI-mediated education. AI can rapidly provide direct answers, explanations, examples, counterexamples, hints, and adaptive dialogue. The present account asks which interaction sequence changes the learner's subsequent continuation space. A system that supplies a correct explanation can be useful at the manifestation level. A stronger educational configuration uses explanation, questioning, comparison, and feedback in ways that support later reconstruction and transfer. The paper therefore avoids a simple opposition between answer delivery and generative teaching. The relevant distinction concerns what the interaction leaves the learner able to do next.

11.6 Generative Translation across Heterogeneous Systems

Generative translation is intended to apply beyond teacher–learner relations. Scholarly configurations can differ by discipline, culture, institution, professional practice, technological embodiment, or Human–AI composition. The degree of heterogeneity changes which interventions are possible and what counts as evidence of target-side generation.

Across disciplines, generative translation can begin from a shared problem while allowing each field to generate a locally valid representation. A mathematical model can be introduced through a target field's own empirical regularities before its source notation is taught. A philosophical distinction can be reconstructed through a policy or legal case before the source genealogy is supplied. Across institutional systems, a concept can be generated through local procedures or precedents that make its function visible even when no direct lexical counterpart exists. Galison's trading-zone analysis and Star and Griesemer's boundary-object account remain relevant interfaces because coordination can emerge through local shared practices while substantial conceptual differences persist [22, 23].

Across cultural language systems, the generative approach can reduce pressure to force a source concept into an apparently equivalent target term. The translator can identify the problem relations that made the source concept necessary and ask whether the target tradition contains, or can generate, a different conceptual response. Historical consciousness is crucial here because the target system's apparent absence of a source category can reflect a different problem history rather than conceptual deficiency. Generative translation therefore supports comparison among independently generated responses without requiring premature semantic convergence.

Human–AI interaction supplies another important case. A Human–AI configuration can use the AI system to propose perturbations, counterexamples, analogies, and sequences of explanation. The human interlocutor can also generatively translate toward the AI by reformulating a problem in ways that expose relevant structure rather than supplying only the final desired wording. Attribution should remain configuration-relative. If the successful interaction depends on repeated prompting, external verification,

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memory tools, and human correction, the generative capacity belongs to that coupled arrangement under the stated support conditions.

The heterogeneous cases also clarify a boundary of the concept. Generative translation requires some evidence that the target configuration's future scholarly activity has changed in a task-relevant way. Immediate agreement, emotional resonance, stylistic imitation, or successful completion of one heavily cued task provide weaker evidence. Longitudinal transfer, independent reconstruction, error correction, and reciprocal refinement provide stronger evidence. The required evidential threshold will vary across domains and should be specified rather than presumed.

Claim 11.3 (Generative translation as capacity-oriented translation)**.** Within the present framework, the distinctive object of generative translation is a change in target-side scholarly capacity relative to a source–target relation, rather than the production of a particular target-side formulation. Manifestations remain necessary evidence, while the stronger attribution depends on what subsequent inquiry becomes available to the target configuration.

Claim 11.3 states the central proposal of the section. It remains a conceptual claim whose empirical operationalization will differ across education, interdisciplinary collaboration, intercultural dialogue, and Human–AI interaction. The proposal can be tested through longitudinal tasks that compare direct translation, guided reconstruction, adaptive prompting, and other intervention forms while measuring reconstruction, transfer, revision, and dependence on support.

Generative translation therefore extends translation from target-side rendering to target-side reorganization. Its stronger evidence lies in reconstruction, transfer, revision, and locally meaningful consequence generation across later tasks. Because interventions that reorganize generative conditions can also steer attention and interpretation, their responsible use depends on regulation of judgment, uncertainty, projection, and interpretive power across heterogeneous language systems.

12 Epistemic-Relational Humility

This section develops epistemic-relational humility as the eighth capacity family in the proposed account of scholarly formation. Its role is to regulate scholarly judgment when inquiry crosses language systems, historical formations, disciplines, institutions, or other configurations whose standards of intelligibility differ. The objective is to distinguish humility from deference, indecision, generalized scepticism, and unrestricted relativism. The discussion proceeds through seven steps. It first relates the present proposal to philosophical and psychological work on intellectual humility, then develops restraint of premature projection, target-internal reconstruction, separation of understanding from endorsement, reciprocal revisability, uncertainty-sensitive judgment, and Human–AI configurations. The method is conceptual and relational. Existing work on intellectual humility and hermeneutic understanding supplies important interfaces, while the GR contribution concerns how limitation-awareness, translation, judgment, historical reconstruction, and power are organized within a history-bearing scholarly configuration.

12.1 Intellectual Limitation and Scholarly Regulation

Contemporary philosophical and psychological accounts commonly associate intellectual humility with an appropriate relation to one's epistemic limitations. Whitcomb and colleagues develop a philosophical account centered on owning intellectual limitations, while Porter and colleagues identify recognition of the limitations of one's beliefs and knowledge as a common element across empirical approaches to intellectual humility [26, 27]. Leary and colleagues likewise distinguish intellectual humility from simple low confidence by examining how people respond to the possibility that their beliefs may be fallible [10]. These traditions provide a useful starting point because they make fallibility recognition an active epistemic capacity rather than a declaration of modesty.

The present paper extends that starting point into cross-system scholarly relations. A scholar can recognize the possibility of personal error while still interpreting another field entirely through the categories of the scholar's own field. Likewise, a scholar can acknowledge uncertainty while preserving

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a strong assumption that the source language supplies the proper terms in which another system should be described. Epistemic-relational humility therefore concerns both the scholar's relation to personal limitation and the scholar's relation to configurations whose conceptual organization can differ from the scholar's own.

Definition 12.1 (Epistemic-relational humility)**.** Within the present framework, *epistemic-relational humility* is a revisable scholarly capacity to recognize relevant limits in one's own knowledge and evaluative repertoire, reconstruct another scholarly configuration through its own historically and relationally situated distinctions where feasible, delay externally imposed evaluation until that reconstruction is sufficiently developed for the task, preserve uncertainty and translation remainder, and permit the encounter to revise one's own subsequent judgment.

Definition 12.1 is procedural and capacity-oriented. It does not assign intrinsic virtue to low confidence, agreement, or self-effacement. A scholar can hold a strongly supported conclusion while remaining humble about its scope, transferability, or interpretation outside the domain in which its warrant was established. Conversely, a scholar can express uncertainty while remaining relationally unresponsive if the uncertainty never changes how another language system is reconstructed or how criticism is received.

The distinction matters for scholarly formation because confidence and humility answer different questions. Confidence concerns the degree of commitment warranted by available evidence under a stated model or language system. Humility concerns how that commitment is situated relative to limitations, alternative systems, uncertainty, and possible revision. Strong evidence can therefore support high confidence and high humility simultaneously.

12.2 Restraint of Premature Projection

Cross-system inquiry creates a recurrent risk of projection. Let $\mathcal{L}_A$ and $\mathcal{L}_B$ denote two scholarly language systems in the sense developed in Section 10. A configuration working primarily through $\mathcal{L}_A$ possesses distinctions, evidence conventions, inferential practices, and assessment standards that make some questions easy to formulate and some answers easy to recognize. When that configuration encounters $\mathcal{L}_B$, those same resources can become a source of premature closure if they are applied before the local organization of $\mathcal{L}_B$ has been reconstructed.

The relevant restraint concerns timing and scope rather than abandonment of judgment. A mathematical framework, for example, can eventually provide a rigorous external analysis of a legal or historical object. Mature scholarship first identifies which features of the object the formalization retains, which features it omits, and whether the target field treats those omitted features as constitutive. A legal concept can illuminate institutional responsibility in another domain while still carrying doctrinal assumptions that cannot simply be transferred. A philosophical vocabulary can expose implicit commitments in a scientific discourse while remaining answerable to the empirical practices that give that discourse local meaning.

This sequencing can be represented through two analytically distinct operations. Let $\mathsf{Rec}_B^{(q,\xi)}$ denote a task-indexed reconstruction of the target configuration's relevant distinctions and inferential relations, and let $\mathsf{Eval}_A^{(q,\xi)}$ denote an external evaluation conducted through a source-side evaluative repertoire. Epistemic-relational humility gives procedural priority to developing $\mathsf{Rec}_B^{(q,\xi)}$ to a level adequate for the task before treating $\mathsf{Eval}_A^{(q,\xi)}$ as a well-grounded judgment about the target system. The representation does not require reconstruction to be complete, which is often impossible. It requires the incompleteness to remain visible in the scope of the later evaluation.

Caution 12.2 (Interpretive restraint and epistemic passivity)**.** Interpretive restraint does not require accepting a target system's self-description as correct, coherent, or normatively legitimate. Internal reconstruction establishes a stronger basis for criticism by clarifying the object being criticized, the standards internal to it, the translation remainders involved, and the location of disagreement.

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Caution 12.2 prevents humility from becoming a prohibition on external critique. The object is disciplined sequencing: understanding sufficient for the local task precedes stronger claims about incoherence, error, inferiority, or legitimacy. Where urgent safety, legal, or ethical conditions require immediate action, complete reconstruction may be unavailable. Humility then appears through explicit uncertainty, reversible measures where feasible, preservation of evidence, and openness to later correction rather than through indefinite delay.

12.3 Target-Internal Reconstruction

Target-internal reconstruction is the constructive component of epistemic-relational humility. It asks how a claim, practice, concept, or disagreement becomes intelligible within the target configuration's own historical and relational organization. Gadamer's philosophical hermeneutics provides an important interface because understanding is treated as historically situated and dialogical rather than as neutral recovery from outside a tradition [9]. The present account uses this interface cautiously. It does not adopt a complete hermeneutic theory. It extracts the methodological significance of allowing an encounter with another interpretive horizon to alter the interpreter's own framing.

The reconstruction can draw on the capacities developed in earlier sections. Historical consciousness identifies the problem constellation within which a target distinction emerged. Relational breadth identifies how the target field is coupled to neighboring fields without erasing local differences. Scholarly translation records which source-side concepts possess adequate target-side counterparts and which produce remainder. Generative translation can then test whether a proposed reconstruction enables the target configuration to generate consequences that make sense within its own language system.

A useful diagnostic is whether the reconstruction can survive correction from competent participants in the target system. This criterion does not make local consensus infallible. It asks whether the external scholar has reached a level at which disagreements concern substantive interpretation rather than elementary misrecognition of the target vocabulary. Where multiple internal traditions disagree, humility requires preserving that plurality rather than selecting one convenient representative as the target system's singular voice.

The same requirement applies to historical reconstruction. A later scholar can possess broader archives or conceptual resources than historical actors possessed, but retrospective interpretation should distinguish the later explanatory vocabulary from categories available to the historical participants. Section 4 developed this distinction in relation to conceptual genesis. Epistemic-relational humility turns it into a general discipline of interpretation: explanatory gain from a later framework does not by itself authorize replacing the historical object's own problem structure with the later one.

12.4 Contextual Coherence and External Evaluation

Understanding another language system does not imply that the system is true, just, complete, or normatively acceptable. A configuration can be internally coherent under its operative assumptions while producing claims that fail when confronted with stronger evidence, broader populations, changed material conditions, or external normative constraints. Epistemic-relational humility therefore preserves a distinction between *contextual coherence* and *external endorsement*.

Contextual coherence concerns whether a claim or practice can be reconstructed as intelligible relative to the target system's history, concepts, evidence rules, and purposes. External evaluation concerns how that claim or practice fares under additional evidential, comparative, aesthetic, normative, legal, or practical standards. The first operation reduces the risk of criticizing an object that has been poorly reconstructed. The second preserves the possibility of cross-system judgment.

This distinction is especially important where language systems possess different forms of evidence. A philosophical argument, an ethnographic interpretation, a statistical model, and a legal judgment can each possess disciplined standards without sharing one universal evidential grammar. Methodological pluralism therefore requires local evaluation of adequacy before cross-domain comparison. Cross-

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domain criticism can remain rigorous by stating which standard is being introduced, why it is relevant to the target object, and which parts of the target claim are being evaluated under it.

The distinction also protects against an easy form of relativism. The fact that a claim is intelligible within $\mathcal{L}_B$ establishes a relation between the claim and that language system. It does not establish that every consequence of the claim is acceptable outside that relation. Likewise, the existence of several coherent language systems does not imply equal evidential support for all their claims. Humility regulates the path by which judgment is formed; it does not predetermine the judgment's outcome.

12.5 Reciprocal Revisability

A stronger form of scholarly humility allows the act of understanding another system to revise the interpreter's own configuration. The relevant change can concern factual beliefs, conceptual distinctions, standards of explanation, perceived relevance, research priorities, or the boundaries of a discipline. This feature connects humility to the assimilation process developed in Section 3. An encounter counts as formative when it produces sufficiently stable changes in what the configuration can subsequently interpret, relate, judge, translate, or generate.

The source-side configuration can therefore be updated after a cross-system encounter. The general development map from Equation 5 already represents such change. Epistemic-relational humility adds a constraint on the interpretation of the update: information from the target system should remain capable of modifying the source-side language system and evaluative repertoire when the evidence or argument warrants modification. A dialogue in which the source framework can only classify the target and can never itself be revised exhibits weaker reciprocity.

This revisability gives humility a temporal structure. A scholar may initially judge that a concept lacks explanatory value, later encounter historical or empirical evidence that changes the relevant problem representation, and subsequently revise the judgment. Mature scholarship records the revision rather than reconstructing the earlier position as though the later understanding had always been available. Intellectual development therefore includes a history of corrected interpretation.

The scientific literature offers a related institutional interface. Hoekstra and Vazire argue that scientific credibility benefits when researchers foreground limitations and uncertainty rather than allowing incentive structures to reward overstatement [28]. Their proposal concerns scientific practice and reporting, whereas the present framework is broader. The common point is that limitations become epistemically productive when they are made available for criticism and future correction.

12.6 Uncertainty, Asymmetry, and the Limits of Humility

Humility operates under asymmetric information and asymmetric consequences. The scholar entering another field may possess little knowledge of its internal history while retaining institutional authority to classify it. A reviewer may possess strong gatekeeping power over a manuscript outside the reviewer's deepest competence. A dominant disciplinary language may define what counts as evidence for a smaller field. In such cases, acknowledgement of limitation has practical consequences because a weakly grounded judgment can still alter funding, publication, reputation, or the survival of a research programme.

Epistemic-relational humility supplies one regulatory capacity relevant to interpretive power. The stronger the asymmetry between the interpreter's authority and the interpreter's understanding of the target system, the more important it becomes to expose uncertainty, seek target-side correction, distinguish reconstruction from evaluation, and preserve routes for appeal or revision.

Humility also has limits. Some claims can be evaluated with high confidence despite disagreement. Some practices impose harms that require timely intervention. Some language systems deliberately obscure evidence or insulate themselves from criticism. A demand for unlimited contextual understanding can itself become a mechanism for delaying justified action. The framework therefore treats humility as one capacity within the larger architecture of scholarly formation, coupled to historical consciousness,

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relational breadth, generative attention, aesthetic judgment, normative judgment, translation, and power analysis. It does not function as a supreme principle that overrides those capacities.

Claim 12.3 (Humility as regulation of cross-system judgment)**.** Within the present framework, epistemic-relational humility strengthens cross-system scholarly judgment when it improves reconstruction of the target configuration, preserves uncertainty and translation remainder, exposes the scope of source-side limitations, and keeps both source- and target-side interpretations open to warranted revision. Its epistemic value therefore lies in the quality of regulated inquiry rather than in agreement, lowered confidence, or permanent suspension of evaluation.

Claim 12.3 states the section's principal proposal. It is conceptual rather than a validated measurement model. Empirical investigation could operationalize parts of the proposal through correction uptake, calibration, explicit uncertainty, quality of target-system reconstruction, responsiveness to counterevidence, and transfer across heterogeneous contexts.

12.7 Human–AI Configurations and Delegated Confidence

AI-mediated scholarship makes epistemic-relational humility especially visible because fluent output can conceal uncertainty in provenance, model limitations, target-system competence, or evidential support. The relevant issue is broader than whether an AI system can display linguistically modest phrases. A Human–AI configuration exhibits stronger humility when it can identify the limits of the evidence available to it, distinguish retrieved support from generated inference, expose unresolved translation remainder, seek correction from domain-appropriate sources, and revise subsequent outputs after criticism.

The configuration perspective avoids attributing humility solely to an isolated model. A workflow can be epistemically humble because retrieval tools preserve provenance, the human operator checks scope conditions, external experts correct target-side reconstruction, and the model maintains explicit uncertainty across revisions. The same model in a different workflow can contribute to overconfident scholarship when generated fluency substitutes for verification or when user preferences are reinforced without adversarial checking. Humility is therefore evaluated relative to the support relations and update procedures of the coupled configuration.

Delegated confidence creates a further problem. A scholar can outsource search, synthesis, translation, or formal manipulation to AI while retaining public responsibility for the resulting claim. The scholar's own uncertainty about the delegated process should therefore remain distinguishable from the confidence expressed in the final manifestation. A polished output supported by an opaque or weakly verified intermediate process may justify less confidence than its surface form suggests. Section 3 already separated manifestations from generative capacity; epistemic-relational humility adds the requirement that uncertainty about the generative path should be reflected in evaluation of the manifestation.

The AI case also clarifies that humility need not be intrinsically human. A recurrent Human–AI configuration may develop procedures that reliably surface uncertainty, request disconfirming evidence, distinguish language systems, preserve competing interpretations, and update after correction. Whether an artificial system independently possesses a virtue-like psychological state is outside the scope of the present paper. The relevant scholarly question is whether the configuration exhibits the functional and relational capacities required for responsible inquiry.

Epistemic-relational humility thus regulates cross-system inquiry through awareness of limitations, target-side reconstruction, confidence calibration, and reciprocal revisability. Its importance increases when an interpreter can make consequential classifications despite limited target-side understanding. Section 13 therefore examines the authority and infrastructures through which interpretations acquire effects beyond the immediate act of understanding.

13 Interpretive Power across Language Systems

This section examines a structural consequence of the translational and humility capacities developed in Sections 10–12: language systems do not encounter one another under equal conditions of interpretation.

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Its role is to distinguish interpretive competence from interpretive authority and to identify conditions under which authority becomes a consequential power relation. The objective is therefore narrower than a general sociology of knowledge. The discussion focuses on scholarly configurations whose classifications, translations, evaluations, or visibility decisions can alter the conditions under which another configuration is understood, circulated, funded, taught, or continued. The method is relational and institutional. It combines the GR requirement that power have directional consequences for generative possibilities with interfaces from sociology of language, social epistemology, empirical work on linguistic inequality, and recent research on platformized scholarly communication.

13.1 Unequal Interpretive Authority

Interpretation and authority should be kept analytically distinct. A scholar may understand a language system well while possessing little institutional authority to define it for others. Another scholar may understand it poorly while occupying a position from which a review, classification, translation, syllabus, funding decision, or editorial judgment becomes consequential. The second configuration therefore possesses a form of interpretive authority even when its interpretive competence is weak.

Bourdieu's account of language and symbolic power provides an important interface for this distinction. Linguistic practice is situated in social relations in which some speakers and forms of expression possess greater recognized authority than others; language functions as a medium of power as well as communication [29]. The present framework uses this insight without importing Bourdieu's complete theory of field, habitus, or symbolic capital. Its narrower concern is the relation between the capacity to interpret and the capacity to make an interpretation consequential for another scholarly configuration.

Let A and B denote history-bearing scholarly configurations interacting in context ξ. The present section records six consequence dimensions in the interpretive consequence profile stated in Equation 22.

$$\mathfrak{Q}^{(\xi)}_{A\curvearrowright B} = \left(Q^{\text{cred}}, Q^{\text{class}}, Q^{\text{vis}}, Q^{\text{adm}}, Q^{\text{res}}, Q^{\text{cont}}\right)^{(\xi)}_{A\curvearrowright B}. \tag{22}$$

The components represent consequences for credibility, classification, visibility, admissibility within a scholarly venue or practice, access to resources, and future continuation possibilities. Equation 22 is a bookkeeping device rather than a metric. Its components need not be scalar, commensurable, or equally important across contexts.

Definition 13.1 (Interpretive power)**.** Within the present framework, a history-bearing scholarly configuration A possesses interpretive power with respect to configuration B in context ξ when A has a relationally supported capacity to produce or stabilize interpretations, classifications, translations, or evaluations whose uptake has directionally consequential effects on at least one component of $\mathfrak{Q}^{(\xi)}_{A\curvearrowright B}$, and when those effects can alter the conditions under which B's claims, practices, or future scholarly continuations become intelligible, credible, visible, admissible, resourced, or reproducible.

Definition 13.1 deliberately requires consequence and relational support. Prestige alone does not establish interpretive power. Persuasive success in one conversation does not establish it either. Nor does the definition require an intention to dominate: a classification can become power-bearing through routine institutional uptake even when no participant aims to constrain the target configuration. The relevant relation becomes power-bearing when an interpretation can modify another configuration's effective scholarly possibilities through institutional, linguistic, infrastructural, or recurrent relational support. This construction is continuous with the broader GR account of power as directionally consequential deformation of generative possibilities while remaining specialized to interpretation.

Miranda Fricker's distinction between testimonial and hermeneutical injustice supplies a complementary epistemic interface. Testimonial injustice concerns credibility deficits produced by prejudice, whereas hermeneutical injustice concerns disadvantages arising from defects in shared resources for social interpretation [30]. The present analysis is neither a replacement nor a restatement of that framework. It asks more generally how interpretive authority becomes embedded in scholarly relations, including

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Table 12: Illustrative supports of interpretive power and their possible scholarly consequences. The entries identify analytical mechanisms rather than exhaustive empirical categories.

Relational support	**Interpretive operation**	**Possible consequence for scholarly formation**
Editorial and review authority	Classification of relevance, rigor, novelty, or disciplinary fit	Publication access, credibility, subsequent visibility, and continuation of a research programme
Funding and institutional authority	Definition of legitimate problems, methods, beneficiaries, or evaluation categories	Resource access, staffing, infrastructure, temporal horizon, and survival of alternative trajectories
Disciplinary vocabulary	Imposition of established concepts and standards on a less institutionally powerful field	Increased legibility together with possible loss of local distinctions or translation remainder
Dominant scholarly language	Requirement that claims be manifested through a linguistically privileged medium	Unequal translation burden, altered expression, and differential participation in international scholarly communication
Platform and indexing infrastructure	Ranking, recommendation, metric production, inclusion, or exclusion	Differential discoverability, reputational feedback, audience formation, and future citation or collaboration opportunities
AI-mediated interpretation	Summarization, retrieval, translation, classification, and synthesis at scale	Amplification of selected categories and sources, compression of minority distinctions, or expansion of cross-system access depending on configuration design

cases involving disciplines, institutions, languages, platforms, and Human–AI infrastructures rather than only person-to-person testimony.

Table 12 emphasizes that interpretive power is frequently distributed. A reviewer can possess gatekeeping authority because a journal delegates it; a language can be dominant because institutions, training systems, and publication practices reinforce it; a platform can affect visibility because scholars and institutions rely on its infrastructure. The relevant unit of analysis is therefore the relational configuration that supports the consequence, not an isolated individual's intention.

13.2 Institutional and Disciplinary Power

Scholarly institutions organize interpretation before any particular claim is accepted or rejected. Journals define scopes and article genres. Funding agencies specify eligible problems and categories. Universities stabilize curricula and disciplinary boundaries. Professional associations establish vocabularies of recognized expertise. Indexing and evaluation systems determine which manifestations become countable, searchable, or comparable. These arrangements are necessary for large-scale scholarly coordination, yet they also create recurrent sites at which interpretations become consequential.

A disciplinary classification can enable inquiry by making a problem legible to a community with relevant methods. The same classification can narrow inquiry when it excludes distinctions that the target configuration treats as constitutive. The evaluative question is therefore not whether classification occurs. Scholarly life requires classification. The relevant question is how classifications are generated, which relations give them force, how much remainder they discard, and whether affected configurations retain routes for correction or reclassification.

The translation framework of Section 10 is useful here. If an institution maps an object x_B into an institutional category c_A, the mapping may preserve only a declared characteristic set β. Translation remainder then records relevant characteristics that the institutional category fails to carry. A power-sensitive analysis adds a further question: what happens when the institution can make c_A authoritative even where the remainder is large? The problem is not merely semantic loss. The imposed category can

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change funding eligibility, peer-review expectations, hiring categories, archival practices, or the future questions that can be asked about the object.

This point also clarifies why disciplinary expertise and interpretive power can diverge. A highly specialized field may possess deep target-side understanding while lacking the institutional resources required to make its classifications authoritative outside the field. A larger or more prestigious discipline may supply the categories through which the smaller field is evaluated. Relational breadth, developed in Section 5, becomes responsible scholarship partly because it can recognize such asymmetries rather than treating cross-domain movement as a neutral exchange of concepts.

Claim 13.2 (Interpretive authority and disciplinary translation)**.** When a source configuration can make its translation or classification institutionally consequential for a target configuration, the quality of scholarly translation should be assessed together with the power relation that governs uptake. A formally intelligible translation can remain epistemically or normatively defective when the target configuration has weak capacity to contest substantial translation remainder or externally imposed categories.

Claim 13.2 links Sections 10–12 without turning every translation into domination. Many translations occur under cooperative conditions and increase the target configuration's effective possibilities. Power analysis becomes especially important when the translator also controls admission, resources, certification, visibility, or the recognized vocabulary of evaluation.

13.3 Linguistic and Platform Dominance

Natural-language difference supplies a concrete case in which interpretive burden is unequally distributed. Scientific publishing is strongly concentrated in English, and this concentration can impose additional monetary, temporal, cognitive, and participation costs on scholars working in other first languages. Ramírez-Castañeda's study of Colombian researchers in the biological sciences documents additional costs in writing, reading, editing, conference participation, and publication associated with English-language dominance [31]. The study is population- and field-specific, so it does not establish one universal magnitude of linguistic inequality. It does demonstrate that a common scholarly language can simultaneously facilitate international coordination and distribute the costs of participation unevenly.

The GR relevance of this case extends beyond linguistic inconvenience. A dominant scholarly language can influence which distinctions are easy to express, which references are widely recoverable, which rhetorical forms appear professionally legitimate, and which scholars are able to enter high-visibility channels with relatively low translation cost. The resulting relation may alter the manifestation layer without eliminating underlying scholarly generativity. A sophisticated idea that requires substantial translation labor can be less visible than a more easily manifested idea. This is another reason to separate scholarly manifestation from scholarly formation.

Digital platforms introduce a related infrastructural layer. Köchling's study of ResearchGate and Academia.edu describes academic social networking sites as infrastructures and organizations that add functions of collaboration, evaluation, promotion, and incorporation to scholarly communication while relying on platform mechanisms such as network effects, commercialization, and control of data [32]. The study also identifies platform-controlled and partly opaque evaluative and visibility mechanisms. The present paper uses this work as an empirical interface rather than generalizing its findings to every scholarly platform.

Platform mediation matters for interpretation because visibility precedes many later acts of interpretation. A paper that is not retrieved, recommended, indexed, translated, or surfaced to a relevant audience cannot easily enter the audience's continuation space. Platform power therefore can operate without issuing an explicit judgment about truth. Ranking and recommendation can change which objects become available for judgment in the first place.

AI-mediated scholarly systems intensify this issue by combining retrieval, ranking, summarization, translation, and synthesis. A model-assisted search interface can expand access across language systems while simultaneously compressing distinctions through summarization or privileging sources that are

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more visible in its retrieval environment. The present framework does not infer systematic bias from this possibility alone. It treats source selection, training and retrieval coverage, ranking, provenance, and correction procedures as empirical properties of specific Human–AI configurations that should be investigated rather than assumed.

13.4 Classification and External Definition

Interpretive power is especially visible when one language system acquires the capacity to define another externally. External definition occurs when a source configuration supplies the categories through which a target configuration is publicly described, compared, evaluated, or administered. Such definition can be useful. External categories enable coordination, legal recognition, cross-disciplinary comparison, and institutional decision. The problem arises when the category's authority outruns its preservation of target-side distinctions and the target has limited capacity to revise the imposed representation.

Fricker's account of hermeneutical injustice is relevant because collective interpretive resources can be structured in ways that disadvantage some subjects in making experience intelligible [30]. At the level of scholarly systems, a related problem can arise when dominant conceptual resources determine which phenomena can be expressed in institutionally recognizable form. The analogy should remain bounded: the present paper does not identify every failed interdisciplinary translation with hermeneutical injustice. It uses the framework to highlight the relation among conceptual access, social power, and recognized intelligibility.

External definition can also generate recursive effects. Once a category becomes administratively or bibliometrically established, scholars may adapt projects, abstracts, keywords, methods, and professional identities to fit it. The imposed interpretation then contributes to production of the very manifestations used to justify the category. A static taxonomy can thereby become a generative condition of future scholarship.

This recursive possibility can be represented through the general scholarly update map. Suppose an external interpretation $c_{A\to B}$ becomes part of the intervention bundle acting on B. The later configuration is stated in Equation 23.

$$\Sigma^{\mathrm{sch}}_{B,t+1} = \mathcal{F}_{B,t}\big(\Sigma^{\mathrm{sch}}_{B,t}, \Delta_{B,t} \cup \{c_{A\to B}\}\big). \tag{23}$$

Equation 23 does not imply that B passively accepts the category. The update can include adoption, strategic compliance, reinterpretation, rejection, counter-classification, or institutional resistance. Its purpose is to show why interpretive power belongs to generative analysis: classifications can become inputs into later scholarly formation rather than remaining descriptions of a fixed object.

Caution 13.3 (External classification and ontological inflation)**.** An institutionally successful classification should not be treated as evidence that the classified object possesses the imposed category as an ultimate ontological property. Within GR's ontological suspension, classificatory success establishes a consequential relation among representations, institutions, and scholarly configurations. Stronger ontological conclusions require independent argument.

Caution 13.3 is particularly important when high-status disciplines or AI systems can produce classifications at scale. Repetition, standardization, and institutional adoption can stabilize a category as relationally real without settling whether the category captures the target's ultimate nature.

13.5 Restraint in Interpretive Power

Epistemic-relational humility acquires a structural meaning once interpretive asymmetry is recognized. For a configuration with substantial interpretive authority, humility includes restraint in the exercise of that authority when target-side understanding is weak, translation remainder is large, or the consequences of classification are difficult to reverse. Restraint does not require silence or withdrawal. It concerns the design of procedures by which consequential interpretation remains corrigible.

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Several practices can instantiate such restraint. The interpreter can distinguish target-side reconstruction from source-side evaluation; preserve alternative target renderings rather than forcing premature equivalence; record provenance and uncertainty; invite target-side criticism before an externally generated category is stabilized; state the institutional purpose and scope of a classification; preserve routes for appeal or reclassification; and prefer reversible or revisable interventions when the evidential basis is weak and the downstream consequences are large.

These practices can be expressed through the continuation-space perspective developed in Section 3. An interpretation becomes especially consequential when it closes future scholarly paths. A funding category can make some questions ineligible. An archival taxonomy can make materials difficult to recover through alternative descriptions. A publication norm can eliminate a language or method from recognized venues. Restraint therefore has a preservation dimension: it can preserve future capacity for reinterpretation and counter-classification while still permitting present coordination.

Bourdieu's analysis helps explain why such restraint cannot be reduced to polite interpersonal behavior. Linguistic authority is socially organized [29]. A respectful individual can still participate in an infrastructure that systematically privileges one language or classificatory repertoire. Conversely, institutional procedures can partially correct asymmetry even when individual participants possess different levels of humility. Scholarly formation should therefore be evaluated at both personal and configuration levels.

Claim 13.4 (Revisability under interpretive asymmetry)**.** For a consequential cross-system interpretation produced under substantial asymmetry of authority, the present framework treats preservation of revision pathways as a scholarly virtue when the interpretation remains epistemically uncertain and when irreversible stabilization would materially narrow the target configuration's future interpretive or generative possibilities.

Claim 13.4 is conditional. Some classifications require stability, and some decisions cannot remain indefinitely open. The proposition identifies one reason to value revisability under uncertainty; it does not establish a universal duty to preserve every classification or every continuation.

13.6 Power-Sensitive Scholarly Dialogue

A dialogue can be intellectually reciprocal even when institutional power is unequal, but such reciprocity requires more than the formal opportunity to speak. The weaker configuration must possess some effective capacity to contest reconstruction, introduce distinctions, correct provenance, preserve unresolved remainder, or alter the terms of subsequent inquiry. Power-sensitive dialogue therefore concerns the generative consequences of participation as well as the visible exchange of statements.

Within the present framework, a stronger dialogue has at least five features. First, the relevant asymmetries of authority are made identifiable rather than treated as background neutrality. Second, translation preserves significant target-side distinctions and records remainder. Third, consequential classifications are scoped to the purpose for which they were generated. Fourth, affected configurations have usable routes for correction and counter-interpretation. Fifth, revisions can propagate into later manifestations, institutional records, or decision procedures rather than remaining merely acknowledged at the conversational level.

These features also clarify the relation between generative translation and power. Generative translation, developed in Section 11, changes another configuration's conditions of generation. Such influence can expand the interlocutor's capacities, but it can also steer attention, problem framing, or conceptual repertoire. Power-sensitive generative translation therefore requires scrutiny of who selects the perturbations, which alternatives remain available, and whether the target configuration can reinterpret or reject the resulting pathway.

Human–AI scholarly dialogue creates a particularly complex case because interpretive authority can be distributed among model developers, retrieval systems, platform operators, institutions, users, and the model-mediated manifestation itself. A fluent AI response can acquire practical authority even where

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its provenance is weak. Conversely, AI can lower barriers created by dominant scholarly languages by supporting translation and access. The relevant evaluation therefore concerns the whole configuration: which sources are available, how they are ranked, whose conceptual distinctions survive summarization, how uncertainty is represented, and whether correction changes later behavior.

Claim 13.5 (Power-sensitive scholarly dialogue)**.** Within the present framework, cross-system scholarly dialogue is stronger when it combines interpretive competence with explicit treatment of authority, preserves consequential translation remainder, provides effective routes for counter-interpretation and revision, and limits irreversible closure where understanding remains weak relative to the power of the interpretation to shape future scholarly possibilities.

Claim 13.5 completes the movement from humility to power. Epistemic-relational humility regulates the interpreter's treatment of limitation; interpretive-power analysis examines the relational structures that make some interpretations consequential for others. The distinction matters because mature scholarship requires both capacities. A scholar may personally recognize uncertainty while still participating in a powerful classificatory infrastructure, and an institution may create procedures for contestation even among participants who differ in individual humility.

The section therefore adds a structural qualification to the paper's account of scholarly formation. Entering another language system responsibly requires more than understanding it. Mature scholarship also requires awareness of the relations that determine whose interpretations travel, whose classifications become authoritative, which manifestations remain visible, and which conceptual systems retain the capacity to reproduce and transform themselves. Section 14 integrates historical consciousness, relational breadth, generative attention and problem formation, aesthetic and normative judgment, translation, generative translation, humility, and power-sensitive practice into one relational architecture of scholarly capacities.

14 Relational Architecture of Scholarly Capacities

This section integrates the capacity families developed in Sections 4–13 into a common relational architecture. Its role is synthetic: the objective is to explain how historical consciousness, relational breadth, generative attention and problem formation, aesthetic judgment, normative judgment, scholarly translation, generative translation, and epistemic-relational humility support, correct, constrain, and sometimes conflict with one another. The section proceeds in six steps. It first specifies the architectural status of the eight capacity families. It then examines historical–relational coupling, evaluative coupling, translational–generative coupling, the regulatory role of humility, and the developmental and contextual variation of capacity profiles. The method is structural and comparative. The resulting architecture is a structural representation of relations among capacities within a scholarly configuration. Psychometric scaling, personal hierarchy, and exhaustive ontology of scholarly excellence remain outside its scope.

14.1 Capacity Families and Architectural Status

The eight capacity families were separated earlier because each performs a different analytical function within the problem addressed by this paper. Section 7 adds two higher-order comparative constructs without expanding the family count: incipient-change sensitivity describes a possible trajectory-oriented transformation of contingency, and mediating judgment describes coordination among already defined capacities when inquiry, timing, trajectory uncertainty, and practical response must be considered together. They are neither asserted to be collectively necessary for every scholarly task nor offered as an exhaustive taxonomy of expertise. Historical consciousness reconstructs the genesis and transformation of concepts and problems. Relational breadth identifies typed and warranted relations across fields while preserving relevant differences; the systemic understanding defined in Section 5 is treated as an integrative mode within this family when several relations must be considered jointly. Generative attention recognizes when an encounter can become an inquiry-generating problem and preserves its

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relational structure long enough for articulation and testing. Aesthetic judgment evaluates intellectual fertility and long-horizon worth. Normative judgment evaluates priority, scale, timing, and consequence within a situated relational order. Scholarly translation reconstructs intelligibility across language systems. Generative translation alters conditions under which another configuration can generate an intelligible counterpart. Epistemic-relational humility regulates projection, confidence, and revisability across heterogeneous systems.

Their analytical separation enables comparison of distinct functions. In mature scholarly practice, one capacity often changes the conditions under which another can be exercised. Historical reconstruction can alter the meaning of a cross-domain analogy. Historical consciousness and relational breadth can jointly prepare the salience structure through which an encounter becomes inquiry-generating. Generative attention can introduce candidate problems that later reshape aesthetic judgment, while aesthetic judgment can recalibrate which kinds of encounter deserve sustained attention. Normative judgment can constrain the scale at which an intellectually attractive programme is pursued. Translation can reveal previously invisible historical assumptions. Generative translation can reorganize the receiving configuration's later historical, relational, and evaluative capacities. Humility can change the sequence, scope, and revisability of each of these operations.

For this reason, the operative capacity component $\mathcal{C}_t$ of the scholarly configuration introduced in Equation 1 can be represented more finely by a question- and context-indexed architecture. The representation is stated in Equation 24.

$$\mathfrak{A}_t^{(q,\xi)} = \left(\mathbf{C}_t^{(q,\xi)}, \Gamma_t^{(q,\xi)}, \Omega_t^{(q,\xi)}\right). \tag{24}$$

In Equation 24, $\mathbf{C}_t^{(q,\xi)}$ denotes the subset of the eight family-level capacities that is operative for scholarly question q in context ξ; $\Gamma_t^{(q,\xi)}$ denotes typed coupling relations among those operative capacities; and $\Omega_t^{(q,\xi)}$ denotes contextual conditions that affect their realization, including supports, institutions, language systems, resource constraints, and relations of interpretive power. The architecture refines the $\mathcal{C}_t$ component of the scholarly configuration; it does not absorb H_t, $\mathcal{R}_t$, $\mathcal{K}_t$, $\mathcal{L}_t$, or $\mathcal{N}_t$ into the capacity vector merely because those components condition capacity realization. The representation deliberately avoids assigning one scalar value to scholarly maturity. Two configurations can exhibit different architectures while remaining strong for different scholarly purposes.

The coupling term $\Gamma_t^{(q,\xi)}$ can contain several kinds of relation. Table 13 identifies six recurring types used in the present section. The list has a bounded analytical purpose and leaves additional coupling types open.

Table 13 makes an important distinction between a capacity and the relation through which it affects another capacity. Historical consciousness, for example, is a capacity family; its role in a particular episode can be enabling, corrective, or generative. Generative attention is a capacity family whose operation can be enabling when an encounter opens a new candidate problem space. Humility is a capacity family whose operation often has a regulatory form. The architecture therefore concerns both what capacities are available and how they are coupled in the scholarly episode under study.

Incipient-change sensitivity and mediating judgment also occupy different positions from the eight families. They are treated as higher-order configurations of historical consciousness, relational breadth, generative attention, situated pattern recognition, aesthetic and normative judgment, and humility. Their relevance depends on context: many scholarly tasks require no trajectory judgment at all, while some strategic, institutional, or historically sensitive inquiries make temporal change central.

Interpretive power occupies a different position. Section 13 treated power as a relational condition through which classifications, translations, visibility decisions, and evaluations become consequential for another configuration. The present architecture locates interpretive power primarily within $\Omega_t^{(q,\xi)}$, alongside the conditions that shape how the eight capacity families become consequential: it changes the consequences of exercising translation, judgment, classification, and humility. Awareness of power can itself become part of scholarly formation, yet the underlying asymmetry is a condition of the relation rather than a personal trait.

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Table 13: Recurring coupling relations within the scholarly-capacity architecture.

Coupling type	Analytical function	Illustrative case
Enabling	Makes another capacity practically available or more effective.	Historical reconstruction supplies the contextual distinctions required for responsible translation.
Constraining	Limits the scope, scale, or permissible use of another capacity.	Normative judgment limits intensive development of an aesthetically attractive project under high foreseeable risk.
Corrective	Exposes error, overreach, or missing remainder in another capacity's operation.	Relational breadth reveals that a cross-domain analogy fails because the compared structures operate at incompatible scales.
Translational	Reorganizes an object so that another capacity can operate across a language-system boundary.	Scholarly translation reconstructs a concept so that target-side evaluative standards become applicable.
Generative	Changes later capacity or continuation structure beyond a present manifestation.	Generative translation enables the target configuration to produce new distinctions, questions, or reconstructions independently.
Regulatory	Calibrates confidence, sequencing, revision, and use of authority.	Epistemic-relational humility delays strong external evaluation until target-side reconstruction is adequate.

Claim 14.1 (Architectural interpretation of capacity families)**.** The eight capacity families should be interpreted through their patterned relations within a scholarly configuration. Counting independently described capacities provides an incomplete basis for evaluating a scholarly architecture; the relevant question is whether the capacities are available, appropriately coupled, mutually corrective where necessary, and responsive to the historical and relational conditions of the inquiry.

Claim 14.1 also prevents a simple deficit model. A configuration can rely on distributed supports for one capacity and local expertise for another. It can be exceptionally strong in a narrow domain while intentionally relying on collaborators for translation or normative analysis. Architectural strength concerns the adequacy of the configuration for a scholarly function, including the reliability of the relations through which complementary capacities become available.

14.2 Historical, Relational, and Problem-Formative Coupling

Historical consciousness, relational breadth, and generative attention are mutually informative because disciplinary boundaries, concepts, methods, cross-domain relations, and patterns of scholarly salience have histories. Generative attention is not an isolated faculty inserted between breadth and judgment. Its operation depends partly on which distinctions a configuration has learned to notice and which relations make a phenomenon intelligible as a possible problem.

Historical consciousness and relational breadth are mutually informative because disciplinary boundaries, concepts, methods, and cross-domain relations have histories. A present-day relation between two fields can appear natural when its historical formation is hidden. Conversely, a historical reconstruction confined to one field can miss the external relations through which its concepts, instruments, institutions, or problems changed.

Historical consciousness contributes at least three functions to relational breadth. First, it identifies whether an apparent similarity is inherited from a genuine historical interaction, independently developed

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under comparable problems, or retrospectively imposed by the present interpreter. Second, it reconstructs the conditions under which a borrowed method or concept changed meaning as it entered another field. Third, it reveals that current disciplinary boundaries can be historically contingent outcomes whose persistence requires separate explanation.

Relational breadth contributes corresponding functions to historical consciousness. It can reveal external institutions, material infrastructures, mathematical resources, political-economic conditions, or neighboring conceptual traditions that a field-internal history leaves invisible. It can also expose multiple genealogies for an apparently singular concept. A research object may have one lineage within a technical discipline, another within policy practice, and another within public language. The relevant historical reconstruction therefore depends on the question being asked and can preserve multiple origin narratives where the evidence supports them.

Generative attention adds a forward-facing function to this coupling. Historical reconstruction can make a weak present phenomenon salient because it resembles an unresolved earlier tension or abandoned branch. Relational breadth can make the same phenomenon salient because it activates a relation to another field, scale, or method. Once a candidate problem is articulated, later aesthetic evaluation can alter the configuration's future salience structure. The coupling is therefore recursive: what a scholar has learned to notice affects which questions become available, and the questions judged worth pursuing reshape what later encounters can mean.

This architecture reframes the familiar idea of a prepared mind as a prepared relational configuration. Preparation can be distributed across archives, collaborators, instruments, disciplinary languages, and recurrent Human–AI supports. Generative attention becomes stronger when those relations preserve weak or unexpected observations long enough for alternative problem framings to be tested, while correction pathways prevent every deviation from being promoted into a research programme.

This coupling also disciplines analogy. Section 5 distinguished analogy from structural equivalence and treated failed translation as informative. Historical reconstruction adds another test: the interpreter can ask whether the proposed relation reflects a shared problem history, a documented transmission, a later formal correspondence, or only a contemporary resemblance. None of these relation types is automatically superior. Their distinction prevents historical influence, formal similarity, and heuristic analogy from being treated as interchangeable evidence.

A useful failure pattern appears when the capacities are uncoupled. Relational breadth with weak historical consciousness can produce rapid cross-domain association whose provenance and boundary conditions remain unclear. Historical consciousness with weak relational breadth can produce detailed genealogies that understate external dependencies or alternative conceptual lineages. The architecture therefore permits unequal strength in the two capacities while treating their correction pathways as important when a scholarly claim depends on cross-domain historical reconstruction.

Claim 14.2 (Mutual correction of historical and relational analysis)**.** When a scholarly claim depends simultaneously on conceptual genealogy and cross-domain relation, the present framework treats historical consciousness and relational breadth as mutually corrective capacities: historical analysis can distinguish inherited, transferred, and retrospectively imposed relations, while relational analysis can expose external conditions and alternative genealogies omitted by a field-internal history.

Claim 14.2 is intentionally conditional. A tightly bounded archival question can require little cross-domain analysis, and a local formal comparison can require limited historical reconstruction. The coupling becomes stronger when the research claim itself crosses historical or disciplinary boundaries.

14.3 Evaluative Coupling

Aesthetic and normative judgment were separated in Sections 8 and 9 because intellectual worth and research priority can diverge. Their separation remains necessary inside the integrated architecture. Coupling preserves the distinct metrics and allows each judgment to change the context in which the other is interpreted and acted upon.

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Historical consciousness can alter aesthetic evaluation by revealing what a problem made possible within its own period. An argument that appears conceptually ordinary after a century of assimilation may have been structurally generative when it first reorganized a field's problem space. Conversely, historical reconstruction can reveal that a celebrated problem inherited prestige from institutional or political conditions that later aesthetic narratives obscure. Relational breadth can likewise change aesthetic judgment by exposing connections whose fertility is invisible within one field, while also identifying cases where apparent elegance depends on suppressing domain-specific remainder.

Normative judgment introduces a different coupling. A research direction can receive high aesthetic evaluation while its large-scale pursuit is constrained by resource intensity, ecological consequence, foreseeable harm, institutional obligation, or opportunity cost. The inverse configuration is also possible: a technically ordinary or aesthetically modest research programme can receive high normative priority because the problem is urgent, neglected, or closely tied to basic social needs. The architecture therefore preserves both profiles.

The interaction becomes more complex when research decisions change future capacities. Section 9 treated resource allocation as a transformation of future inquiry conditions. Funding one programme can create instruments, archives, training pathways, and communities that later alter which problems appear aesthetically promising. Normative priority decisions can therefore influence future aesthetic repertoires without establishing that the resulting aesthetic preferences were normatively correct. The historical sequence matters: evaluation and institutional development can become recursively coupled.

Power also enters evaluative coupling. Institutional actors can convert one aesthetic or normative judgment into funding priorities, publication standards, curricula, or classification regimes. A widely adopted judgment can thereby shape the candidate problems visible to later scholars. The architecture should consequently distinguish an evaluation's content from the power through which the evaluation is stabilized.

Caution 14.3 (Evaluative distinction under coupling)**.** Relations among aesthetic judgment, normative judgment, institutional priority, and later scholarly development preserve the analytical distinction among these objects. Aesthetic value can inform normative deliberation, normative conditions can constrain action on aesthetic judgments, and institutional decisions can reshape later evaluative repertoires while the underlying evaluative dimensions remain analytically distinct.

Caution 14.3 preserves the paper's earlier refusal of a universal conversion rate between intellectual beauty and practical priority. It also prepares the Human–AI analysis in Section 15: systems that generate high-quality candidate evaluations still require analysis of which evaluative dimension is being approximated, whose criteria are represented, and how the resulting recommendation becomes consequential.

14.4 Translational and Generative Coupling

Scholarly translation and generative translation form the most direct pair of capacities in the architecture, yet their relation is asymmetric. Scholarly translation reconstructs an object so that it becomes intelligible within another language system while preserving task-relevant structure and remainder. Generative translation acts on the receiving configuration's conditions of inquiry so that the configuration can later generate, reconstruct, test, or extend an intelligible counterpart. A successful manifestation-oriented translation can therefore support generative translation, while generative translation can also proceed through questions, examples, counterexamples, or conceptual perturbations that do not initially produce a complete target-side rendering.

Historical consciousness supports both capacities by recovering why source-side distinctions arose and which functions they served. Relational breadth supports them by identifying structural correspondences and boundaries across systems. Aesthetic judgment can influence the selection of examples, analogies, or representations that expose a fertile structure, while normative judgment can constrain interventions that would be manipulative, disproportionately costly, or harmful. Humility regulates whether the translator treats the target system as a passive container or as a configuration with its own history, inferential standards, and capacity for counter-interpretation.

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Generative translation also creates feedback into the rest of the architecture. If the receiving configuration assimilates the intervention, its later historical reconstruction can change because new genealogies become visible. Its relational breadth can change because previously inaccessible correspondences become available. Its aesthetic repertoire can change because new problem structures become salient. Its normative judgment can change because the intervention exposes consequences or affected perspectives that were previously absent. Generative translation is therefore capable, in principle, of transforming several capacity families at once.

This breadth of effect is precisely why power-sensitive analysis is required. The same intervention that expands one continuation space can narrow another by steering attention, standardizing terminology, or making one conceptual pathway institutionally dominant. Section 13 therefore qualifies the generative success criterion. A target configuration's later production of source-compatible concepts provides only limited evidence of scholarly success when the pathway depends on coercive closure, concealed alternatives, or asymmetry that prevents meaningful counter-interpretation.

The architecture consequently distinguishes *generative efficacy* from *generative legitimacy*. Efficacy concerns whether an intervention changes what the target configuration can subsequently generate or reconstruct. Legitimacy concerns the epistemic and normative conditions under which that change is produced, including provenance, contestability, preservation of relevant alternatives, and the distribution of interpretive authority. The two can interact without becoming identical.

Claim 14.4 (Generative translation as architectural transformation)**.** Within the present framework, generative translation can count as an architectural transformation when its assimilation changes later operation of one or more scholarly capacities in the receiving configuration, including historical reconstruction, relational comparison, judgment, translation, or the generation of viable continuations.

Claim 14.4 is stronger than defining generative translation by target-side restatement. It requires evidence that the intervention changes subsequent scholarly practice. Section 16 examines educational and developmental conditions under which such changes can become more stable.

14.5 Humility across the Capacity Architecture

Epistemic-relational humility has a distinctive position because it often regulates the operation of other capacities without replacing them. Historical reconstruction requires humility when archival gaps, retrospective categories, or competing genealogies limit confidence. Relational breadth requires humility when analogies are attractive but their domains of validity remain uncertain. Generative attention requires humility when a striking encounter can be overinterpreted, retrospectively mythologized, or promoted before alternative explanations are considered. Aesthetic judgment requires humility when taste is historically situated and vulnerable to prestige or survivorship effects. Normative judgment requires humility when consequences, affected interests, or future conditions are incompletely known. Translation and generative translation require humility when the interpreter lacks full access to the target system or possesses disproportionate authority to stabilize one rendering.

This regulatory role can be described through four recurrent operations: calibration, sequencing, exposure, and revision. *Calibration* aligns confidence with evidential support and scope. *Sequencing* can place target-side reconstruction before strong external evaluation when the latter depends on understanding the target system. *Exposure* keeps relevant uncertainty, remainder, and alternative interpretations visible. *Revision* preserves the possibility that later evidence or dialogue changes the interpreter's own categories.

Humility functions as calibrated regulation of judgment. Excessive suspension can prevent necessary criticism, decision, or commitment, while strong conclusions remain appropriate when evidence and argument support them. The architectural question is whether the route to that conclusion remains sensitive to the limits and counterevidence relevant to the claim. Humility therefore calibrates the use of other capacities rather than assigning them a permanently weak output.

Reciprocal revisability, developed in Section 12, gives the architecture a further developmental implication. A cross-system encounter can modify the interpreter's own language and evaluative repertoire.

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Humility is therefore generative when it keeps the configuration permeable to warranted correction. A scholar who reconstructs another language system solely to classify it more efficiently can display interpretive competence while exhibiting limited reciprocal revisability. The architecture treats these as distinct profiles.

The relation to power is especially important. When interpretive authority is high, a small error in translation or classification can have large downstream consequences. Humility can then interact with institutional design through provenance requirements, appeal procedures, reversible classification, plural representation, or target-side participation. The capacity and the procedures remain analytically distinct, and their interaction illustrates the configuration-level character of scholarly formation.

Claim 14.5 (Humility as regulatory capacity)**.** Within the present architecture, epistemic-relational humility functions primarily as a regulatory capacity when it calibrates confidence, sequences reconstruction and evaluation, exposes relevant uncertainty and remainder, and preserves warranted revision across the exercise of historical, relational, evaluative, and translational capacities.

Claim 14.5 identifies a recurrent structural role while leaving additional roles open. Humility can also motivate inquiry, improve collaboration, or support learning. The regulatory formulation is useful because it explains why the same capacity can matter across otherwise heterogeneous scholarly practices.

14.6 Developmental and Contextual Profiles

A relational architecture supports the study of scholarly formation through profiles and trajectories indexed to particular scholarly functions. Different tasks activate different subsets of the architecture. Archival history can place exceptional demands on historical reconstruction and provenance. Mathematical research can place stronger demands on formal depth and aesthetic discrimination. Diplomacy or interdisciplinary policy research can place unusual weight on translation, normative judgment, and power-sensitive interpretation. Experimental science can depend heavily on craftsmanship, instrumentation, and team coordination that the eight-family architecture does not attempt to exhaust.

For this reason, the architecture should be indexed to a scholarly question and context, as in Equation 24. A capacity that is weakly relevant to one task can become decisive in another. This contextuality prevents a single profile from becoming a universal template of the ideal scholar. It also permits specialization: mature scholarship can include configurations in which some capacities are distributed across collaborators or institutions rather than concentrated in one person.

Development can also be uneven and non-monotonic, with gains, losses, and reorganization occurring across different capacity families. A scholar can deepen historical understanding while becoming more specialized and less relationally broad. An institution can expand translation infrastructure while narrowing the normative range of admissible research. AI assistance can enlarge retrieval and cross-domain exposure while either strengthening or weakening assimilation, depending on how the workflow is organized. Loss of mentors, archives, instruments, funding, language access, or community can reduce capacities that were previously relationally available. Scholarly formation therefore has a trajectory, not merely an accumulated stock.

The architecture also permits analysis of task-relative bottlenecks while preserving the strength of capacities that remain effective elsewhere in the configuration. A configuration may possess strong historical, relational, and aesthetic capacities while lacking adequate translation for a particular collaboration. The local bottleneck can prevent those other capacities from becoming effective across the interface. In another task, the same translation limitation may be irrelevant. Bottlenecks are consequently task-relative constraints on coupling rather than globally defining deficits.

A stronger architecture can be described through *coordination and correction pathways*. Coordination means that capacities become available to one another when the task requires them. Correction means that overreach in one capacity can be detected and revised through another capacity, interlocutor, or institutional procedure. Historical consciousness can correct anachronistic translation; relational breadth can correct analogy inflation; generative attention can preserve a weak signal while aesthetic

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judgment prevents indiscriminate escalation; normative judgment can constrain aesthetically attractive but socially damaging commitments; humility can expose confidence beyond warrant. The presence of such pathways can matter as much as the isolated strength of each capacity.

This perspective suggests a provisional distinction between architectural coherence and architectural fragility. *Architectural coherence* refers to a configuration in which task-relevant capacities can be coordinated, their boundaries remain intelligible, and correction pathways are available when one capacity overreaches. *Architectural fragility* refers to a configuration in which strong manifestations depend on narrow supports, hidden substitutions, uncorrected coupling failures, or authority that stabilizes an interpretation despite weak reconstruction. These terms serve as analytical descriptions of configurations and task-relative relations.

Definition 14.6 (Capacity-architecture profile)**.** A *capacity-architecture profile* is a context-indexed description of which scholarly capacity families are operative in a configuration, how they are coupled, which supports and power relations condition their realization, and which coordination or correction pathways remain available for the scholarly function under investigation.

Definition 14.6 provides the bridge to the next stage of the manuscript. The Human–AI analysis can focus on how coupled configurations organize specific scholarly capacities. Section 15 examines how AI changes particular capacity profiles: whether retrieval becomes assimilated into historical consciousness, whether cross-domain synthesis acquires warranted relational structure, whether weak or contingent encounters become durable problem formations, whether candidate generation is coupled to aesthetic and normative judgment, whether translation becomes generative, and whether delegated interpretation preserves humility, provenance, and correction pathways.

The synthesis therefore supports the paper's broader thesis. Scholarly formation can be approached as an evolving architecture in which history, relation, generative attention, evaluation, translation, generativity, humility, support, and power condition what a scholarly configuration can notice, understand, judge, communicate, revise, and continue to generate.

15 Scholarly Formation across Human–AI Configurations

This section uses Human–AI research configurations as a stress test of the capacity architecture developed in Sections 4–14. Its role is analytical rather than comparative ranking. The objective is to determine which distinctions remain necessary when retrieval, synthesis, candidate generation, writing, translation, coding, experimental execution, and review can be partly or extensively mediated by artificial-intelligence systems. The section proceeds through capacity-specific and coordination-specific comparisons before examining coupled scholarly configurations as the appropriate unit of analysis. The method combines conceptual reconstruction with bounded empirical interfaces from recent AI-and-science research. The discussion does not presume that the capacities identified in this paper are intrinsically human, nor does successful automation of a scholarly manifestation by itself establish a complete scholarly-formation architecture.

Recent research already makes a simple Human–AI opposition analytically inadequate. AI systems have been integrated into hypothesis generation, experimental design, data analysis, scientific coding, and generative design across scientific domains [1]. In a bounded machine-learning setting, Lu and colleagues report an agentic pipeline that generates research ideas, implements and runs computational experiments, analyses results, writes manuscripts, and performs automated review [35]. These developments make it increasingly important to distinguish the observable completion of research tasks from the organization of the historical, relational, problem-formative, evaluative, translational, and self-corrective capacities through which a scholarly configuration develops over time.

Table 14 summarizes the distinctions examined in this section. The table does not assign the listed activity to a fixed agent type. Its purpose is to identify what additional evidence would be required before an AI-supported activity can be interpreted as evidence for the corresponding scholarly capacity.

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Table 14: Human–AI stress tests for the scholarly-capacity architecture.

AI-supported activity	**Adjacent scholarly capacity**	**Additional evidence relevant to capacity attribution**
Literature retrieval and summarization	Historical consciousness	Reconstruction of historical locus, provenance, competing genealogies, contemporaneous problem structures, and later transformation.
Cross-domain synthesis	Relational breadth and systemic understanding	Typed relations, scale discipline, warrant assessment, preserved remainders, and correction of attractive but unsupported correspondences.
Anomaly detection, weak-signal surfacing, or candidate-question generation	Generative attention and problem formation	Retained provenance, encounter-sensitive salience, alternative framings, distinction of signal from noise, and evidence that the encounter changes later problem formulation.
Trend inference or early-warning synthesis	Incipient-change sensitivity and mediating judgment	Prospective calibration, alternative trajectory hypotheses, branching and reversal sensitivity, explicit action horizon, and revision after later evidence.
Research-idea generation	Aesthetic judgment	Stable and revisable discrimination concerning depth, fertility, compression, structural consequence, and long-horizon intellectual worth.
Ranking or recommending research directions	Normative judgment	Explicit treatment of consequences, distribution, resource use, reversibility, institutional obligations, affected parties, and alternatives.
Linguistic or conceptual reformulation	Scholarly and generative translation	Preservation of inferential and evidential function, target-side criticism, assimilation, transfer, reconstruction, and later independent use.
Perspective generation or role simulation	Epistemic-relational humility	Accurate target-side reconstruction, calibrated uncertainty, willingness to expose limitations, and reciprocal revisability under criticism.
End-to-end workflow automation	Coupled scholarly configuration	Traceable history, recurrent assimilation, correction pathways, provenance, responsibility, and stable coordination across tasks and episodes.

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15.1 Retrieval and Historical Consciousness

AI-mediated retrieval can greatly enlarge the set of historical materials, references, summaries, and candidate connections available to a scholarly configuration. Within the formalism of Section 3, the most immediate effect is often a change in the accessible knowledge resources $\mathcal{K}_t$ and in the relations through which those resources can be reached. Historical consciousness, as defined in Section 4, requires a stronger transformation. The retrieved material must become organized through the historical locus, problem constellation, available repertoire, intervention, uptake, and conceptual afterlife relevant to the

inquiry.

The distinction matters because abundance of historical text can coexist with weak historical reconstruction. A system can retrieve an earlier use of a term while missing the institutional practice that gave the term force, or can summarize a later canonical interpretation while obscuring how the earlier actors described their own problem. It can also compress disagreement among competing genealogies into a single fluent chronology. Section 4.6 therefore treated retrieval as a resource for historical consciousness rather than as its sufficient condition.

Messeri and Crockett's analysis of AI in scientific research is relevant to this distinction because it identifies risks of *illusions of understanding*: researchers can become confident that they understand more than the tool-supported epistemic process warrants, while the broader research system becomes less able to see narrowed methodological or conceptual alternatives [33]. Their framework is not a direct empirical measure of historical consciousness. It nevertheless supports the present paper's caution against inferring assimilated understanding from efficient access or fluent synthesis.

For a Human–AI configuration, historical consciousness can therefore be evaluated at the level of the configuration. Relevant evidence includes whether the configuration can recover primary or near-contemporary sources when available, distinguish contemporary descriptions from retrospective categories, represent competing reconstructions, preserve provenance, state uncertainty, revise a genealogy after contrary evidence, and use the reconstructed history to alter later interpretation or problem formation. None of these functions requires that one human mind independently store the entire history. They require reliable relations through which the configuration can reconstruct and revise it.

15.2 Cross-Domain Synthesis and Systemic Understanding

AI systems can generate large numbers of cross-domain associations with low marginal effort. This capability is potentially valuable for relational breadth because it increases the number of candidate relations that a scholarly configuration can inspect. The same abundance also raises the cost of discriminating among historical influence, method transfer, formal correspondence, scale relation, conceptual translation, analogy, causal constraint, and normative tension. Section 5 treated those relation types as analytically distinct because a correspondence that is productive under one type can be misleading under another.

The principal stress test is therefore whether synthesis preserves typed warrant. A Human–AI configuration that proposes a relation between a concept in physics and a concept in political economy, for example, should be able to specify whether the relation is historical, formal, analogical, methodological, or merely heuristic. It should state which properties are being compared, which assumptions differ, and which remainder prevents stronger equivalence. Systemic understanding additionally requires identifying how several such relations jointly condition the problem rather than merely producing a broad list of adjacent literatures.

This distinction becomes especially important when AI systems produce fluent interdisciplinary prose. Linguistic coherence can make a weak analogy appear structurally established. Conversely, AI-supported search can sometimes reveal a genuine relation that disciplinary specialization had hidden. The relevant criterion is therefore neither distrust nor deference toward machine-generated synthesis. It is whether the configuration contains correction pathways for relation typing, source verification, scale checking, failed translation, and domain-expert criticism.

A useful implication follows for scholarly division of labor. A configuration can possess strong relational breadth even when no single participant has equal expertise in every connected field, provided that the relations among specialists, archives, instruments, and AI systems make the required warrants and corrections practically available. The configuration becomes fragile when cross-domain reach expands faster than the relations through which proposed correspondences can be checked.

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15.3 Candidate Generation and Generative Attention

AI systems can generate candidate questions at a scale that makes problem production visibly distinct from encounter-sensitive problem formation. Section 6 defined generative attention through the relation among an encounter, a history-bearing configuration, and the candidate problem framings made salient by that encounter. An AI system that produces thousands of plausible questions from a prompt can expand the available candidate set without demonstrating that it can notice which weak, ordinary, or unexpected phenomena should alter the problem space.

The comparative analysis in Section 7 adds a neighboring stress test. Forecasting, trend extrapolation, and early-warning synthesis can generate plausible future trajectories without establishing the higher-order coordination described there as mediating judgment. Stronger evidence would require prospective records of which weak changes were treated as trajectory-relevant, representation of branching and reversal rather than one favored storyline, calibration against later developments, and explicit separation between a trajectory hypothesis and the normative or practical decision made under it. A Human–AI configuration can therefore contribute strongly to incipient-change sensitivity without the model itself being treated as an oracle or autonomous sage.

The relevant stress test is therefore whether the Human–AI configuration preserves encounters whose significance was not already encoded in the task. A configuration can become more generatively attentive when sensors retain anomalies, retrieval connects a local observation to distant literatures, interaction history reveals recurring friction, or a model proposes several alternative framings of an observation that would otherwise be discarded. The same configuration can become less attentive when summarization, denoising, benchmark optimization, or dominant classification schemes systematically suppress peripheral signals.

Capacity attribution requires longitudinal evidence. Useful indicators include whether unexpected observations are retained with provenance, whether alternative explanations are considered before escalation, whether the system learns from earlier overlooked signals, and whether a preserved encounter later changes research questions or continuation paths. A single surprising output or novel question remains weak evidence because novelty can arise from stochastic variation or recombination without stable encounter-sensitive salience.

This distinction is particularly important for automated science. Instrumentation and models can expand the perceptual and computational field beyond unaided human capacity, while human histories and institutions can supply context needed to interpret the observation. Generative attention can therefore be genuinely distributed. The empirical question is whether the coupled configuration can transform encounter into revisable inquiry rather than merely maximize the volume of candidate questions.

15.4 Problem Generation and Aesthetic Judgment

Research-idea generation provides a particularly clear test of the distinction between candidate production and aesthetic judgment. Sections 6 and 8.1 separated encounter-sensitive problem formation from evaluation within a candidate problem space. Expansion of that space does not itself determine intellectual worth. Recent empirical work supports keeping these functions separate. In a large-scale study involving more than one hundred NLP researchers, Si, Yang, and Hashimoto report that ideas produced by their LLM ideation agent were judged more novel than expert-human ideas in blind evaluation, while receiving somewhat weaker feasibility judgments; the authors also identify limitations in LLM self-evaluation and diversity of generation [34]. The study concerns a bounded NLP-ideation setting and does not establish a general ordering of human and AI scientific creativity.

Its relevance to the present framework is narrower. High-quality candidate generation can occur without settling how long-horizon intellectual worth is selected. Novelty is one dimension in the aesthetic profile developed in Section 8; depth, structural fertility, explanatory compression, relation to existing problem structures, and generative consequence remain analytically separate. A configuration that generates one thousand plausible problems therefore requires some process for deciding which few deserve prolonged attention.

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AI can participate in that process as well. Models can critique candidates, compare them with literature, estimate feasibility, generate counterexamples, or simulate reviewer reactions. The question for capacity attribution is whether the resulting evaluative practice displays stable, revisable discrimination rather than merely reproducing a proxy such as predicted acceptance, lexical novelty, or similarity to previously rewarded work. Aesthetic judgment becomes especially significant where the consequences of a research direction cannot be known in advance and where the scholar or scholarly configuration commits years of attention before validation is available.

The framework therefore does not reserve aesthetic judgment for biological humans. It places the evidential burden on the organization of the evaluative process. A recurrent Human–AI configuration could plausibly support aesthetic judgment if its selections remain sensitive to domain history, structural consequence, alternative framings, later criticism, and the actual development of the research programme. The same configuration would display architectural fragility if polished novelty scores replaced these longer-horizon correction processes.

15.5 Recommendation and Normative Judgment

AI systems can recommend research directions by ranking expected impact, feasibility, novelty, funding fit, citation potential, or other specified criteria. Such rankings can be valuable inputs to normative judgment, yet the ranking function inherits the choice of criteria, the representation of consequences, and the institutional objectives encoded in the decision environment. Section 9 therefore treated normative priority as a situated evaluation of action, scale, timing, resource use, distribution, reversibility, and responsibility rather than as a property contained in the research topic itself.

The distinction can be stated operationally. Recommendation answers a question defined by an evaluative specification: given a represented option set and stated criteria, which option scores better under the procedure? Normative judgment can also revise the specification. It can ask whether the criteria omit affected parties, whether foreseeable externalities are represented, whether the available option set was itself shaped by institutional power, whether a high-impact pathway crowds out valuable alternatives, and whether uncertainty warrants a more reversible commitment.

This capacity is therefore closely connected to the political-economic conditions examined in Section 9.4. Hao and colleagues report, in the natural sciences, an association between AI-augmented research and higher individual output and citation impact, alongside contraction in collective topical coverage and reduced follow-on engagement among scientists [3]. Their observational design does not by itself establish that AI causes a particular normative failure, and the operationalization is specific to their dataset. The result nevertheless illustrates why an individually advantageous recommendation criterion can diverge from a collective scholarly objective.

A Human–AI configuration can support normative judgment when it makes such conflicts visible and revisable. It can help enumerate stakeholders, model scenarios, retrieve regulatory or historical precedents, estimate resource demands, and surface alternative allocations. The normative capacity remains underdetermined by these inputs because different relational orders can assign different weights or reject common commensuration. The stronger configuration records the basis of the judgment and preserves a route for later revision when consequences, values, or available alternatives change.

15.6 Linguistic and Generative Translation

Generative AI has made fluent reformulation across natural languages, disciplinary registers, and levels of technicality increasingly accessible. This development directly increases the availability of translation-like manifestations. Sections 10 and 11 nevertheless distinguished several stronger objects: preservation of inferential and evidential function, explicit translation remainder, target-side criticism, and interventions that alter the recipient's capacity to generate and use the relevant concept independently.

For Human–AI scholarship, the first stress test is whether fluency conceals structural loss. A technically elegant paraphrase can omit the source field's evidence standard or import a target-side category

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that changes the claim. A useful AI-supported translation process therefore exposes provenance, alternative renderings, uncertain correspondences, and the characteristics that were intentionally preserved. Target-side experts remain important sources of criticism because some remainders become visible only inside the receiving practice.

The second stress test concerns generative translation. An AI system can generate questions, examples, analogies, counterexamples, diagrams, exercises, and staged explanations adapted to an interlocutor. These outputs can become components of the generative intervention bundle defined in Equation 20. Their scholarly value depends on what happens after the immediate interaction. Evidence for generative translation lies in whether the receiving configuration can later reconstruct the concept, vary it, transfer it to a new problem, identify its limits, and produce locally meaningful consequences.

This distinction also changes how AI-supported education can be evaluated. A system that efficiently supplies correct final answers may improve short-run task completion while contributing little to the learner's future continuation space. Another interaction may use direct explanation extensively yet still be generative because the explanation becomes assimilated into later independent reasoning. The relevant contrast is therefore between manifestation delivery and durable reorganization of generative capacity, rather than between direct and indirect teaching techniques.

15.7 Viewpoint Simulation and Epistemic Humility

Large language models can rapidly produce multiple perspectives on a disputed question, restate objections, or simulate the discourse associated with different scholarly positions. These abilities can support the exposure function of epistemic-relational humility developed in Section 14.5: they can make alternative assumptions or vocabularies visible to a configuration that might otherwise remain inside one interpretive frame. Viewpoint multiplicity, however, does not establish accurate target-side reconstruction.

A simulated perspective can be composed from dominant descriptions of a minority position, can flatten internal disagreement, or can assign confidence where the underlying source base is weak. The problem becomes especially serious under the interpretive-power conditions described in Section 13. A system trained primarily on institutionally visible texts can reproduce an externally imposed classification with considerable fluency while leaving the target community's own generative distinctions underrepresented.

Epistemic-relational humility therefore requires more than generating an opposing paragraph. In a Human–AI configuration it can be expressed through provenance checks, explicit uncertainty, target-side source retrieval, preservation of competing reconstructions, requests for correction, and willingness to revise both the AI-supported representation and the human interpreter's prior framing. The configuration should also distinguish simulation from participation: generating a plausible description of another practice does not confer the experience, responsibilities, or authority associated with membership in that practice.

Messeri and Crockett's warning about illusions of understanding is again relevant here [33]. AI-supported breadth can increase the number of perspectives a scholar can encounter while simultaneously increasing confidence that those perspectives have been adequately understood. The GR account treats humility as one correction mechanism for this divergence. The desired outcome is not permanent hesitation, but confidence calibrated to the reconstructive and evidential relations that the configuration can actually sustain.

15.8 Coupled Scholarly Configurations

The preceding comparisons motivate a configuration-level unit of analysis. When an AI system is used recurrently for retrieval, interpretation, coding, candidate generation, criticism, translation, or experimentation, the relevant scholarly process can no longer be represented adequately by assigning the visible output entirely to an isolated human or isolated model. The scholarly configuration introduced in Equa-

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tion 1 can be indexed to the selected Human–AI boundary. The resulting representation is stated in Equation 25.

$$\Sigma_t^{HA} = \left(H_t^{HA}, \mathcal{R}_t^{HA}, \mathcal{K}_t^{HA}, \mathcal{L}_t^{HA}, \mathcal{N}_t^{HA}, \mathcal{C}_t^{HA}\right). \tag{25}$$

The superscript HA in Equation 25 indicates an analytical boundary selected for the research question. It makes no claim that a Human–AI configuration forms a single metaphysical subject. The history component records relevant interaction history and retained provenance; the relation component includes dependencies among human participants, models, archives, tools, institutions, and other supports; the knowledge and language components include resources and representational systems practically available through the coupling; the normative component records applicable standards and obligations; and the capacity component records what the recurrent configuration can reliably do under the conditions being studied.

A transient use of a chatbot need not be treated as a fully coupled scholarly configuration. Stronger reasons for doing so arise when the relation is recurrent, when outputs become assimilated into later inquiry, when feedback from later results changes subsequent use, when provenance and dependencies matter for reconstruction, and when responsibility for verification or action is distributed across the arrangement. This criterion keeps the analytical boundary task-sensitive. The same AI system can function as an external instrument in one episode and as a recurrent component of a longer scholarly configuration in another.

Lu and colleagues' AI Scientist provides a useful contemporary boundary case [35]. Their system automates ideation, literature search, experimental planning and implementation, analysis, manuscript writing, and review in machine-learning research, and one generated manuscript reached the acceptance threshold of a workshop peer-review process. The authors also report substantial limitations: the work is confined to computational experiments, the submitted outputs were manually filtered for relevance, correct implementation, and formatting, only one of three submitted papers cleared the workshop threshold, and their own assessment found that none met the higher bar of a main ICLR conference publication [35]. The case therefore demonstrates meaningful automation across a long research workflow without settling whether the resulting system instantiates the full architecture of scholarly formation proposed here.

Definition 15.1 (Coupled scholarly configuration)**.** For a specified inquiry and context, a *coupled scholarly configuration* is a history-bearing arrangement of human participants, artificial-intelligence systems, archives, instruments, institutions, and other supports whose recurrent relations make a set of scholarly capacities practically available and whose outputs, corrections, and dependencies can affect subsequent inquiry within the selected analytical boundary.

Definition 15.1 shifts the central question away from substitution. A useful empirical programme can ask which capacities are locally supplied by people, models, communities, or infrastructures; which are genuinely distributed; where correction occurs; how failures propagate; and which dependencies become invisible in the final manifestation. Such an analysis can also represent configurations in which AI improves scholarly formation, configurations in which it substitutes for a narrow task without altering formation, and configurations in which polished outputs coexist with architectural fragility.

Caution 15.2 (Boundary transparency)**.** The boundary of a Human–AI scholarly configuration should be stated explicitly. Narrow boundaries can hide human curation, data labor, institutional infrastructure, model development, or target-side expertise on which the observed capability depends. Very broad boundaries can make capacity attribution analytically uninformative. The appropriate boundary depends on the question and should preserve the dependencies relevant to the claim being made.

Caution 15.2 is especially important when AI-generated manifestations are used to infer autonomy. End-to-end task completion can be a significant technical achievement while still depending on human-selected objectives, training data, evaluation rules, tool interfaces, or institutional standards. Conversely, dependence on distributed support is not a defect unique to AI. Human scholarship is likewise constituted

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through libraries, collaborators, instruments, educational histories, and institutions. The GR account therefore evaluates the organization and transparency of dependency rather than treating independence as the default measure of maturity.

The Human–AI stress test ultimately reinforces the paper's central distinction between scholarly manifestations and scholarly formation. AI systems can increasingly participate in the production of manifestations that resemble outputs historically associated with mature scholarship. This development weakens the diagnostic value of the manifestation alone. The stronger analytical object is the history-bearing configuration that can reconstruct, relate, notice inquiry-generating encounters, judge, translate, revise, and continue inquiry across time. Whether that configuration is predominantly human, extensively AI-mediated, or deeply coupled remains an empirical and developmental question rather than a premise of the framework.

16 Formation, Education, and Scholarly Development

This section develops the developmental implications of the capacity architecture established in Sections 3–15. Its role is to examine how historical consciousness, relational breadth, generative attention and problem formation, aesthetic and normative judgment, scholarly and generative translation, and epistemic-relational humility can become more stable, mutually available, and revisable within a scholarly configuration. The objective is not to prescribe a universal curriculum for scholars. It is to identify several recurrent formation mechanisms through which the capacities analyzed earlier can be cultivated, coupled, corrected, and sometimes reorganized. The method is synthetic and developmental: established literatures on situated learning, adaptive expertise, tutoring, conceptual change, reflective practice, and interdisciplinary formation are used as interfaces, while the GR framework organizes their relation to the history-bearing configuration and capacity architecture already defined.

The developmental problem follows directly from Equation 5. A scholarly configuration changes through encounters, practices, institutions, tools, and interventions that alter its history, relations, accessible resources, language systems, normative orientation, and operative capacities. Education therefore concerns more than transferring propositions into $\mathcal{K}_t$. It can reorganize the relations through which resources become usable, the distinctions through which problems become visible, the standards through which claims are evaluated, and the correction pathways through which overreach becomes revisable. The National Academies' synthesis of learning research likewise emphasizes that learning is shaped by prior knowledge, culture, motivation, context, and the environments in which activity occurs [38]. Within the present framework, those considerations support treating scholarly formation as a situated process of assimilation and reorganization rather than as accumulation alone.

Table 15 summarizes the seven formation mechanisms developed in this section. The entries identify their principal architectural contributions and characteristic failure modes. The table is heuristic: a single educational episode can activate several mechanisms at once, and the effectiveness of each mechanism depends on disciplinary, institutional, cultural, and individual conditions.

16.1 Intellectual-Historical Study

Historical consciousness is cultivated most directly when study reconstructs why a concept, method, or problem became intelligible and consequential within a particular historical-relational field. Section 4 distinguished this capacity from the possession of historical information. The developmental implication is that historical study should repeatedly exercise reconstruction of the relations among problem constellations, available vocabularies, institutions, material conditions, competing proposals, uptake, and later reinterpretation. Skinner's contextualist method and Koselleck's conceptual-historical attention to changing temporal and semantic structures provide established interfaces for such work [8, 11].

A formation-oriented historical exercise therefore differs from memorizing a canonical sequence. The learner can be asked to reconstruct which alternatives were available to participants at a given moment, which descriptions were contemporaneously available, what pressures made a distinction salient,

Table 15: Formation mechanisms and their principal contributions to the scholarly-capacity architecture.

Formation mechanism	**Principal architectural contribution**	**Characteristic risk when weakly organized**
Intellectual-historical study	Reconstructs conceptual genesis, changing problem fields, alternative repertoires, and historical contingency.	Chronological recall, retrospective inevitability, canon repetition, or anachronistic projection.
Apprenticeship and immersion	Makes tacit discrimination, situated judgment, exemplars, feedback, and responsibility relationally available through practice.	Passive imitation, authority dependence, local convention mistaken for universal validity, or exclusionary gatekeeping.
Interdisciplinary encounter	Develops typed cross-domain relations, boundary sensitivity, scale discipline, and awareness of irreducible remainder.	Analogy inflation, superficial breadth, prestige-driven borrowing, or premature synthesis.
Encounter journaling and anomaly preservation	Develops generative attention by retaining weak signals, failed expectations, ordinary recurrences, and later reinterpretations as possible inquiry origins.	Noise fixation, retrospective mythology, indiscriminate question proliferation, or premature escalation.
Dialogue across conceptual systems	Exercises translation, target-side reconstruction, reciprocal revisability, and power-sensitive interpretation.	Fluent paraphrase without understanding, asymmetric classification, or simulated agreement that suppresses disagreement.
Generative teaching	Alters the learner's conditions for reconstruction, transfer, revision, and subsequent inquiry.	Answer substitution, dependency, unproductive withholding, or manipulation of the learner's generative path.
Reflective situated judgment	Compares expectations, actions, consequences, uncertainty, and correction across repeated episodes.	Retrospective rationalization, outcome bias, unstructured self-report, or reflection disconnected from later practice.

and which later categories would be anachronistic if projected backward without qualification. The same concept can then be followed through later appropriations in order to examine how its function changes when institutions, problems, or language systems change. Such exercises cultivate sensitivity to historical contingency and to the gap between a concept's origin, its later canonization, and its present manifestation.

This method can also strengthen aesthetic and normative judgment. A problem that appears obvious or important in the present can become less self-evident once its historical conditions are reconstructed. Conversely, a concept that appears obsolete can reveal a still-productive distinction when its original problem field is recovered. Historical study can therefore alter which research questions appear deep, urgent, or overdetermined. The contribution is generative when the recovered history changes present problem formation rather than remaining ornamental context.

AI-mediated study can support this mechanism by expanding access to primary texts, translations, bibliographies, competing reconstructions, and chronology. The developmental criterion remains assimilation. A learner who can retrieve more historical material without distinguishing contemporaneous evidence from retrospective interpretation has expanded $\mathcal{K}_t$ while only weakly altering historical con-

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sciousness. A stronger configuration uses AI-supported retrieval to compare genealogies, expose missing provenance, identify conflicts among sources, and revise later inquiry. Educational design should therefore evaluate what historical reconstruction the learner can perform after support is removed, changed, or challenged, rather than counting the amount of material surfaced during the interaction.

16.2 Apprenticeship and Long-Term Immersion

Some scholarly capacities depend on forms of participation that are difficult to acquire through explicit instruction alone. Polanyi's account of tacit knowing and the expertise literature reviewed in Section 2 already indicate that reliable discrimination can depend on histories of practice that exceed fully articulated rules [7, 4]. Lave and Wenger provide a complementary social account: learning can proceed through changing participation in communities of practice, where newcomers gain access to activities, artifacts, discourse, identities, and responsibilities through legitimate peripheral participation [36]. Their account is particularly useful here because apprenticeship need not be reduced to a fixed dyad between a single master and apprentice.

Within the GR framework, apprenticeship matters because it can make otherwise inaccessible supports relationally available. A novice may initially depend on a senior scholar, laboratory, archive, seminar, instrument, or community to recognize what counts as an anomalous result, an elegant simplification, an irresponsible inference, a historically implausible reading, or a promising question. Repeated participation can gradually change the novice's own $\mathcal{L}_t$ and $\mathcal{C}_t$: distinctions that once required explicit prompting become available earlier in the inquiry, and correction can occur before a weak manifestation is finalized.

Long-term immersion should therefore be specified by developmental structure rather than duration alone. Time in a field contributes to formation when it includes sufficiently varied cases, feedback, responsibility, exposure to failure, comparison with stronger exemplars, and opportunities to revise previous judgment. Adaptive-expertise research likewise emphasizes learning conditions that support competent response to novel situations rather than routine efficiency alone [6]. A decade of repeated routine can stabilize narrow competence; a shorter period of deliberately varied participation can sometimes reorganize the learner more substantially. The present paper consequently treats immersion as repeated situated participation with changing responsibility and correction opportunities.

Apprenticeship also carries risks that belong inside the formation analysis. Seniority can transmit local prejudices, prestige hierarchies, or historically contingent conventions along with genuine expertise. A community can make some practices visible while rendering alternatives difficult to articulate. Gatekeeping can restrict who gains access to the relations through which tacit knowledge is learned. The educational value of apprenticeship therefore depends partly on the correction pathways surrounding authority. Historical consciousness, relational breadth, and humility can help learners distinguish inherited craft from universal warrant, while plural mentorship and cross-community encounter can expose assumptions that one local practice leaves unchallenged.

16.3 Interdisciplinary Encounter

Relational breadth develops through encounters in which disciplinary difference remains strong enough to matter. Section 5 argued that interdisciplinarity requires typed and warranted relations rather than accumulation of adjacent vocabulary. The National Academies' account of interdisciplinary research similarly emphasizes integration across specialized bodies of knowledge while preserving the depth required to contribute responsibly to the participating fields [12]. Keestra and Menken further emphasize that integration is difficult precisely because disciplines differ in practices, concepts, and standards [13].

A formation-oriented interdisciplinary encounter should therefore expose the learner to both connection and resistance. Productive activities can include reconstructing how two fields formulate the same practical problem differently, tracing a method as it moves across domains, testing whether a formal analogy survives changes of scale, or asking which evidential standards block a proposed translation.

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Failure to integrate can be as educational as successful synthesis when the failure reveals which local assumptions, units, causal structures, or normative commitments remain irreducible.

This mechanism depends on sufficient local depth. A learner who encounters many fields only through summaries can develop broad familiarity while remaining unable to judge whether a proposed correspondence is admissible. Mature relational breadth requires access to target-side criticism from participants who can identify where a borrowed concept has lost its disciplinary function. Trading-zone and boundary-object literatures provide useful interfaces because they show that coordination can occur without complete conceptual unification [22, 23]. Educational design can therefore value local coordination, partial translation, and explicit remainder rather than treating total synthesis as the measure of success.

Interdisciplinary formation also changes the architecture of humility. Encounter with another field can reveal that familiar concepts are local solutions rather than universal primitives. It can also reveal asymmetries of prestige: a mathematically formal field may be granted interpretive authority over a qualitative field, or a globally dominant discipline may define what counts as rigor for a smaller tradition. Repeated cross-domain work can cultivate the capacity to distinguish transferable structure from prestige-driven borrowing and to ask whether the receiving field retains authority to contest the translation.

16.4 Encounter Journaling and Problem-Formation Practice

Generative attention can be cultivated only indirectly because educational design cannot specify in advance which future encounter will become a significant inquiry origin. It can, however, strengthen the configuration's capacity to preserve and revisit encounters before their significance is known. Relevant practices include recording anomalies, failed expectations, recurring frictions, surprising examples, ordinary phenomena that resist current explanation, and questions that arise during reading, experiment, fieldwork, or dialogue.

The developmental value lies in delayed comparison. An encounter journal, laboratory notebook, research diary, or provenance-preserving AI memory can allow a scholar to compare earlier observations with later conceptual resources. A trace that initially appears trivial can become intelligible after historical study or cross-domain encounter changes the configuration. Conversely, later evidence can show that an initially striking anomaly was measurement error or noise. Such revision trains attention together with restraint.

Problem-formulation exercises provide a complementary mechanism. Learners can be given the same phenomenon and asked to produce several problem representations, identify which assumptions make each framing possible, and compare what each framing renders visible or invisible. The problem-recognition literature reviewed in Section 6 provides an interface for treating these early stages of problem solving as legitimate objects of study rather than as invisible preliminaries to solution.

AI can support this formation mechanism when it preserves provenance, generates alternative framings, retrieves analogous cases, and helps revisit neglected observations across time. It can weaken the mechanism when it immediately converts uncertainty into a polished answer and thereby closes the encounter before the learner has articulated why it might matter. Formation-oriented use should therefore preserve some unresolved traces long enough for later reinterpretation while maintaining correction procedures that prevent noise from becoming self-reinforcing theory.

The comparative structure in Section 7 suggests a second exercise: retrospective trajectory reconstruction with prospective discipline. Learners can examine historical cases in which a minor early change later became consequential, but they should also record cases in which similar weak signals disappeared, reversed, or proved irrelevant. The purpose is to cultivate sensitivity to incipient change without training hindsight bias. A stronger exercise asks the learner to state several plausible trajectories and an action horizon before later outcomes are revealed, then compare the earlier judgment with what actually followed.

An open educational problem remains. Text-centered study can provide indispensable historical and conceptual depth while presenting inquiry through a problem space already filtered by earlier acts of

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problem formation, aesthetic and normative judgment, institutional selection, translation, publication, canonization, and preservation; learners may consequently mistake inherited questions for the natural boundaries of what can be asked. AI may intensify this risk by making established problem framings, candidate questions, and polished answers unusually abundant. How education can cultivate sensitivity to contingencies that have not yet been problematized, together with the judgment needed to decide which deserve pursuit, the capacity to sense changing trajectories, and the practical ability to respond appropriately—without rewarding noise fixation, arbitrary intuition, retrospective myth-making, or indiscriminate novelty seeking—remains an open problem for the present framework and likely requires situated encounter and practice in addition to textual study.

16.5 Dialogue across Conceptual Systems

Dialogue is a developmental mechanism when it exposes a scholarly configuration to interpretations that cannot be generated reliably from its own current language system. Gadamer's hermeneutics is relevant because understanding is treated as historically situated and dialogical rather than as extraction of context-free meaning [9]. Sections 10 and 12 translated that insight into a GR architecture of language systems, translation remainder, target-side reconstruction, and reciprocal revisability. The developmental question is how repeated dialogue can stabilize those capacities.

A useful dialogue for scholarly formation does more than exchange conclusions. Participants can be required to restate the other's problem in target-side terms, identify what evidence the other side would regard as relevant, mark which propositions remain untranslated, and specify which disagreement arises from evidence, inference, value, scale, or language-system difference. These practices exercise translation and humility together. They also create opportunities for the interpreter to discover that an apparently irrational claim becomes coherent under a different problem framing, while preserving the possibility of later criticism.

Reciprocal revisability is the stronger developmental outcome. The learner should sometimes leave the dialogue with a modified distinction, revised confidence level, new question, or changed model of the other system. Such modification does not require convergence. A dialogue can improve scholarly formation by making disagreement more precisely locatable and by preventing one system from absorbing the other through premature equivalence. This is especially important when participants occupy unequal institutional positions, because the party with greater interpretive authority can stabilize a convenient translation before the weaker party's remainder becomes visible.

Human–AI dialogue can contribute to this mechanism when it broadens the range of formulations, counterarguments, examples, or disciplinary vocabularies available for inspection. It becomes a weak substitute when simulated perspectives are treated as evidence for the actual views of affected communities or traditions. Target-side interlocutors, texts, institutions, and practices remain important sources of correction. The developmental use of AI is therefore strongest when it prepares, supplements, or records dialogue while preserving provenance and the difference between model-generated perspective simulation and evidence about real interlocutors.

16.6 Generative Teaching

Generative teaching provides the most direct educational application of the distinction developed in Section 11. The objective is to change what a learner can subsequently reconstruct, vary, test, transfer, and generate, rather than to maximize immediate production of correct manifestations. Wood, Bruner, and Ross's analysis of tutoring provides an established interface for structured assistance that recruits the learner into problem solving, reduces unproductive complexity, and adjusts support to performance [24]. Posner and colleagues provide a complementary interface through conceptual-change research, where learning can require reorganization of prior conceptions rather than addition of isolated propositions [25].

Generative teaching can therefore combine direct explanation with questions, examples, contrasts, partial models, counterexamples, and carefully chosen perturbations. The decisive issue is the learner's later capacity architecture. A direct explanation is educationally generative when it becomes assimilated

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and supports reconstruction or transfer. Conversely, withholding an answer is not inherently generative; it can waste time, preserve confusion, or convert instruction into an unnecessary test. The relevant distinction concerns what the intervention leaves the learner able to do next.

The general scholarly update map in Equation 5 provides a compact representation of this developmental process. A teaching episode supplies part of Δ_t, while the resulting change depends on the learner's existing history and relations. Identical instruction can therefore produce different developmental effects across learners. One student may acquire a useful formula, another may reorganize a conceptual distinction, and a third may reject the instruction because it conflicts with a stronger existing framework. Evaluation should consequently examine later reconstruction, transfer, error correction, and problem generation in addition to immediate answer accuracy.

Generative teaching also creates a responsibility problem. An instructor who can shape another person's generative conditions possesses interpretive and developmental power. The distinction introduced in Section 13 therefore applies to pedagogy: effective influence is not by itself evidence of legitimate influence. Responsible generative teaching should preserve opportunities for contestation, disclose relevant framing choices, distinguish evidence from interpretation, and avoid making dependency on the instructor the hidden condition of continued success.

AI tutoring makes this issue especially salient. Adaptive systems can provide abundant explanation, feedback, questioning, and examples at low marginal cost, yet high interaction volume does not by itself establish formation. A learner can become efficient at eliciting completed manifestations while losing practice in reconstruction, verification, or judgment. A stronger Human–AI educational configuration uses AI support to vary cases, surface assumptions, compare strategies, preserve provenance, and gradually test whether the learner can perform the relevant scholarly operations under changed support conditions.

16.7 Reflective and Situated Judgment

Reflection connects developmental episodes across time. Schön's account of professional practice emphasizes knowing-in-action and reflection-in-action: professionals encounter situations whose uncertainty and uniqueness cannot always be handled by applying explicit rules, and they can learn by reflecting within and on their practice [37]. This interface fits the present architecture because scholarly judgment is already treated as situated, history-bearing, and revisable. Reflection makes earlier episodes available as objects for later reconstruction rather than allowing successful or failed action to disappear into unexamined habit.

A formation-oriented reflective practice can reconstruct four relations: what the scholar expected, which cues or assumptions shaped the judgment, what action or interpretation followed, and what later evidence changed the assessment. The aim is not exhaustive introspection. It is to create a usable history of judgment that can support recalibration. Research notebooks, decision records, error logs, peer debriefing, replication attempts, retrospective case comparison, and explicit records of abandoned hypotheses can all serve this function when they preserve enough context to make later reconstruction possible.

Reflection is particularly important for aesthetic and normative judgment because both can be vulnerable to retrospective success. A successful research programme can make the original choice appear obviously beautiful, while an unsuccessful programme can make an initially reasonable judgment appear foolish. Reflective records created before outcomes are known help distinguish the reasons available at the time from later narrative reconstruction. The same principle applies to normative decisions: documenting expected harms, benefits, uncertainty, alternatives, and affected parties makes later revision more accountable than evaluating the decision solely by realized outcomes.

Situated reflection also supports humility. A scholar can compare confidence with later evidence, identify recurring translation failures, observe when disciplinary prestige distorted relation typing, or notice that a preferred aesthetic criterion systematically excluded certain problem classes. Repeated reflection can therefore modify the coupling structure described in Section 14, strengthening correction pathways among capacities. Reflection contributes to formation when it changes later practice, not

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merely when it produces an articulate retrospective account.

Claim 16.1 (Evidence of capacity-architectural development)**.** Within the present framework, an educational or practical episode provides stronger evidence of scholarly formation when its later effects extend beyond resource access and include sufficiently stable changes in the relations, language systems, operative capacities, or correction pathways through which a configuration can reconstruct, judge, translate, revise, or continue inquiry across changed contexts.

Claim 16.1 states an evidential criterion derived from the architecture without implying that one educational pathway fits every discipline or learner or that change along every listed dimension is required. Intellectual-historical study, apprenticeship, interdisciplinary encounter, dialogue, generative teaching, and reflective judgment provide different routes through which the architecture can change. Their effects remain contingent on prior formation, institutional support, available time, power relations, and the quality of feedback.

A final implication concerns educational assessment. If scholarly formation is history-bearing and relational, a single polished output gives limited evidence about development. Stronger assessment can sample performance across changed problems, require explanation and reconstruction, test transfer, inspect provenance, invite revision after criticism, and observe whether support can be reduced or reorganized without collapse. Such assessment remains demanding and domain-specific, but it corresponds more closely to the capacities this paper seeks to analyze than output quality alone.

These developmental claims remain bounded. The analysis has described plausible formation mechanisms and their relation to the proposed architecture; it does not establish that the eight capacity families exhaust scholarly maturity, that the mechanisms operate identically across cultures and disciplines, or that celebrated senior scholars provide an unbiased empirical sample of successful formation. Those limits are part of the framework's epistemic and normative boundary conditions.

17 Epistemic and Normative Boundaries

This section defines the principal boundaries of the account developed in Sections 2–16. Its role is to separate the framework's analytical proposals from stronger descriptive, evaluative, and predictive claims that the present manuscript does not establish. The objective is threefold: to specify where the eight-capacity architecture is intended as a heuristic representation rather than a completed taxonomy; to identify disciplinary, cultural, institutional, and technological conditions under which its interpretation may change; and to state the empirical work required before the framework can support broader claims about scholarly maturity. The method is critical and scope-sensitive. Existing evidence is used to delimit rather than inflate the reach of the formalism, and the section treats disagreement about scholarly excellence as part of the research object rather than as noise to be removed.

The boundaries are summarized in Table 16. Each row distinguishes a useful contribution of the present framework from a stronger conclusion that would require additional evidence or argument. The table is not an exhaustive inventory of limitations. It records the boundaries most likely to affect interpretation of the manuscript's central claim that scholarly formation can be studied as a history-bearing, relationally organized generative capacity.

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Table 16: Principal epistemic and normative boundaries of the proposed scholarly-formation framework.

Boundary	**Present framework supports**	**Additional evidence required for**
Claim status	A structured vocabulary for analyzing capacities, couplings, conditions, and development.	A universal definition of good scholarship or a complete account of how scholars actually develop.
Disciplinary variation	Task- and context-indexed capacity profiles with room for different evidential and methodological practices.	One invariant weighting of capacities across mathematics, history, engineering, philosophy, medicine, or other fields.
Cultural plurality	Explicit preservation of language-system difference, translation remainder, and historically situated judgment.	Cross-cultural universality of the proposed capacity architecture or of any particular ideal of scholarly maturity.
Senior-scholar observations	Heuristic hypotheses generated from experienced scholarly practice.	Representative empirical generalization from eminent, visible, or institutionally recognized scholars.
Breadth/depth	Relational breadth can coexist with disciplinary depth and boundary preservation.	A general prescription that broader scholarship is superior to specialized scholarship.
AI capability change	A configuration-based method for evaluating capacities independently of fixed human/AI categories.	Stable claims about which capacities future AI systems will or will not possess.
Definition power	Analysis of how institutions and dominant language systems shape recognized scholarly maturity.	A politically neutral or institution-independent criterion of scholarly excellence.
Empirical/formal status	A preliminary representational architecture and set of testable distinctions.	Ontological proof, validated measurement model, or empirically calibrated theory of scholarly formation.

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17.1 Descriptive and Normative Status

The manuscript contains several kinds of claims whose epistemic status should remain distinct. Some are definitional within the proposed framework, such as the distinction between scholarly manifestation and generative capacity. Some are interpretive proposals, such as treating historical consciousness as generative reconstruction rather than historical recall. Others are empirical hypotheses, including the expectation that stronger scholarly formation will often support transfer, revision, reconstruction, and longer-horizon continuation across changed contexts. Still others are normative claims, for example that interpretive authority should be exercised with greater restraint when target-side understanding is weak and consequences are difficult to reverse.

These claim types cannot be validated by the same method. A conceptual distinction can be assessed for coherence, explanatory usefulness, and compatibility with the cases it is meant to organize. A descriptive hypothesis requires comparative evidence. A developmental mechanism requires longitudinal, educational, or ethnographic investigation. A normative proposal requires reasons concerning value, legitimacy, responsibility, affected parties, and alternative institutional arrangements. The paper therefore does not infer a normative duty directly from the fact that a capacity contributes to scholarly continuation.

This distinction is especially important for the eight capacity families. Historical consciousness, relational breadth, generative attention and problem formation, aesthetic judgment, normative judgment, scholarly translation, generative translation, and epistemic-relational humility are selected because they illuminate the problem developed in this paper. The manuscript has not shown that every excellent

scholar exhibits them to the same degree, that they are individually necessary, jointly sufficient, exhaustive of scholarship, or deserving of equal institutional reward. The architecture is intended to make such questions investigable without settling them in advance.

Caution 17.1 (Analytical importance and normative priority)**.** A capacity can be analytically important to the explanation of scholarly formation without thereby acquiring universal normative priority. Educational time, institutional resources, disciplinary purpose, and social responsibility can justify different developmental emphases across contexts.

Caution 17.1 also applies to AI-mediated education. If a particular Human–AI arrangement strengthens one capacity while weakening another, the framework can describe that trade-off. Whether the arrangement should be adopted depends on the purposes of the institution, the reversibility of the effects, available alternatives, and the distribution of benefits and burdens. A descriptive account of capacity change is therefore only one input into normative judgment.

17.2 Disciplinary Variation

The capacity architecture is deliberately task- and context-indexed because scholarly excellence is evaluated through different disciplinary practices. Lamont's study of fellowship and grant peer review documents substantial differences in evaluative cultures across humanities and social-science fields, including differences in how originality, methodological rigor, significance, and appropriate evidence are recognized [39]. The point relevant here is methodological: a framework for scholarly formation should allow the same capacity label to be instantiated differently across disciplines.

Historical consciousness, for example, can be central to intellectual history while taking a different form in experimental physics or molecular biology. Aesthetic judgment in mathematics can emphasize proof structure or conceptual economy, while aesthetic judgment in historical scholarship may concern explanatory fit, archival sensitivity, or the fertility of a reconstruction. Normative judgment can be unusually salient in medicine, climate research, military technology, or human-subject research, yet remain present in less immediately interventionist fields through resource allocation, institutional responsibility, and the choice of research priorities.

Relational breadth must therefore preserve disciplinary sovereignty in the limited analytical sense developed in Section 5: cross-domain movement should remain accountable to the evidential, methodological, and scale conditions of the domains being related. The National Academies' work on interdisciplinary research and Keestra and Menken's account of integration already provide interfaces for this tension between disciplinary depth and cross-domain integration [12, 13]. The present paper adds a capacity architecture, but it does not establish a discipline-independent weighting rule.

One practical implication concerns assessment. A fixed rubric assigning the same numerical weight to the eight capacities across fields would contradict the context-sensitive commitments of the framework. More appropriate empirical work would compare how different disciplines instantiate, combine, and correct the capacities under specific tasks. Such work could identify recurrent patterns without presuming that convergence on one profile is desirable.

17.3 Cultural Plurality of Scholarly Ideals

The paper's initial observations arose from encounters with experienced scholars and from literatures that are themselves concentrated in particular academic traditions. This origin limits claims about cultural universality. Scholarly ideals are historically shaped by institutions, languages, educational systems, intellectual traditions, and relations of geopolitical and material power. Concepts such as originality, rigor, independence, humility, elegance, or appropriate scholarly distance can therefore carry different meanings and normative weight across settings.

A general methodological warning comes from cross-cultural behavioral science. Henrich, Heine, and Norenzayan show that broad claims about human psychology have often been built from unusually narrow populations and argue for greater caution about generalizing from such samples [40]. Their

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analysis does not establish how scholarly ideals vary across cultures, and the present paper does not use it as evidence for a particular cross-cultural pattern. Its relevance is narrower: observations drawn from a restricted scholarly population should not be treated as transparent evidence of universal human or scholarly capacities.

The GR framework is designed to make plurality visible through language systems, historical location, translation remainder, and power-sensitive interpretation. These devices, however, do not guarantee cultural adequacy. A framework developed in one academic language can still redescribe other traditions in its own categories while believing that it has preserved difference. Comparative work should therefore include target-side scholarship, multilingual sources where relevant, and opportunities for participants to challenge the categories through which they are represented.

Cultural plurality also places a boundary around the normative use of humility. The paper has treated epistemic-relational humility as restraint of premature projection and openness to revision. This formulation should not be converted into a culturally uniform behavioral style. Deference, direct disagreement, silence, self-assertion, and public uncertainty can carry different meanings under different institutional and cultural conditions. The underlying analytical interest is calibration and revisability, not conformity to one interpersonal performance of modesty.

17.4 Senior-Scholar Selection Effects

Several motivating observations concern proficient, senior, or widely respected scholars. Such observations are valuable for hypothesis generation because mature practice can make otherwise hidden forms of judgment, historical reconstruction, translation, and relational breadth visible. They are also subject to strong selection effects. Publicly recognized scholars are selected through institutional histories, disciplinary prestige, language access, publication systems, networks, resources, and retrospective narratives of success. Visibility is therefore an imperfect proxy for scholarly maturity.

Survivorship creates a second problem. Long-horizon aesthetic judgment appears especially impressive when a research programme later becomes fruitful. Failed commitments made under similarly reasonable conditions are less likely to become canonical examples. Section 8 therefore treated retrospective success as weak evidence for the quality of the original judgment unless the reasons available at the time can be reconstructed. The same caution applies to accounts of mentors, intellectual breadth, and interdisciplinary movement: biographies often preserve successful crossings more readily than unproductive or misleading ones.

A third selection effect concerns institutional role. Senior scholars can possess greater freedom to cross disciplinary boundaries because prior reputation, tenure, networks, and accumulated symbolic capital reduce the cost of boundary crossing. A junior researcher displaying the same breadth may be evaluated as unfocused. The observed behavior of eminent scholars therefore cannot be translated directly into advice for scholars in different structural positions. Section 13 provides the relevant corrective: capability, recognized authority, and the consequences of exercising a capability should remain analytically distinct.

The appropriate empirical response is comparative sampling. Future work could examine scholars at different career stages, across institutional positions, disciplines, linguistic communities, and recognition levels. It could also include scholars whose trajectories were intellectually serious but institutionally unsuccessful. Such comparison would help determine whether the capacities identified here characterize mature scholarly formation, particular elite environments, or a mixture of both.

17.5 Breadth and Specialization

The emphasis on relational breadth creates an obvious risk of treating wide-ranging scholarship as intrinsically superior to specialization. The framework does not support that conclusion. Many scholarly advances depend on sustained attention to narrow objects, high technical competence, instrument-specific skill, long data collection, or deep familiarity with a restricted archive. Specialization can create precisely the local discriminations that make later relational work possible.

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The relevant contrast is therefore not breadth versus depth as mutually exclusive ideals. It is between configurations whose specialization remains capable of locating its assumptions, interfaces, and consequences when the task requires it, and configurations whose boundary becomes invisible even when external relations are materially important. Conversely, breadth becomes weak when it accumulates analogies without enough local competence to evaluate them. Section 5 described this risk as analogy inflation and premature synthesis.

The balance is also career- and project-dependent. A research group can distribute breadth and specialization relationally: one participant may hold deep formal expertise, another historical knowledge, another field-specific empirical competence, and another translation capacity. The relevant scholarly configuration can therefore possess a broader architecture than any single individual. This is one reason the GR account avoids identifying scholarly formation solely with an isolated person's inventory of skills.

A future empirical programme should investigate where relational breadth is best located. In some contexts it may be an individual capacity; in others it may be produced through teams, institutions, editorial structures, or Human–AI configurations. The framework predicts only that the relevant relations and correction pathways must become available somewhere in the configuration if cross-domain claims are to be responsibly sustained.

17.6 AI Capability Change

Claims about AI are especially vulnerable to temporal obsolescence. The studies used in Section 15 document particular systems, tasks, and evaluation conditions. They demonstrate that contemporary AI can support substantial portions of scientific workflows, generate research candidates that receive favorable expert evaluations in bounded settings, and create new risks of apparent understanding without corresponding assimilation [35, 34, 33]. They do not establish fixed boundaries around future AI capabilities.

For this reason, the paper's main distinctions are functional rather than species-based. Retrieval is separated from historical consciousness because the two require different evidence; candidate generation is separated from aesthetic judgment because novelty alone does not establish stable discrimination; fluent reformulation is separated from generative translation because target-side development requires evidence beyond surface adequacy. If future systems demonstrate stronger reconstruction, transfer, calibration, revision, historical continuity, or target-sensitive generativity, the attribution of capacities should change accordingly.

The configuration-based approach also makes capability attribution dependent on system boundaries. A model may lack persistent history in isolation while a recurrent Human–AI research environment supplies memory, provenance, archives, feedback, and institutional responsibility. Conversely, a nominally persistent system may still produce weak scholarly formation if its history is inaccessible, uncorrectable, or disconnected from later judgment. The relevant empirical question therefore concerns the architecture actually instantiated by the selected configuration.

Claim 17.2 (Capability-revisability principle)**.** Within the present framework, attributions of scholarly capacity to Human–AI configurations should remain revisable with changes in system capability, coupling structure, retained history, evaluative evidence, and analytical boundary. No capacity distinction developed in this paper entails an intrinsic human monopoly.

Claim 17.2 protects the manuscript from a common failure mode in AI-era scholarship: converting a contingent limitation of current systems into a metaphysical claim about intelligence or scholarship. It also prevents the opposite error of treating a successful manifestation as sufficient evidence that the full capacity architecture has been instantiated.

17.7 Power in Defining Scholarly Maturity

Any account of scholarly maturity participates in a field of evaluation. Universities, journals, professional societies, funding agencies, ranking systems, languages, platforms, and disciplinary gatekeep-

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ers already influence which performances count as rigorous, original, relevant, or excellent. Lamont's study shows that evaluative criteria differ across disciplinary cultures and are negotiated in concrete peer-review settings [39]. Bourdieu's analysis of symbolic power and Fricker's account of epistemic injustice provide broader interfaces for understanding how recognized authority and unequal interpretive resources can shape whose claims become credible or intelligible [29, 30].

The present framework therefore cannot be treated as politically neutral merely because it uses formal notation. Selecting historical consciousness, relational breadth, judgment, translation, and humility as salient capacities already foregrounds a particular conception of scholarship. If institutions operationalize these capacities through hiring, promotion, funding, or automated assessment, the categories could become performative: scholars may reorganize their work to satisfy the framework, and the framework could then help produce the very pattern it claims to measure.

This risk is heightened when evaluation is asymmetric. A dominant institution can define another tradition as insufficiently rigorous, insufficiently interdisciplinary, excessively local, or insufficiently humble while controlling the standards through which those judgments become consequential. Section 13 therefore applies reflexively to the current paper. Users of the framework should preserve the possibility that target communities reject its categories, propose alternative scholarly virtues, or deny that a local practice should be evaluated through the same architecture.

The most responsible use of the framework is consequently diagnostic and dialogical. It can help make assumptions visible, compare capacity profiles, identify hidden substitutions, or design empirical questions. It should not be treated as a ready-made ranking instrument. Where institutional consequences are substantial, procedures for contestation, provenance, contextual interpretation, and revision become part of the legitimacy of the evaluation itself.

17.8 Empirical and Formal Limits

The formal objects introduced throughout the manuscript are representational devices. The configuration Σ_t^{sch}, continuation space, capacity architecture, translation relations, evaluative profiles, and interpretive-consequence structures organize distinctions that would otherwise remain difficult to compare. They have not been calibrated as measurement models, and the paper does not provide validated indicators for their components. Their usefulness therefore depends on whether subsequent historical, qualitative, educational, computational, and comparative studies can operationalize parts of the framework without destroying the distinctions it was designed to preserve.

Several empirical programmes are possible. Longitudinal studies could examine how scholars' reconstruction, transfer, and correction capacities change through apprenticeship or AI-assisted practice. Comparative disciplinary studies could test whether the proposed capacity families recur with different local manifestations. Ethnographic work could study how translation and interpretive power operate in interdisciplinary teams. Educational experiments could compare answer-oriented and generative-support conditions while evaluating delayed transfer and revision rather than immediate output alone. Human–AI studies could examine whether recurrent configurations retain usable histories and improve calibration across tasks.

Formal development also remains open. The relations among capacity families have been typed qualitatively rather than assigned universal weights. Continuation spaces have been used to represent possible future inquiry without a complete topology or probability measure. Evaluative profiles remain multidimensional because the paper has not justified a common scale. Interpretive consequence profiles similarly resist scalar reduction because credibility, visibility, resource access, and continuation can change in different directions. These are deliberate restraints at the present stage rather than missing calculations that can be filled by arbitrary coefficients.

Claim 17.3 (Boundary-preserving use of the framework)**.** The present GR account is most defensible when used to formulate comparative questions, reconstruct scholarly histories, identify capacity couplings and failure modes, and guide empirical inquiry while preserving disciplinary, cultural, institutional, and technological variation. Stronger ranking, predictive, or universal claims require evidence

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beyond the conceptual architecture developed here.

Claim 17.3 summarizes the epistemic stance of the paper. The framework gains value by making distinctions available for investigation, not by converting them prematurely into a universal metric of scholarly worth. This stance is also consistent with the manuscript's account of epistemic-relational humility: the theory should remain capable of being revised by the scholarly configurations it seeks to describe.

Under these boundaries, scholarly formation remains a provisional account of history-bearing relational generativity. Its mature manifestations can involve historical reconstruction, relational breadth, generative attention and problem formation, and aesthetic or normative judgment. They can also involve translation, generative translation, humility, and correction under asymmetric interpretive power. The framework remains intentionally non-exhaustive, culturally revisable, and technologically open.

17.9 Classical Comparison and Predictive Restraint

The comparison with the classical sage ideal in Section 7 has a deliberately limited evidential status. The *Zhouyi* passages are used to reconstruct an historically important articulation of sensitivity to minute change, temporal development, and timely action. They do not function as empirical validation of divination, omen interpretation, cosmological correspondence, or supernatural prediction. The formal analogy concerns how a configuration transforms a minor encounter into a question, a trajectory hypothesis, or a practical judgment.

The same restraint applies in the opposite direction. Modern forecasting, statistical early-warning systems, and expert pattern recognition should not be treated as epistemically superior merely because they use contemporary technical vocabularies. Their warrant depends on calibration, data quality, model assumptions, domain stability, and prospective performance. The comparative section therefore supports neither romanticization of classical wisdom nor technological triumphalism. It isolates a shared problem of contingency-sensitive judgment and leaves the truth conditions of particular interpretive systems to domain-specific evaluation.

18 Conclusion

This section consolidates the paper's argument without adding new capacity families or external literature. The central proposal is that scholarly formation can be investigated as a history-bearing, relationally organized generative capacity whose quality depends on both the availability of particular capacities and the relations through which they coordinate, correct, and constrain one another. The conclusion restates that proposal, draws together the Human–AI implications, and identifies the empirical interfaces required to develop the framework beyond its present conceptual status.

18.1 Scholarly Formation as History-Bearing Generativity

AI-mediated scholarship makes a longstanding analytical distinction increasingly visible: a scholarly manifestation and the capacity architecture that produced it are related but non-identical objects. Retrieval, synthesis, drafting, translation, coding, and candidate generation can now be distributed across heterogeneous Human–AI configurations. A polished paper, model, explanation, or problem proposal therefore supplies evidence about scholarly capacity only when its provenance, support conditions, assimilation, and later use are also considered.

Equation 1 represented a scholarly configuration through its relevant history, relational structure, accessible knowledge resources, operative language systems, normative conditions, and capacities. The history term records the path through which present discrimination and competence became available; the relational terms record the persons, institutions, artifacts, infrastructures, and authority structures that support or constrain inquiry; and the generative component concerns what forms of reconstruction,

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judgment, translation, revision, and continuation remain possible. Definition 3.3 further separated access to a resource from its assimilation into later scholarly practice.

This representation supports the paper's principal analytical shift. Scholarship is not exhausted by the production or possession of knowledge manifestations. A configuration can retrieve extensive information while lacking historical reconstruction, generate many difficult problems while lacking stable aesthetic discrimination, or produce fluent cross-domain language while preserving weak inferential fidelity. Conversely, generativity can increase when inquiry eliminates unproductive branches, exposes hidden assumptions, improves correction pathways, or reorganizes the language in which later questions become expressible. The continuation-space representation in Equation 4 was introduced to keep these differences visible.

The proposal remains a research representation rather than an invariant essence of scholarship. Its value lies in making visible differences among histories, support structures, assimilation, correction pathways, and future inquiry possibilities that may be obscured when evaluation focuses primarily on finished artifacts.

18.2 Capacity Relations in Mature Scholarship

The eight capacity families perform distinct functions. Historical consciousness reconstructs conceptual genesis and transformation. Relational breadth identifies typed and warranted relations across domains. Generative attention recognizes when contingent, ordinary, weak, or unexpected encounters can become inquiry-generating problem formations. Section 7 shows that the same upstream contingency sensitivity can also support provisional judgments about incipient change. That comparison does not add a ninth family; it clarifies how mature configurations can coordinate problem formation with trajectory sensitivity and, where action is required, with mediating judgment. Aesthetic judgment discriminates intellectual fertility and long-horizon promise. Normative judgment evaluates priority, scale, timing, consequence, and responsibility within a situated relational order. Scholarly translation reconstructs intelligibility across language systems. Generative translation reorganizes conditions under which another configuration can later reconstruct or extend an object. Epistemic-relational humility calibrates confidence, projection, and revisability across heterogeneous systems.

Section 14 integrated these capacities through Equation 24. The resulting architecture distinguishes operative capacity families, typed couplings among them, and contextual conditions such as institutions, resources, language systems, and interpretive power. This architecture explains why scholarly maturity is poorly represented by a checklist or scalar score. Historical reconstruction can correct anachronistic translation; relational breadth can expose analogy inflation or scale mismatch; generative attention can preserve a weak signal while aesthetic judgment prevents indiscriminate escalation; normative judgment can constrain intensive pursuit of an aesthetically attractive programme; translation remainder can reveal apparently hidden disagreement; and humility can expose confidence that exceeds warrant. Architectural coherence therefore concerns coordination and correction pathways as well as local strength.

Interpretive power occupies a related but different position. Section 13 treated power primarily as a relational condition that changes the consequences of classification, translation, evaluation, and visibility. Awareness and responsible handling of such asymmetry can become part of scholarly formation, while the underlying authority relation remains a property of the configuration. This distinction matters because the same interpretive error can have very different downstream effects depending on who can stabilize it institutionally.

The architecture is intentionally task- and context-indexed. Different fields can require different capacity profiles, and many capacities can be distributed across collaborators, archives, instruments, institutions, or computational systems. Mature specialization is therefore compatible with the framework. The relevant question is whether the configuration assembled for a scholarly function contains adequate capacities, support relations, and correction mechanisms for that function.

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18.3 Human–AI Scholarly Configurations

Human–AI scholarship served as a stress test because AI systems increasingly participate in activities that once functioned as visible proxies for scholarly maturity. Section 15 therefore separated retrieval from historical consciousness, cross-domain synthesis from systemic understanding, candidate generation from generative attention, problem generation from aesthetic judgment, recommendation from normative judgment, linguistic reformulation from generative translation, and viewpoint simulation from epistemic-relational humility. These distinctions concern evidence and function; they do not reserve the deeper capacities to human agents by definition.

Definition 15.1 provides a flexible unit for studying recurrent Human–AI arrangements. Capacity attribution becomes stronger when interaction histories persist, generated materials are assimilated into later inquiry, provenance is retained, feedback changes future behavior, and responsibilities for verification or correction are identifiable. Boundary transparency remains essential because a narrow Human–AI boundary can hide curators, infrastructure, communities, or target-side expertise, while an excessively broad boundary can make attribution uninformative.

The framework therefore supports the capability-revisability principle in Claim 17.2. Attributions should change when system capabilities, retained histories, coupling structures, or evidence change. Current limitations are contingent evidence, and sophisticated manifestations are likewise insufficient by themselves to establish deeper capacities. As AI makes polished manifestations less diagnostic of their generative histories, evaluation can place greater weight on provenance, reconstruction, transfer, revision after criticism, calibration, and continuation across changed tasks or support conditions.

18.4 Research Interfaces for Empirical and Educational Development

The framework requires empirical development. Historical and comparative studies can test how the proposed capacities appear across disciplines and traditions, which capacities are locally embodied or institutionally distributed, and how different histories alter their expression. Longitudinal expertise research can examine assimilation through delayed reconstruction, transfer, correction, and persistence after support changes. Ethnographic and organizational research can study how teams negotiate translation, authority, disagreement, and correction in actual scholarly practice.

Educational research can treat the mechanisms in Section 16 as hypotheses rather than established prescriptions. Intellectual-historical study, apprenticeship, interdisciplinary encounter, encounter journaling and problem-formation practice, comparative reconstruction of incipient change, generative teaching, and reflective judgment may cultivate different parts of the architecture under different conditions. Their effects should be assessed through later capabilities and correction pathways, not only immediate task performance.

Human–AI research can compare configurations with different memory, provenance, feedback, retrieval, and tool structures. Relevant outcomes include historical reconstruction, relation typing, preservation and reinterpretation of weak encounters, calibration after error, transfer across contexts, preservation of translation remainder, and robustness when support changes. Institutional research can ask how funding systems, publication structures, archives, language regimes, platforms, and educational arrangements preserve or narrow future scholarly possibilities.

The formal representations introduced here also remain provisional. Configuration tuples, continuation spaces, translation relations, evaluative profiles, consequence profiles, and capacity architectures organize distinctions; they are not calibrated universal metrics. Domain-specific operationalizations, longitudinal models, graph representations, or computational simulations may become appropriate when empirical questions warrant them.

The resulting research programme is intentionally revisable. Different disciplines, cultures, institutions, and future Human–AI configurations may reveal omitted capacities, different coupling structures, or limits in the present categories. Such revision would test the framework on its own terms. A generative account of scholarly formation should preserve the conditions under which its concepts can themselves be reconstructed, translated, criticized, and transformed.

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