

Towards Criticality Learning: A Preliminary Discussion

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Abstract

This discussion paper introduces *criticality learning* as a preliminary framework for thinking about exploratory, interdisciplinary, and cross-framework learning through the conceptual language of nonlinear dynamics. Disciplines, theories, religious traditions, and value frameworks can develop relatively stable conceptual grammars that organize what questions are salient, what relations become visible, what counts as an adequate explanation, and how new knowledge is generated. Such structures can be provisionally understood as epistemic attractors. Entering an attractor can support depth, precision, and sustained disciplinary generation. At the same time, increasingly stable attraction can reduce sensitivity to alternative grammars and make one local framework appear to constitute the background structure of inquiry itself. Criticality learning concerns the deliberate cultivation of an epistemic state in which a learner can approach and enter multiple attractor-like structures while preserving the capacity to return to a comparatively open region of inquiry. The relevant critical state is therefore understood as a metastable and generative condition rather than a fixed point. Learning proceeds through repeated movements of immersion, awareness, return, and recombination. Each disciplinary excursion can transform the learner, while return permits the newly acquired grammar to be situated among other possible grammars and to participate in subsequent acts of comparison and creation. The returned state is consequently different from the state that preceded the excursion. The paper develops three capacities that are especially important to this process. *Attractor awareness* concerns the learner's capacity to notice when a disciplinary, conceptual, affective, or identity-based structure is acquiring increasing control over the available space of interpretation. *Epistemic returnability* concerns the preservation of a learner's capacity to leave a locally dominant framework and re-enter a space from which other forms of inquiry remain accessible. *Re-recognition* concerns the capacity to encounter concepts, values, and possible worlds again after one's own epistemic structure has already been transformed by prior learning. Together, these capacities support forms of learning in which commitment and specialization remain compatible with continued epistemic mobility. Criticality learning is proposed particularly for contexts in which the generation of new questions, comparison across heterogeneous systems, and creative recombination are important, including interdisciplinary inquiry, comparative religious study, international relations, and other value-heterogeneous fields. The paper treats nonlinear dynamics as a conceptual and methodological resource rather than as an empirical claim that human learning literally follows a specified physical dynamical system. Its aim is to establish a preliminary vocabulary for examining how learners may enter knowledge structures deeply enough to be transformed by them while preserving the conditions for subsequent return, re-recognition, and further generation.

Keywords: criticality learning; interdisciplinary learning; epistemic attractors; epistemic returnability; re-recognition; nonlinear dynamics

Discussion Paper Note

This paper is a preliminary conceptual discussion of *criticality learning*. It develops a dynamical vocabulary for examining forms of learning in which a learner repeatedly enters, leaves, compares, and recombines heterogeneous disciplinary, theoretical, religious, or value frameworks. The paper is concerned especially with learning situations in which the generation of new questions, cross-framework understanding, and creative recombination are important.

The term *criticality* is used as a conceptual and methodological resource drawn from the language of nonlinear dynamics. The paper does not claim that human learning literally follows a particular physical critical system, nor that disciplinary thought can presently be reconstructed as a fully specified dynamical system. Terms such as *state*, *attractor*, *metastability*, *critical region*, *perturbation*, and *return* are used to make explicit relational and temporal structures that are easily obscured when learning is represented only as the accumulation of information.

A discipline or conceptual framework is provisionally represented as an attractor-like structure A_i . Such a structure does more than contain a collection of propositions. It can organize characteristic questions, concepts, standards of evidence, inferential habits, evaluative distinctions, and forms of salience. For a learner whose epistemic state is denoted by x_t , sustained engagement with a framework can therefore be represented schematically as

$$x_t \longrightarrow A_i.$$

This movement is neither intrinsically undesirable nor a pathology. Disciplinary attraction supports depth, precision, accumulated competence, and the acquisition of a generative grammar internal to a field. A learner who never remains within a disciplinary structure long enough to acquire its grammar may preserve breadth while failing to achieve the depth required for serious comparison or creation.

The concern of this paper begins when attraction becomes sufficiently rigid that one local grammar increasingly determines what can be perceived, questioned, or regarded as intelligible. A framework can then cease to appear as one mode of inquiry among others and begin to function as an unexamined background geometry of thought. The problem is therefore not attraction itself, but the possible loss of epistemic mobility under increasingly stable attractor capture.

Criticality learning is introduced to describe a different learning dynamic. Let K_t denote a comparatively open and metastable epistemic region from which several attractor-like structures remain meaningfully accessible. A minimal cycle of criticality learning is

$$K_t \longrightarrow A_i \xrightarrow{\mathcal{R}} K_{t+1},$$

where $\mathcal{R}$ denotes a return process. The learner enters a framework sufficiently deeply to be changed by it, while preserving a reasonable capacity to leave its locally dominant grammar and re-enter a region in which alternative frameworks can again become visible.

Return does not mean restoration of an earlier untouched state. In general,

$$K_{t+1} \neq K_t.$$

A learner who has seriously studied a discipline, religion, theory, or value framework cannot simply return to the epistemic condition that preceded the encounter. Concepts, distinctions, experiences, and questions acquired during the excursion remain available and may alter the structure of later inquiry. Criticality learning is therefore generative rather than restorative. Its idealized movement is more accurately represented as

$$K_0 \longrightarrow A_i \longrightarrow K_1 \longrightarrow A_j \longrightarrow K_2 \longrightarrow \cdots ,$$

where successive returns produce transformed regions of comparative possibility.

Three capacities are especially important within this process.

Attractor awareness refers to the learner's capacity to notice the grammar through which an object is currently being perceived and to detect when that grammar is acquiring increasingly exclusive control over the available interpretive space. Awareness therefore concerns more than ordinary attention. It includes the capacity to recognize a framework that has become difficult to perceive precisely because it has become familiar.

Epistemic returnability refers to the capacity to move away from a locally dominant framework without requiring the knowledge acquired within that framework to be erased. Returnability does not require equal distance from all frameworks, the absence of commitment, or the avoidance of specialization. It concerns whether movement remains possible after commitment and transformation have occurred.

Re-recognition refers to the capacity to encounter another concept, framework, value system, or possible world again after prior learning has already transformed the learner's epistemic structure. Re-recognition is not a return to an original neutrality. It is the possibility of renewed access from a historically altered position.

These distinctions are especially important because criticality learning does not treat neutrality as the absence of judgment. A learner may conclude that one theory is more convincing than another, commit deeply to a religious or philosophical tradition, or specialize strongly within a discipline. Criticality learning does not require

$$A_1 = A_2 = \cdots = A_n$$

in epistemic value, explanatory adequacy, or personal commitment. Its concern is whether a locally preferred framework becomes irreversibly privileged in a way that destroys the possibility of seriously re-entering alternatives.

Comparative inquiry therefore remains compatible with directional evaluation. One framework may legitimately be used to interrogate another:

$$\Gamma_i(\Gamma_j).$$

The methodological difficulty arises when this direction becomes invisible and irreversible, so that Γ_i functions permanently as the unexamined meta-language through which every other framework must appear. Criticality learning consequently places particular importance upon framework mobility, reflexive reversal, and the preservation of return.

The normative orientation of the paper can be stated provisionally as a principle of epistemic re-recognizability:

Any knowledge, theory, or educational practice whose mode of acquisition irreversibly, or with substantial difficulty of revision, diminishes a subject's capacity to re-recognize alternative conceptual systems, value frameworks, or possible worlds should be regarded as ethically suspect.

This principle does not identify specialization, conviction, or commitment with epistemic injustice. Serious learning inevitably changes the distribution of attention, competence, and interpretive preference. A mathematician may become highly specialized in mathematical reasoning; a religious practitioner may commit deeply to one tradition; a scholar may regard one theoretical framework

as presently more adequate than its alternatives. Such asymmetries are compatible with criticality learning when reasonable conditions of re-recognition and revision remain available.

The relevant ethical distinction is therefore between transformation and foreclosure. Learning may transform the learner's epistemic landscape. Criticality learning asks whether that transformation preserves a meaningful capacity for later movement:

transformation $\nrightarrow$ irreversible capture.

This distinction also separates criticality learning from indiscriminate breadth. Continual switching among subjects without sufficiently deep entry can produce fragmentation rather than generativity. Conversely, prolonged residence within a single attractor may produce great depth while reducing sensitivity to other grammars. The proposed learning problem is therefore not to maximize either breadth or depth independently. It is to regulate immersion, returnability, and recombination under conditions in which the appropriate duration and depth of disciplinary entry are themselves context-dependent.

A provisional architecture of criticality learning may consequently be summarized as

Awareness $\rightarrow$ Immersion $\rightarrow$ Return $\rightarrow$ Re-recognition $\rightarrow$ Recombination

with the qualification that these processes need not occur in a fixed linear order. Awareness may emerge during immersion; re-recognition may trigger return; recombination may produce a new attractor; and an enriched critical region may itself later become stabilized.

The framework is intended primarily for exploratory and generative contexts. Interdisciplinary research, comparative religious studies, international relations, cross-cultural inquiry, philosophy, and creative work frequently require a learner to move among heterogeneous grammars whose assumptions cannot be reduced to a single common vocabulary without loss. In such contexts, the capacity to enter a framework deeply enough to understand its internal generativity while remaining capable of later movement becomes especially important.

The framework does not imply that criticality should be maintained at all times. Many learning tasks require stable attraction, repetition, specialization, and exploitation of an already acquired grammar. Mathematical proof, language acquisition, musical technique, laboratory practice, and professional expertise may all require sustained residence within relatively stable structures. Criticality learning is therefore proposed as one learning mode within a larger ecology of learning rather than as a universal replacement for disciplinary mastery.

The central claim of this preliminary discussion is accordingly limited. Learning can be examined not only in terms of what knowledge is acquired, but also in terms of how acquisition changes the learner's future epistemic mobility. A generative learning process may permit knowledge to transform the learner while preserving reasonable conditions for subsequent return, re-recognition, and further generation.

In this sense, the guiding orientation of criticality learning can be stated compactly:

Enter deeply enough to be transformed; preserve enough returnability to encounter the world again.

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1 Introduction

This section establishes the conceptual problem addressed by the paper, locates criticality learning in relation to interdisciplinary learning and nonlinear approaches to pedagogy, and states the scope of the proposed framework. The argument begins from a simple observation. Learning across disciplines requires more than the accumulation of propositions from several fields. Each discipline also supplies characteristic questions, distinctions, standards of evidence, inferential habits, and ways of determining what is salient. Serious interdisciplinary learning therefore requires movement among heterogeneous epistemic organizations. The central difficulty concerns how a learner can enter such organizations deeply enough to acquire their internal generative capacities while preserving the possibility of later movement among alternatives.

1.1 Disciplinary Structures and Interdisciplinary Learning

Interdisciplinary education is commonly associated with the capacity to draw upon more than one discipline in producing an understanding that would be difficult to obtain through a single disciplinary approach [16]. Such work requires disciplinary knowledge, knowledge concerning disciplinary perspectives, and higher-order capacities for integration and communication. This requirement already suggests that interdisciplinarity presupposes some degree of disciplinarity. A learner cannot meaningfully integrate perspectives that have never been understood with sufficient internal depth.

The difficulty is that a discipline consists of more than a detachable set of facts. Kuhn’s account of scientific paradigms and later disciplinary matrices emphasized that scientific communities share symbolic generalizations, exemplars, values, commitments, and characteristic ways of identifying legitimate problems [11]. Subsequent pedagogical work has similarly treated disciplinary learning as the acquisition of ways of thinking that may become so familiar to experts that the cognitive operations required by novices become difficult for those experts to articulate [13]. A disciplinary perspective can therefore be understood as a structured mode of epistemic organization through which some relations become easier to perceive, some questions become easier to formulate, and some forms of inference become easier to perform.

This paper uses the term *disciplinary grammar* for this generative organization. The term does not imply that every discipline can be reduced to a formal grammar. It marks the more limited claim that disciplinary competence includes recurrent rules, distinctions, habits, and transformations through which further questions and representations can be generated. Let

$$\Gamma_i$$

denote such a grammar associated with discipline or framework i . Learning within the framework changes the probability that the learner will deploy certain distinctions and inferential operations when encountering a new problem. Sustained disciplinary education may therefore stabilize a characteristic region of epistemic activity.

A dynamical representation provides one way to make this stabilization explicit. Let the epistemic state of a learner at time t be represented schematically by

$$x_t \in \mathcal{M}_t,$$

where $\mathcal{M}_t$ denotes an effective space of currently available epistemic states. A discipline may then be represented provisionally as an attractor-like structure A_i toward which repeated use of Γ_i tends to organize subsequent cognition:

$$x_t \longrightarrow A_i. \quad (1)$$

Equation (1) is a conceptual representation. It does not assert that a discipline corresponds to a physically measurable attractor or that a learner's epistemic state can presently be reconstructed as a complete dynamical phase space. The representation is introduced because the language of attraction captures an educational phenomenon that static accounts describe less directly: learning changes the likelihood of future ways of seeing, questioning, and reasoning.

Such attraction is indispensable to expertise. A mathematician acquires habits of formalization that permit increasingly complex mathematical generation. A historian develops sensitivity to provenance, sequence, context, and the conditions under which records were produced. A legal scholar learns to organize problems through sources of authority, interpretation, precedent, procedure, and institutional competence. A scholar of religion may learn to distinguish doctrinal, ritual, historical, phenomenological, and institutional dimensions that remain difficult to perceive without sustained study. Depth emerges partly because repeated engagement lowers the effective cost of moving within a disciplinary structure.

Interdisciplinary learning consequently faces a structural tension. The learner requires sufficient attraction to obtain depth, while the same stabilization can progressively shape which alternatives remain cognitively available.

1.2 Epistemic Attraction and Framework Mobility

Once a disciplinary grammar has become highly available, it can begin to organize problems beyond the domain in which it was initially learned. This extension can be intellectually productive. Mathematical structures can reveal regularities in social systems. Historical analysis can expose temporal assumptions hidden inside apparently universal concepts. Legal reasoning can clarify the institutional conditions under which abstract political values become operative. Religious concepts can open dimensions of experience that remain difficult to articulate within secular vocabularies.

The same extension can also reduce epistemic mobility. A locally powerful grammar may become increasingly transparent to the learner. Its assumptions cease to appear as assumptions and instead begin to function as the background against which other approaches are evaluated. The learner can then remain capable of receiving new information while becoming progressively less capable of allowing another framework to reorganize the problem itself.

Let a learner have access to a set of epistemic grammars

$$\mathcal{G}_t = \{\Gamma_1, \Gamma_2, \dots, \Gamma_n\}.$$

The relevant concern is not whether one grammar is used more frequently than the others. Specialization naturally produces unequal use. The concern arises when the effective accessibility of alternatives contracts in a manner such as

$$P_t(\Gamma_j \mid Q) \longrightarrow 0 \quad \text{for many } j \neq i, \quad (2)$$

across a widening class of problems Q . In this condition, Γ_i has begun to acquire an increasingly exclusive role in the learner's epistemic organization.

The paper refers to the stronger forms of this process as *epistemic attractor capture*. Capture does not mean that the learner has formed a conviction, reached a conclusion, or developed expertise. A person may judge one theory more persuasive than another while retaining substantial capacity to reconstruct the alternatives. Capture concerns the narrowing of the conditions under which alternative frameworks can become genuinely intelligible again.

Comparative religious inquiry provides a useful example. A researcher may legitimately use Buddhist concepts to interrogate Christian theology, or use Christian theology to interrogate Buddhist accounts of personhood, temporality, or liberation. Directional comparison is itself a productive method. A problem emerges when one direction of comparison becomes epistemically invisible. If one framework permanently functions as the unexamined meta-language in which every other tradition must be translated, the comparative relation becomes increasingly difficult to reverse.

The same structure appears in international relations. Realist, institutionalist, constructivist, legal, historical, political-economic, and other approaches can direct attention toward different relations within the same event. A researcher may ultimately regard one framework as more adequate for a particular explanatory purpose. Critical inquiry nevertheless requires the continued ability to identify which grammar is presently organizing the event and, where relevant, to allow another grammar to reorganize the description.

The difficulty can therefore be expressed as a problem of mobility among epistemic structures. Let $C_R(A_i, t)$ denote schematically the effective cost of leaving attractor-like structure A_i at time t . Deep learning may increase both competence within A_i and the cost of departure:

$$\frac{d \text{Competence}(A_i, t)}{dt} > 0, \quad \frac{d C_R(A_i, t)}{dt} \geq 0 \quad (3)$$

under some learning conditions. Equation (3) does not imply a necessary trade-off. Many forms of expertise preserve substantial intellectual openness. It identifies a possibility that an account of interdisciplinary learning should be able to examine: increasing depth and increasing return cost can coexist.

1.3 Criticality as a Learning Vocabulary

Nonlinear approaches to pedagogy have already demonstrated the usefulness of concepts including self-organization, constraints, metastability, variability, and criticality for learning design. In nonlinear pedagogy, especially in skill acquisition and ecological approaches to learning, the learner and learning environment are treated as a coupled system whose behavior can be shaped through the manipulation of interacting constraints [2]. Metastable regions are of particular interest because they can support adaptive transitions among multiple functional solutions.

Criticality has also been studied in neural and computational systems, where states near critical regimes have been associated with properties such as sensitivity to input and dynamical range. The relationship between criticality and learning remains complex, and critical signatures in neural models do not provide a direct educational theory [3]. The present paper therefore uses nonlinear dynamics at a different level of analysis. Its primary object is the organization of inquiry across disciplines and frameworks.

The proposal begins with an epistemic region K_t in which several attractor-like structures remain meaningfully accessible. The adjective *critical* refers to a condition of heightened transition possibility among these structures. The intended model is closer to metastability than to permanent instability. A learner can temporarily develop coherent engagement with one framework and subsequently reorganize toward another.

A minimal cycle can be written as

$$K_t \xrightarrow{\mathcal{I}_i} A_i \xrightarrow{\mathcal{R}} K_{t+1}, \quad (4)$$

where $\mathcal{I}_i$ denotes a process of disciplinary immersion and $\mathcal{R}$ denotes a return process. The central condition is

$$K_{t+1} \neq K_t. \quad (5)$$

Return is therefore non-restorative. A learner who has genuinely entered a discipline cannot recover an epistemic state in which that encounter never occurred. Concepts, distinctions, practices, and experiences acquired during the excursion become part of subsequent inquiry. The educational value of return lies in preserving mobility while retaining transformation.

Repeated learning may consequently take the form

$$K_0 \longrightarrow A_i \longrightarrow K_1 \longrightarrow A_j \longrightarrow K_2 \longrightarrow A_k \longrightarrow K_3 \longrightarrow \dots. \quad (6)$$

This structure differs from a model in which interdisciplinary learning consists primarily of assembling disciplinary outputs after each discipline has completed its analysis. The learner’s own epistemic organization evolves through the sequence. Each excursion can alter the critical region from which the next excursion begins.

Recent work on interdisciplinary education has similarly emphasized dynamic, relational, and comparatively open learning environments. Overend, for example, develops the idea of “undisciplined learning spaces” that preserve creativity and unpredictability rather than organizing interdisciplinarity entirely through predetermined integration [14]. Criticality learning is compatible with this general concern while focusing on a different object: the learner’s capacity for repeated epistemic movement among sufficiently developed frameworks.

The term *criticality learning* is therefore used in this paper for a mode of exploratory learning characterized by four linked processes:

$$\text{awareness} \longrightarrow \text{immersion} \longrightarrow \text{return} \longrightarrow \text{recombination}. \quad (7)$$

The sequence in Equation (7) is analytical rather than strictly chronological. Awareness may arise during immersion. Recombination may reveal that return has remained incomplete. Encountering an alternative framework may itself create awareness of a previously invisible attractor. The important feature is the preservation of transition capacity.

1.4 Returnability and Re-recognition

The framework places particular importance on two capacities.

The first is *epistemic returnability*. Returnability concerns whether a learner who has entered an attractor-like framework can subsequently move away from its locally dominant grammar while retaining what has been learned. It does not require restoration of an original neutral position. It concerns the continued availability of meaningful epistemic movement after transformation.

The second is *re-recognition*. Learning changes the learner who later encounters another concept or framework. A person who has seriously studied one religious tradition, political theory, mathematical formalism, or philosophical ontology cannot encounter the next one from an untouched position. Re-recognition refers to the capacity to let another object or framework become intelligible again from this historically altered position.

This distinction becomes especially important when learning produces strong commitment. Criticality learning does not require a learner to suspend every judgment or distribute confidence equally across competing frameworks. Such a requirement would make sustained inquiry and commitment difficult. The normative concern lies instead with the preservation of reasonable conditions under which a framework can later be reconsidered, reversed in comparison, or placed into a newly generated relation.

The paper therefore adopts the following preliminary principle.

Proposition 1.1 (Principle of Epistemic Re-recognizability). *Any knowledge, theory, or educational practice whose mode of acquisition irreversibly, or with substantial difficulty of revision, diminishes a subject’s capacity to re-recognize alternative conceptual systems, value frameworks, or possible worlds warrants ethical scrutiny.*

Proposition 1.1 is deliberately limited. It does not classify specialization as a pathology. It does not require permanent epistemic neutrality. It does not establish the equal validity of alternative frameworks. Its object is the relation between knowledge acquisition and the future conditions of knowing.

The resulting distinction can be summarized as

$$\text{epistemic transformation} \neq \text{epistemic foreclosure.} \quad (8)$$

A learner may be deeply changed by a discipline while retaining the capacity to encounter another discipline seriously. A religious commitment may become central to a person’s life while leaving substantial capacity to understand another tradition in its own terms. A political or theoretical judgment may become firm while remaining revisable under new relations, evidence, or experience. Criticality learning concerns the conditions under which such mobility can be cultivated and preserved.

1.5 Scope and Contribution

This paper is a preliminary conceptual study. It develops a vocabulary for a specific class of learning problems and leaves empirical operationalization for subsequent work. The proposed concepts should therefore be read as analytical constructions whose value depends on whether they clarify recognizable learning dynamics and generate testable or practically useful questions.

The first contribution is the concept of *criticality learning* itself. The concept shifts attention from interdisciplinary content aggregation toward the dynamics of epistemic movement. The relevant educational variable becomes not only which perspectives a learner has acquired, but also whether the learner remains capable of moving among them.

The second contribution is the concept of *attractor awareness*. A learner requires some capacity to recognize when a disciplinary grammar, value framework, identity, affective commitment, or social belonging has become increasingly dominant in the organization of inquiry. Awareness provides the precondition for deliberate return because an invisible attractor cannot readily become an object of regulation.

The third contribution is *epistemic returnability*. Interdisciplinary competence is treated partly as a problem of preserving exit and re-entry conditions across deep learning episodes. Returnability provides a way to distinguish productive specialization from forms of epistemic lock-in without requiring the elimination of disciplinary depth.

The fourth contribution is the principle of *re-recognition*. This principle gives the framework a normative dimension. Learning is evaluated partly by how it modifies the learner’s future conditions of knowing. A mode of education that generates competence while making alternative worlds increasingly impossible to recognize presents a different ethical structure from one that generates equally deep commitment while preserving revisability.

The fifth contribution is methodological. Nonlinear dynamical concepts are used as a disciplined conceptual vocabulary for learning across heterogeneous frameworks. The paper adopts attraction, metastability, perturbation, return, and path dependence as tools for reasoning about epistemic movement while maintaining a clear boundary between conceptual modeling and empirical claims about neurobiological dynamics.

Criticality learning is expected to be most useful in exploratory contexts in which heterogeneity itself has epistemic value. Interdisciplinary research, comparative religion, international relations, philosophy, cross-cultural inquiry, and creative theoretical work provide representative cases. Highly specified procedural learning may require long periods of stable disciplinary attraction. The present framework therefore forms one component of a broader learning ecology.

The subsequent sections develop this proposal in stages. Section 2 introduces the dynamical vocabulary of epistemic states, attractor-like disciplinary structures, metastability, and critical regions. Section 3 develops attractor awareness and the detection of epistemic capture. Section 4 examines immersion, depth, and the conditions under which disciplinary learning becomes generative. Section 5 develops epistemic returnability and possible return operators. Section 6 formulates re-recognition and its relation to revisability. Section 7 considers comparative and value-heterogeneous inquiry, with particular attention to religion and international relations. Section 8 examines recombination and creative generation. Section 9 discusses limitations, operational questions, and possible educational applications. The final section summarizes the preliminary framework and identifies directions for further theoretical and empirical research.

2 Theoretical and Philosophical Context

This section locates criticality learning within several established lines of educational and philosophical thought. Its purpose is neither to construct a complete history of learning theory nor to derive the present framework from a single intellectual lineage. The objective is to identify a set of neighboring problems that have already been recognized in educational theory, cognitive research, philosophy of science, hermeneutics, interdisciplinary education, and nonlinear pedagogy, and then to clarify the specific level at which criticality learning intervenes.

Several themes recur across these traditions. Learning changes the learner. Experience has consequences for later experience. Development depends upon social and symbolic mediation. Reflection can make the processes of knowing available to further regulation. Complex knowledge often requires movement among multiple representations. Disciplinary communities stabilize distinctive ways of seeing and reasoning. Understanding can transform the horizon from which subsequent understanding proceeds. Interdisciplinary inquiry requires movement across established epistemic boundaries. Nonlinear approaches to learning emphasize self-organization, metastability, and transitions among temporarily stable configurations.

Criticality learning brings these themes into a common dynamical problem:

$$\text{deep epistemic entry} \longrightarrow \text{transformation} \longrightarrow \text{continued mobility.} \quad (9)$$

The central concern is the preservation of the learner's capacity to move after meaningful transformation has occurred. The framework therefore focuses on the dynamics of attraction, immersion, awareness, return, re-recognition, and recombination across heterogeneous epistemic structures.

2.1 Experience, Development, and the Continuity of Learning

A first lineage concerns the temporal continuity of experience. Dewey's *Experience and Education* places experience at the center of education while also rejecting the assumption that experience is educational merely because it occurs [4]. His account gives particular importance to continuity and interaction. An educational experience enters into the conditions under which later experiences

become possible, meaningful, or constrained. Education therefore concerns a temporal process in which the effects of an encounter extend beyond the moment in which it occurs.

This temporal orientation is important for criticality learning. If learning were exhausted by the information acquired at a particular moment, the future structure of epistemic mobility would remain external to educational evaluation. Once present experience is understood as participating in the formation of later capacities and possibilities, a different question becomes available:

$$E_t \longrightarrow \mathcal{C}_{t+1}, \quad (10)$$

where E_t denotes an educational experience and $\mathcal{C}_{t+1}$ denotes part of the conditions under which later learning occurs.

A learning experience can consequently have value beyond immediate comprehension. A concept encountered before the learner possesses the experience required for its fuller significance may remain latent and become meaningful under later conditions. Conversely, an educational experience can produce habits, aversions, or interpretive closures that alter future access to a field. The temporality of education therefore includes effects that may become visible only after considerable delay.

Kolb's experiential learning theory develops another influential account of learning as a process through which experience is transformed [10]. Its familiar movement among concrete experience, reflective observation, abstract conceptualization, and active experimentation places learning within an iterative developmental process. The importance of this lineage for the present paper lies in its treatment of learning as transformation rather than simple reception.

Criticality learning extends this temporal concern from cycles of experience to movement among epistemic organizations. The relevant sequence is not only

experience $\rightarrow$ reflection $\rightarrow$ conceptualization,

but also

epistemic region $\rightarrow$ framework immersion $\rightarrow$ transformed epistemic region.

The learner who returns from a serious disciplinary encounter returns with a changed repertoire of concepts and distinctions. In the notation developed later,

$$K_{t+1} \neq K_t. \quad (11)$$

Deweyan continuity therefore provides an important philosophical background for the claim that the ethical and pedagogical consequences of learning include the conditions that learning creates for subsequent learning. Criticality learning adds a more specific concern with whether those later conditions continue to permit meaningful access to epistemic alternatives.

2.2 Mediation, Readiness, and Repeated Encounter

A second lineage concerns the development of capacities through mediated interaction. Vygotsky's cultural-historical account rejects an isolated model of mind and emphasizes the role of social relations, language, tools, and symbolic mediation in the development of higher psychological functions [18]. The relation between learning and development is therefore neither reducible to passive maturation nor adequately represented as an independent individual process.

This perspective matters for criticality learning because the learner's epistemic organization is partly relationally generated. Access to a discipline depends upon teachers, texts, languages,

institutions, examples, practices, communities, and technologies. The effective space of available thought is consequently conditioned by a historically accumulated environment:

$$\mathcal{M}_t = \mathcal{M}(H_t, L_t, R_t, C_t), \quad (12)$$

where H_t denotes learning history, L_t symbolic and linguistic resources, R_t relational structures, and C_t wider learning conditions.

Bruner's *The Process of Education* provides another relevant developmental orientation [1]. His account of curriculum emphasizes the possibility of introducing fundamental ideas in forms appropriate to an earlier stage and returning to them in increasingly formal and complex forms. The spiral curriculum therefore treats repeated encounter as developmentally productive. An idea need not be exhausted by its first presentation.

The importance of repeated encounter becomes particularly clear when the learner's conceptual resources evolve between encounters. Let Q denote an object of learning first encountered at t_0 and encountered again at t_1 . In general,

$$\text{Meaning}(Q \mid x_{t_0}) \neq \text{Meaning}(Q \mid x_{t_1}). \quad (13)$$

The difference may arise because the learner has acquired new experiences, languages, concepts, or relations. Repetition therefore need not reproduce an earlier learning event. It can generate a qualitatively different encounter.

Criticality learning shares this developmental sensitivity while shifting the object of repeated movement. The return discussed in this paper is not restricted to the pedagogical revisiting of a particular concept. It also concerns return from a framework that has temporarily reorganized the learner's interpretive field. A learner may move deeply into mathematics, religious studies, political theory, or historical inquiry and later return to a more open comparative region from which the earlier subject matter, alternative disciplines, and the learner's own prior assumptions can be encountered differently.

This distinction will later support the concept of *re-recognition*. Repeated encounter acquires a stronger form when the learner who encounters the object again has already been transformed by an intervening epistemic history.

2.3 Reflection, Metacognition, and Perspective Transformation

A third lineage concerns the learner's capacity to make cognition itself available for observation and regulation. Flavell's foundational discussion of metacognition distinguishes knowledge about cognitive processes from the monitoring of ongoing cognitive activity and places both within a developmental research program [5]. Metacognitive capacities allow the learner to observe aspects of remembering, understanding, strategy use, and task performance rather than remaining wholly absorbed in first-order cognitive activity.

This literature is a direct neighbor of the concept of *attractor awareness*. Criticality learning does not require a new general theory of metacognition. It identifies a particular object for metacognitive monitoring: the framework through which cognition is currently being organized.

Ordinary monitoring may ask

Do I understand this argument?

or

Is this strategy working?

Attractor awareness adds questions such as

Which grammar is making this argument intelligible to me?

and

Has this grammar begun to determine which alternatives I can still recognize?

The object of awareness therefore shifts from the success of cognition within a framework to the framework's changing position within the learner's epistemic landscape.

Schön's account of reflective practice provides a related perspective [15]. Reflection-in-action concerns the practitioner's capacity to respond to situations whose complexity exceeds the direct application of established technical rules. Professional judgment can involve reframing the situation while action is already underway. This is important for criticality learning because epistemic return frequently requires a change in framing rather than the substitution of one answer for another.

Suppose a problem has been progressively organized by framework Γ_i :

$$Q \xrightarrow{\Gamma_i} Q_i. \quad (14)$$

A reflective transition can make the transformation itself visible:

$$Q \rightarrow [\Gamma_i, Q_i].$$

Once the framework becomes an object of awareness, the learner gains a possible point of leverage for decentering and return.

Mezirow's transformative learning theory develops the relation between reflection and changes in meaning structures further. In *Transformative Dimensions of Adult Learning*, learning can involve the transformation of meaning schemes and meaning perspectives through reflection upon assumptions that organize experience [12]. This provides an especially important precedent for the claim that serious learning can transform the position from which subsequent experience is interpreted.

Criticality learning accepts this transformative character and adds a further problem. Once a meaning perspective has been transformed, what conditions permit the learner to re-enter an alternative perspective seriously? The relevant sequence becomes

$$\text{perspective transformation} \longrightarrow \text{new epistemic organization} \longrightarrow \text{future re-access.} \quad (15)$$

The third term is central to the present framework. Transformation can be educationally valuable while also modifying the cost of later movement. Criticality learning therefore examines the relation between transformative depth and preserved epistemic mobility.

2.4 Cognitive Flexibility and Ill-Structured Knowledge

Cognitive Flexibility Theory provides one of the closest educational predecessors to the present proposal. Developed by Spiro and colleagues for advanced knowledge acquisition in complex and ill-structured domains, the theory responds to learning failures produced by oversimplified and excessively well-structured representations of complex subject matter [17]. It emphasizes multiple representations, multiple conceptual perspectives, nonlinear traversal, repeated examination of cases, and the construction of context-sensitive knowledge assemblies.

The landscape metaphor associated with Cognitive Flexibility Theory is especially relevant. A complex conceptual domain cannot be adequately mastered through a single traversal. Repeated

movement through the same material from different directions can reveal aspects that a single organizational scheme makes difficult to perceive. The resulting objective is a form of flexible knowledge that can be assembled responsively under changing problem conditions.

Criticality learning shares four commitments with this tradition:

1. complex objects may require multiple epistemic representations;
2. a single representation can conceal dimensions of the object;
3. repeated traversal can generate richer understanding;
4. flexibility is itself an educational capacity.

The present framework nevertheless places emphasis on a different dynamical problem. Cognitive Flexibility Theory primarily examines flexible representation and assembly within complex knowledge domains. Criticality learning focuses on the learner’s movement among relatively stabilized epistemic grammars, including cases in which those grammars possess distinct standards of evidence, value structures, identities, institutional locations, or modes of salience.

The difference can be represented schematically. Cognitive flexibility may be concerned with

$$Q \longrightarrow \{M_1, M_2, \dots, M_n\} \longrightarrow M_Q^*, \quad (16)$$

where multiple representations are assembled responsively for a problem. Criticality learning adds the historical effect of sustained immersion:

$$K_t \longrightarrow A_i \longrightarrow K_{t+1}, \quad K_{t+1} \neq K_t. \quad (17)$$

The question becomes whether the acquisition of Γ_i alters the learner’s future access to Γ_j . A learner may possess multiple representations while one framework progressively acquires an unexamined privilege over the others. Criticality learning therefore introduces attractor capture, return cost, and re-recognition as problems that arise after flexibility itself has been placed in a historical and relational dynamical system.

This difference should not be interpreted as a rejection of Cognitive Flexibility Theory. The present proposal is better understood as extending a neighboring concern from flexible knowledge assembly toward the temporal governance of epistemic mobility.

2.5 Disciplinary Frameworks and Hermeneutic Transformation

The conceptualization of disciplines as attractor-like structures also has important philosophical precedents. Kuhn’s account of scientific paradigms, normal science, disciplinary matrices, anomaly, crisis, and scientific revolution challenged accounts of science organized primarily as the linear accumulation of propositions [11]. A mature scientific tradition includes shared exemplars, values, symbolic resources, and problem-solving practices. Scientific development therefore occurs within historically stabilized communities of inquiry.

For criticality learning, the important implication is that entering a discipline involves entering a structured epistemic practice. A learner acquires more than conclusions. The learner acquires ways of identifying problems, determining relevance, evaluating solutions, and organizing relations among observations.

This provides philosophical support for the use of the expression *disciplinary grammar*. A framework Γ_i can shape

salience, problem formation, admissible evidence, inference, evaluation.

Once these structures become habitual, they can acquire precisely the background character that motivates the language of epistemic attraction.

Kuhn's work also makes differences among scientific frameworks historically significant. The transition between paradigms cannot always be represented as the addition of further propositions inside a stable conceptual matrix. A change of framework can alter the organization through which observations and problems become meaningful.

Philosophical hermeneutics provides another relevant lineage. Gadamer's *Truth and Method* treats understanding as historically situated and linguistically mediated [7]. Understanding involves the relation between prior horizons and that which is encountered, and the hermeneutic event can transform the horizon within which meaning becomes possible. The associated concept of a fusion of horizons describes an encounter in which the familiar and the unfamiliar enter a newly generated context rather than remaining unchanged external objects [7].

This structure is close to the non-restorative return proposed in criticality learning:

$$K_t \longrightarrow \text{encounter} \longrightarrow K_{t+1}, \quad K_{t+1} \neq K_t. \quad (18)$$

The hermeneutic lineage is especially important because it prevents returnability from being misunderstood as recovery of an original, perspective-free neutrality. A historically situated learner cannot erase the history through which understanding has developed. Returnability concerns the capacity for renewed movement from a changed horizon.

Criticality learning therefore places the following sequence at the center of its epistemology:

$$\text{historical situatedness} \longrightarrow \text{transformative encounter} \longrightarrow \text{renewed accessibility}. \quad (19)$$

The third term extends the hermeneutic concern toward the governance of future epistemic movement. The learner asks whether transformation by one encounter still permits another heterogeneous framework to appear with sufficient independence to reorganize the field again.

2.6 Interdisciplinary Learning and Integration

The established literature on interdisciplinary learning provides the most direct educational context for criticality learning. Spelt and colleagues define interdisciplinary thinking in terms of the capacity to integrate knowledge from two or more disciplines in ways that produce a cognitive advancement difficult to obtain through a single discipline [16]. Their systematic review also identifies knowledge of disciplinary paradigms, perspective changing, integration, communication, openness, reflection, and the capacity to move between depth and breadth as relevant to interdisciplinary development.

This literature establishes an important point: interdisciplinarity requires disciplinary competence and metacognitive coordination across disciplinary differences. Multiple disciplines placed beside one another do not by themselves produce interdisciplinary understanding.

A simplified integration model can be represented as

$$A_i + A_j \xrightarrow{\mathcal{I}} I_{ij}, \quad (20)$$

where I_{ij} denotes an interdisciplinary understanding produced through integration.

Criticality learning focuses on the epistemic dynamics that make such integration possible:

$$K_0 \rightarrow A_i \rightarrow K_1 \rightarrow A_j \rightarrow K_2 \rightarrow I_{ij}. \quad (21)$$

The difference is one of analytical level. Interdisciplinary integration examines relations among disciplinary contributions. Criticality learning examines the evolving learner who performs the movement among them.

This distinction becomes important when disciplinary entry is asymmetric. Suppose a learner has extensive formation in A_i and only brief exposure to A_j . The formal presence of two disciplines does not imply equivalent epistemic accessibility:

$$C_R(A_i, t) \gg C_R(A_j, t) \quad (22)$$

or, alternatively,

$$P(\Gamma_i | Q) \gg P(\Gamma_j | Q).$$

The integration process may then be organized almost entirely through Γ_i , while Γ_j contributes vocabulary or evidence without being allowed to reorganize the problem.

Criticality learning treats the capacity for genuine perspective transition as an important precondition for strong interdisciplinary comparison. The learner should be able, at least temporarily, to permit another disciplinary grammar to alter what the problem itself appears to be.

This requirement does not imply symmetry among disciplines. Some problems legitimately require one field to play a larger role. The relevant criterion concerns whether directional dominance follows from inquiry or from an unnoticed loss of framework mobility.

2.7 Nonlinear Pedagogy and Metastable Learning

The closest methodological lineage for the term *criticality* comes from nonlinear and complex-systems approaches to learning. Nonlinear pedagogy has used concepts from ecological dynamics, self-organization, constraints, metastability, variability, and self-organized criticality to understand learner-environment systems and to design conditions that support adaptive behavior [2].

This body of work is especially important because it already rejects a simple linear relation between instruction and educational outcome. Learning emerges through interactions among organismic, environmental, and task constraints. Metastable regions can permit temporary coordination while retaining the possibility of transition toward alternative functional patterns.

Criticality learning adopts this dynamical sensibility while changing the principal level of analysis. The relevant states in the present paper are epistemic organizations, and the relevant transitions occur among disciplinary, conceptual, religious, theoretical, and value grammars.

The relation can be represented as follows:

$$\text{nonlinear pedagogy : learner-environment coordination} \rightarrow \text{adaptive action}, \quad (23)$$

while the present proposal emphasizes

$$\text{criticality learning : epistemic-framework coordination} \rightarrow \text{continued epistemic mobility}. \quad (24)$$

The distinction is analytical rather than disciplinary. Human cognition, action, social relation, and environment remain coupled. Criticality learning simply selects a particular problem within that larger coupled system: the preservation of movement among learned epistemic structures.

The concept of metastability is especially useful. A learner engaged in criticality learning does not remain permanently undecided among frameworks. Temporary local coherence is required for serious learning. A discipline must be inhabited long enough for some of its internal generative

relations to become operational. Metastability provides a language for this combination of temporary organization and retained transition capacity.

The resulting educational ideal can be represented as

$$\text{local coherence} + \text{transition capacity}. \quad (25)$$

The first term protects depth. The second protects mobility.

2.8 Critical Pedagogy and Terminological Boundary

The expression *criticality learning* also requires differentiation from *critical pedagogy*. Freire's *Pedagogy of the Oppressed* develops a political and emancipatory account of education concerned with oppression, dialogue, critical consciousness, praxis, and the transformation of dehumanizing social relations [6]. This tradition has generated a large field of educational theory whose use of the term *critical* concerns social critique, domination, emancipation, and political consciousness.

The term *criticality* in the present paper has a different immediate source. It refers to a dynamical condition associated with transition possibility, susceptibility to perturbation, metastability, and the relation among competing attractor-like structures.

The distinction can be summarized as

$$\text{critical pedagogy} \rightarrow \text{critical consciousness and emancipatory praxis}, \quad (26)$$

and

$$\text{criticality learning} \rightarrow \text{epistemic mobility near multiple attractor-like structures}. \quad (27)$$

The two traditions can nevertheless enter productive dialogue. The capacity to perceive an epistemic attractor may include awareness of institutional power, disciplinary authority, social belonging, identity, and exclusion. Similarly, the loss of epistemic mobility may be produced by relations of power rather than by conceptual habit alone. These normative questions become important in later discussions of returnability and re-recognition.

The terminological distinction is therefore intended to preserve conceptual clarity while leaving open substantive connections between nonlinear epistemic dynamics and critical educational theory.

2.9 Position of Criticality Learning

The preceding traditions establish that the principal elements surrounding criticality learning already possess substantial intellectual histories. Experience has temporal continuity. Learning is socially mediated. Development includes repeated encounter. Metacognition enables cognitive monitoring. Reflection can reorganize framing. Transformative learning can alter meaning perspectives. Cognitive Flexibility Theory supports nonlinear movement among multiple representations. Kuhnian philosophy shows the structuring force of disciplinary matrices. Hermeneutics treats understanding as historically transformative. Interdisciplinary education develops perspective integration and boundary crossing. Nonlinear pedagogy supplies a vocabulary of self-organization, metastability, and criticality.

Criticality learning is therefore proposed as a relational organization of these neighboring problems around one specific object:

$$\boxed{\text{the preservation of epistemic mobility after transformative learning}} \quad (28)$$

Table 1 summarizes this location.

Table 1: Theoretical location of criticality learning

Tradition	Relevant contribution	Criticality-learning extension
Deweyan education	Continuity of experience and the effect of present experience upon later growth	Future accessibility of alternative epistemic paths after learning
Experiential learning	Learning through transformation of experience	Transformation across repeated disciplinary excursions and returns
Cultural-historical development	Social and symbolic mediation of developing cognitive capacities	Relational formation of epistemic state spaces and framework accessibility
Spiral curriculum	Repeated encounter with concepts under developing cognitive conditions	Re-entry from transformed epistemic positions
Metacognition and reflective practice	Monitoring cognition and reframing situations during inquiry	Detection of attractor capture and regulation of framework dominance
Transformative learning	Transformation of meaning schemes and perspectives	Transformation with preservation of later epistemic mobility
Cognitive Flexibility Theory	Multiple representations, nonlinear traversal, and flexible knowledge assembly	Historical effects of deep framework entry, return cost, and re-recognition
Kuhnian philosophy of science	Historically stabilized disciplinary matrices and framework-dependent inquiry	Disciplinary structures represented as epistemic attractor-like organizations
Philosophical hermeneutics	Historically situated understanding and transformation of horizons	Non-restorative return and renewed accessibility after transformation
Interdisciplinary learning	Perspective change, disciplinary integration, and boundary crossing	Dynamics of the learner moving among disciplinary structures before and during integration
Nonlinear pedagogy	Self-organization, constraints, metastability, and adaptive transition	Metastable epistemic movement among disciplinary and value grammars
Critical pedagogy	Critical consciousness, dialogue, power, and emancipatory transformation	Potential normative analysis of social conditions that constrain epistemic mobility

The synthesis can be represented schematically as

$$\boxed{\text{Awareness} \rightarrow \text{Immersion} \rightarrow \text{Return} \rightarrow \text{Re-recognition} \rightarrow \text{Recombination}} \quad (29)$$

Each term has an established intellectual neighborhood. The proposed contribution lies in treating their relation as a dynamical learning problem.

Awareness concerns the learner's capacity to perceive the epistemic grammar currently organizing inquiry and to recognize increasing attractor capture.

Immersion concerns sufficiently sustained entry into a framework for its internal generative organization to become operational.

Return concerns the preservation and exercise of a transition away from a locally dominant framework without erasing what has been learned.

Re-recognition concerns renewed access to other frameworks after the learner's epistemic state has already been historically transformed.

Recombination concerns the generation of questions, representations, and relations that become possible because multiple learned grammars remain available without being collapsed prematurely into a single one.

The framework therefore occupies a position between two limiting learning dynamics. One limiting process produces shallow multiplicity:

$$A_1 \rightarrow A_2 \rightarrow A_3 \rightarrow \cdots \quad \text{with insufficient immersion.} \quad (30)$$

Such movement can accumulate vocabulary while leaving the learner without the internal generative competence required for serious comparison.

A second limiting process produces rigid specialization:

$$K \rightarrow A_i \rightarrow A_i \rightarrow A_i \rightarrow \cdots, \quad (31)$$

with progressively rising return cost and decreasing accessibility of alternatives.

Criticality learning concerns a third configuration:

$$K_0 \rightarrow A_i \rightarrow K_1 \rightarrow A_j \rightarrow K_2 \rightarrow A_k \rightarrow K_3 \rightarrow \cdots, \quad (32)$$

in which each excursion is capable of producing real transformation and each return preserves a meaningful possibility of further heterogeneous entry.

The theoretical lineage reviewed in this section also establishes an important limitation. Criticality learning should not be presented as a universal theory of education. Stable repetition, apprenticeship, disciplinary specialization, procedural mastery, social mediation, reflection, and experiential transformation remain indispensable modes of learning. Criticality learning addresses a narrower class of conditions in which the learner benefits from sustained access to several heterogeneous frameworks and where premature epistemic capture can reduce inquiry, comparison, or creation.

Its strongest expected applications therefore occur in fields such as interdisciplinary research, comparative religious studies, international relations, philosophy, cross-cultural inquiry, and creative theoretical work. In these settings, the learner often encounters frameworks whose concepts, values, inferential practices, and standards of relevance cannot be translated into one another without remainder. The educational challenge is consequently to develop enough local depth for each framework to become genuinely generative while preserving sufficient mobility for another framework to become genuinely visible.

The next section develops the nonlinear dynamical vocabulary required to formalize this problem more precisely. Epistemic states, evolving state spaces, attractor-like structures, metastability, critical regions, perturbation, return, and path dependence will provide the conceptual apparatus through which the sequence in Equation (32) can be examined.

3 A Dynamical Vocabulary for Criticality Learning

This section develops the minimal dynamical vocabulary required for criticality learning. Its purpose is methodological. The concepts introduced here provide a structured language for describing epistemic movement, stabilization, transition, and return across heterogeneous frameworks. They do not constitute an empirical reconstruction of cognition as a known physical dynamical system.

The discussion proceeds through six elements: epistemic states and evolving state spaces, attractor-like structures, metastability, critical regions, perturbation and excursion, and path-dependent return. Together they provide the conceptual architecture for the learning dynamics developed in later sections.

3.1 Epistemic States and Evolving State Spaces

Let the epistemic state of a learner at time t be represented by

$$x_t \in \mathcal{M}_t, \quad (33)$$

where $\mathcal{M}_t$ denotes an effective epistemic state space. The state x_t may include, at an appropriate level of abstraction, currently available concepts, inferential habits, questions, salience structures, interpretive expectations, practical competencies, and relations among these elements.

The notation is intentionally schematic. No claim is made that a complete human epistemic state can presently be represented by a finite-dimensional vector or reconstructed from observable educational data. The state-space representation serves instead to make temporal and relational dependence explicit.

A minimal dynamical expression is

$$\dot{x} = F_t(x; C_t, R_t, H_t), \quad (34)$$

where C_t denotes relevant learning conditions, R_t denotes relational structures, and H_t denotes accumulated learning history. The dependence upon t is important because learning changes both the learner and the conditions under which subsequent learning occurs.

The effective state space itself may also evolve:

$$\mathcal{M}_{t_0} \neq \mathcal{M}_{t_1}. \quad (35)$$

Learning can therefore generate new distinctions, new operations, and new possible transitions that were previously unavailable or practically inaccessible. A learner who acquires musical notation, differential geometry, legal interpretation, or a religious conceptual vocabulary may subsequently be able to perceive and generate relations that had no effective place in the learner's earlier epistemic organization.

Equation (35) introduces an important qualification to ordinary fixed-state-space models. Development can involve movement within an epistemic space and transformation of the effective space in which later movement becomes possible.

For local analysis, however, a fixed-space approximation may remain useful. Over a sufficiently limited interval

$$[t, t + \Delta t],$$

the evolution of $\mathcal{M}_t$ may be treated as slow relative to a particular learning excursion. The present paper therefore moves between an evolving-space interpretation and local fixed-space approximations according to the conceptual problem under examination.

3.2 Attractor-Like Epistemic Structures

Nonlinear dynamical systems commonly contain regions toward which trajectories tend to evolve under specified conditions. Attractors and basins of attraction provide a language for describing such stabilization [8, 9]. Criticality learning adopts this language at the epistemic level.

Let

$$A_i \subseteq \mathcal{M}_t \tag{36}$$

denote an attractor-like epistemic structure associated with a discipline, theory, conceptual framework, religious tradition, value system, or other relatively stable organization of inquiry.

The expression *attractor-like* is used deliberately. A disciplinary framework need not satisfy the formal mathematical conditions required of a dynamical attractor. The concept identifies a functional pattern: repeated engagement with the framework can increase the probability that subsequent questions and observations are organized through its characteristic grammar.

For a disciplinary grammar Γ_i , repeated use may produce a sequence

$$x_t \rightarrow x_{t+1} \rightarrow x_{t+2} \rightarrow A_i. \tag{37}$$

As attraction increases, some epistemic transitions become progressively easier. A mathematician may increasingly recognize formal invariants; a historian may increasingly notice provenance and temporal discontinuity; a lawyer may increasingly perceive questions of authority and procedure; a realist scholar of international relations may increasingly perceive security competition and strategic constraint.

The relevant phenomenon can be expressed through an effective transition cost

$$c_i(x \rightarrow x'), \tag{38}$$

where repeated disciplinary learning may decrease the cost of transitions that are internal to A_i :

$$\frac{\partial c_i(x \rightarrow x')}{\partial t} < 0, \quad x, x' \in A_i, \tag{39}$$

under sustained practice.

This reduction is one source of expertise. A well-developed attractor-like structure provides efficient access to operations that would otherwise require substantial conscious reconstruction.

An attractor also has an associated effective basin of attraction, schematically denoted by

$$\mathcal{B}_i = \mathcal{B}(A_i). \tag{40}$$

States within $\mathcal{B}_i$ have an increased tendency to evolve toward A_i under the relevant conditions. Epistemically, a basin can include problems that are increasingly likely to be reformulated through the grammar of the framework even when the problems originated elsewhere.

The boundaries among epistemic basins are expected to be permeable, context-dependent, and historically changing. Frameworks can overlap, share concepts, modify one another, or generate hybrid structures. The model therefore does not assume a partition

$$\mathcal{M} = \bigsqcup_i \mathcal{B}_i.$$

Several attractor-like structures may remain simultaneously influential.

3.3 Metastability and Temporary Disciplinary Coherence

Criticality learning requires a concept of temporary stability. A learner must be able to remain within a framework long enough for its internal grammar to become operational, while retaining the possibility of subsequent reorganization.

The concept of *metastability* provides a useful vocabulary for this condition. In dynamical and coordination research, metastability describes patterns that possess temporary coherence while retaining the possibility of transition into alternative organizations [9, 2].

Let the learner remain in the neighborhood of A_i for an interval

$$t \in [t_0, t_0 + \tau_i], \quad (41)$$

where τ_i denotes the disciplinary dwell time.

Very short dwell times may provide exposure without the acquisition of an operational grammar. Longer dwell times can permit the formation of internal competence:

$$\tau_i \uparrow \Rightarrow D_i \uparrow \quad (42)$$

over some region, where D_i denotes depth of usable disciplinary organization.

The relation in Equation (42) should not be interpreted as globally monotonic. Additional time can produce repetition, diminishing returns, or forms of lock-in. Its purpose is to represent the elementary fact that depth requires some duration of coherent engagement.

Criticality learning therefore depends upon a form of metastable immersion:

$$\text{coherence within } A_i \quad + \quad \text{continued transition capacity.} \quad (43)$$

This condition distinguishes criticality learning from rapid informational sampling. Reading one paragraph from many disciplines can generate variety without producing the internal generative capacity required for serious comparison. A learner must remain within a framework long enough to let it reorganize perception and reasoning.

Metastability also distinguishes the present framework from permanent disciplinary detachment. Criticality learning permits substantial local stability. The relevant concern is whether such stability preserves meaningful transition possibilities.

3.4 Critical Regions and Epistemic Susceptibility

The term *criticality* has several mathematically specific meanings in physics, nonlinear dynamics, neural systems, and complex systems. The present paper does not identify criticality learning with one universal mathematical critical point. It uses *critical region* for an epistemic configuration in which several transitions remain comparatively available and the learner retains heightened susceptibility to heterogeneous intellectual perturbations.

Let

$$K_t \subseteq \mathcal{M}_t \quad (44)$$

denote such a region.

A state $x_t \in K_t$ is characterized schematically by three properties.

First, more than one epistemic attractor remains meaningfully accessible:

$$|\mathcal{A}_{\text{acc}}(x_t)| > 1, \quad (45)$$

where $\mathcal{A}_{\text{acc}}(x_t)$ denotes the set of attractor-like structures that can be entered without prohibitive epistemic cost.

Second, perturbations associated with different frameworks can still produce distinct trajectories:

$$\delta_i \neq \delta_j \quad \Rightarrow \quad \Phi(x_t, \delta_i) \neq \Phi(x_t, \delta_j) \quad (46)$$

for relevant perturbations δ_i and δ_j .

Third, no single local grammar has made alternative entry effectively unavailable:

$$C_R(A_i, t) < \infty \quad (47)$$

for the attractor-like structures relevant to the learner's current inquiry, where C_R represents an effective return cost.

These properties are qualitative conditions rather than operational measurements. They define the conceptual role of K_t : a region from which different epistemic organizations can still exert meaningful influence upon the learner's future trajectory.

Criticality learning therefore does not seek maximal instability. A state in which no structure can persist long enough to support reasoning would have little educational value. The relevant condition combines sensitivity and temporary coherence.

This balance can be represented schematically as

$$\mathcal{C}_t = \Psi(S_t, M_t), \quad (48)$$

where S_t denotes local stability and M_t denotes epistemic mobility. Criticality learning concerns regions in which both remain sufficiently present to support deep excursion and subsequent transition.

3.5 Perturbation, Excursion, and Return

A learning encounter can be treated as a perturbation to the current epistemic organization. A perturbation may consist of a book, lecture, formal model, conversation, ritual, field observation, artistic experience, unfamiliar language, historical document, empirical anomaly, or encounter with another value framework.

Let

$$\delta_i \quad (49)$$

denote a perturbation associated with framework i . Applied within the critical region, it may initiate an excursion

$$K_t \xrightarrow{\delta_i} \mathcal{B}_i \rightarrow A_i. \quad (50)$$

The excursion is educationally significant when it produces more than contact with disciplinary content. It permits the learner to acquire some portion of the framework's generative grammar:

$$\Gamma_i : Q \mapsto \{Q'_i, M_i, I_i\}, \quad (51)$$

where a question Q can be transformed into new questions Q'_i , representations M_i , and inferential possibilities I_i .

The excursion becomes part of criticality learning when a return process remains possible:

$$A_i \xrightarrow{\mathcal{R}_i} K_{t+1}. \quad (52)$$

The notation $\mathcal{R}_i$ represents a family of possible return operations rather than a single universal procedure. Later sections examine possible mechanisms including de-centering, recovery of the original problem, de-jargonization, reflexive comparison, framework reversal, unstructured observation, and creative recombination.

The central structural condition remains

$$K_{t+1} \neq K_t. \quad (53)$$

Return therefore preserves the effects of learning. The learner does not remove Γ_i from the epistemic repertoire. The framework is carried back into a wider field of possible relations.

The resulting process can be represented as

$$K_t \xrightarrow{\delta_i} A_i \xrightarrow{\mathcal{R}_i} K_{t+1} \xrightarrow{\delta_j} A_j \xrightarrow{\mathcal{R}_j} K_{t+2}. \quad (54)$$

Criticality learning thus consists of structured excursions whose outcomes alter the conditions of later excursions.

3.6 Path Dependence and the Order of Learning

The non-restorative character of return introduces path dependence. If each learning episode changes the region from which later learning begins, the order of disciplinary encounters can influence the resulting epistemic organization.

Let

$$\mathcal{E}_i = \mathcal{R}_i \circ \mathcal{I}_i$$

denote an immersion-return episode associated with framework i . In general,

$$\mathcal{E}_j \circ \mathcal{E}_i(K_0) \neq \mathcal{E}_i \circ \mathcal{E}_j(K_0). \quad (55)$$

Equation (55) expresses the *non-commutativity of learning order*. A learner who studies dynamical systems and subsequently encounters political theory may perceive political change differently from a learner who first studies political theory and later encounters dynamical systems. A learner who approaches Christianity after sustained Buddhist study encounters a different comparative field from a learner whose historical order of encounter is reversed.

The inequality does not imply that either sequence is superior. It establishes that epistemic history participates in the generation of later meaning.

A learner's state after n episodes can therefore be written as

$$K_n = \mathcal{E}_{i_n} \circ \mathcal{E}_{i_{n-1}} \circ \cdots \circ \mathcal{E}_{i_1}(K_0). \quad (56)$$

The sequence

$$(i_1, i_2, \dots, i_n)$$

forms part of the learner's epistemic history. Criticality learning does not erase this history in pursuit of an impossible view from nowhere. Its concern is whether the historically transformed learner retains sufficient mobility to encounter further frameworks without requiring every new object to be fully absorbed into an already dominant grammar.

Path dependence also explains why returnability cannot mean reversal to an earlier state. In a learning process,

$$\mathcal{R}_i \neq \mathcal{I}_i^{-1}. \quad (57)$$

Return is not the inverse of immersion. It is a new transition performed by a learner whose epistemic organization has already changed.

This distinction is central to the concept of re-recognition developed later in the paper. The learner encounters an alternative framework again from a new historical position. The ethical and pedagogical problem concerns whether this renewed encounter remains possible.

3.7 Attractor Capture and Loss of Mobility

The dynamical vocabulary above permits a more precise formulation of epistemic capture.

Let the effective return cost from attractor A_i at time t be

$$C_R(A_i, t). \quad (58)$$

Increasing expertise may coexist with an increase in this cost. Such an increase can arise from several coupled processes:

$$C_R = C_R(\text{conceptual habit, identity, social belonging, institutional reward, affective investment, historical commitment}) \quad (59)$$

A disciplinary attractor can therefore be stabilized by more than conceptual coherence. Professional identity, publication incentives, institutional membership, religious commitment, social recognition, and accumulated investment may all contribute to the persistence of a framework.

Attractor capture occurs when the cost of meaningful departure becomes sufficiently large that alternative grammars cease to function as serious epistemic possibilities. Schematically,

$$C_R(A_i, t) \rightarrow C_{\text{prohibitive}}. \quad (60)$$

The precise threshold is context-dependent. The relevant change is functional: the learner becomes increasingly unable to reconstruct another framework without immediately subordinating it to the dominant grammar.

This condition can also be represented through the contraction of effective epistemic accessibility:

$$|\mathcal{A}_{\text{acc}}(x_t)| \downarrow. \quad (61)$$

Criticality learning seeks to maintain sufficient accessibility for continued movement while permitting strong local attraction and specialization.

The resulting dynamical distinction is

$$\text{attraction} \longrightarrow \text{metastable immersion} \longrightarrow \text{return} \quad (62)$$

as one generative pattern, and

$$\text{attraction} \longrightarrow \text{reinforcement} \longrightarrow \text{capture} \quad (63)$$

as a contrasting pattern.

The difference cannot be inferred from disciplinary depth alone. Deep specialization can coexist with high returnability, while comparatively limited learning can become strongly identity-bound and difficult to revise. The central variable is the evolving relation between attraction and mobility.

3.8 Methodological Status of the Dynamical Model

The framework developed in this section occupies an intermediate level between ordinary metaphor and empirical dynamical modeling. Its terms are intended to constrain reasoning. Once learning is described through attractors, metastability, return costs, and path dependence, several consequences follow: learning order can matter; identical information can have different effects from different initial states; increasing depth can alter future transition costs; and successful return cannot be represented as restoration of an unchanged learner.

At the same time, the present theory does not provide empirical values for

$$x_t, \quad \mathcal{M}_t, \quad A_i, \quad C_R, \quad \delta_i.$$

The framework therefore does not support numerical prediction of an individual learner's trajectory. Empirical operationalization would require the specification of observable proxies, temporal scales, relevant perturbations, and criteria for identifying stable or metastable epistemic patterns.

The nonlinear literature provides precedent for treating cognition, coordination, and learning through self-organization, stability, transition, and metastability [8, 9, 2]. The present proposal extends this vocabulary toward movement among disciplinary and value grammars. That extension remains a conceptual hypothesis whose usefulness should ultimately be assessed by its capacity to organize observations, generate distinctions, and support future empirical inquiry.

For the purposes of the present paper, the framework establishes one central dynamical proposition:

Proposition 3.1 (Criticality Learning Dynamics). *Criticality learning occurs when a learner can enter sufficiently coherent epistemic attractor-like structures to acquire locally generative grammars, while preserving enough transition capacity to return to a transformed region from which alternative structures remain meaningfully accessible.*

Proposition 3.1 places neither permanent instability nor permanent neutrality at the center of learning. Its central object is the continued possibility of movement after meaningful transformation.

4 Attractor Awareness and Epistemic Capture

The dynamical vocabulary developed in the previous section describes how a learner may enter, remain within, and eventually become strongly organized by an epistemic attractor-like structure. The present section turns to the first cognitive capacity required for criticality learning: *attractor awareness*.

Attractor awareness concerns the learner's capacity to recognize the epistemic structures that are presently organizing perception, inquiry, and judgment. Its importance follows from a simple asymmetry. A learner cannot deliberately regulate an attractor that remains invisible as an attractor.

A framework that is experienced merely as “the way the problem is” cannot readily become an object of comparison, decentering, or return.

The central problem can therefore be expressed as

$$A_i \longrightarrow \text{background organization} \longrightarrow \text{reduced visibility of } A_i \quad (64)$$

even while the causal or organizational influence of A_i is increasing.

Criticality learning requires a partial reversal of this process:

$$A_i \longrightarrow \text{object of awareness.} \quad (65)$$

The learner must become capable of seeing the grammar through which the learner is seeing.

4.1 The Object of Attractor Awareness

Metacognition provides the nearest established educational context for this capacity. Flavell’s foundational account identifies knowledge and monitoring of one’s own cognitive processes as a distinct field of cognitive-developmental inquiry [5]. Criticality learning retains this metacognitive orientation while specifying a different object of monitoring.

The relevant object is not merely whether a learner understands a proposition, remembers information, or successfully applies a strategy. It is the organizational framework within which those cognitive operations acquire their apparent relevance.

Let

Γ_i

denote the grammar associated with epistemic attractor A_i . Attractor awareness concerns the learner’s capacity to recognize that a question Q has been transformed through Γ_i :

$$Q \xrightarrow{\Gamma_i} Q_i. \quad (66)$$

This transformation may alter what is perceived as relevant, which distinctions are foregrounded, what evidence appears admissible, and what kind of answer seems intelligible.

For example, an international conflict may be organized primarily through security competition, legal obligation, historical grievance, political economy, identity formation, or institutional interdependence. Each organization can reveal genuine relations. Attractor awareness does not ask the learner to suppress these forms of organization. It asks whether the learner can identify which one is presently active.

The elementary form of attractor awareness can therefore be represented as

$$\boxed{\text{I am not only thinking about } Q; \text{ I am thinking about } Q \text{ through } \Gamma_i.} \quad (67)$$

This reflexive distinction is a precondition for later framework mobility.

4.2 Familiarity and the Invisibility of Grammar

Attractor awareness becomes difficult precisely when disciplinary competence becomes highly developed. Repeated use of a framework can reduce the conscious effort required to deploy its distinctions. What once required explicit instruction becomes habitual.

This process is educationally valuable. Expertise depends partly upon the availability of operations that no longer require deliberate reconstruction. Yet the same fluency can make the framework itself increasingly transparent.

A learner may therefore experience

$$\text{Influence}(\Gamma_i, t) \uparrow \quad \text{while} \quad \text{Visibility}(\Gamma_i, t) \downarrow. \quad (68)$$

Equation (68) expresses one of the central difficulties of criticality learning. The grammar exerting the greatest organizational force may become the grammar least readily noticed.

Kuhn's account of normal science provides an important philosophical background for this phenomenon. A mature disciplinary matrix structures legitimate problems, exemplars, values, and problem-solving practices in ways that are shared within a scientific community [11]. Competence within such a structure can make its conventions function as the ordinary conditions of inquiry rather than as continuously explicit choices.

Criticality learning therefore requires a capacity to recover the contingency and locality of a grammar without denying its intellectual achievement.

The relevant transition is

$$\Gamma_i : \text{transparent background} \longrightarrow \text{visible epistemic structure}. \quad (69)$$

This transition resembles reflective reframing. Schön's account of reflective practice emphasizes the practitioner's ability to make aspects of an ongoing problematic situation available for reconsideration while inquiry or action continues [15]. Attractor awareness applies a similar reflexive movement to the epistemic frame itself.

4.3 Attractor Capture

Attraction should be distinguished from capture.

A learner may possess a strong preference for framework Γ_i , use it frequently, and regard it as especially powerful without having been captured by it. Criticality learning does not require symmetrical confidence among competing theories or disciplines.

Let the learner's currently available grammars be

$$\mathcal{G}_t = \{\Gamma_1, \Gamma_2, \dots, \Gamma_n\}. \quad (70)$$

A skewed distribution

$$P(\Gamma_i | Q) \gg P(\Gamma_j | Q) \quad (71)$$

does not by itself establish capture. Such a distribution may reflect expertise, evidence, relevance, or legitimate specialization.

Capture concerns a stronger condition in which alternative grammars become increasingly difficult to deploy as serious reorganizations of the problem:

$$P(\Gamma_j \text{ reorganizes } Q) \longrightarrow 0 \quad \text{for many } j \neq i. \quad (72)$$

The learner may still be able to describe Γ_j , cite its vocabulary, or summarize its conclusions. What has been reduced is the capacity to allow Γ_j to alter the field of inquiry.

This distinction is important because epistemic capture can coexist with large quantities of information about alternative frameworks.

A scholar may know many facts about another religion while remaining unable to let its internal concepts reorganize the problem.

A political theorist may accurately summarize an opposing school while treating its concepts only as defective approximations of the preferred framework.

A scientist may recognize the vocabulary of another discipline while translating every claim immediately into the categories of the home field.

The problem is therefore not informational absence. It is a reduction in *framework-level susceptibility*.

4.4 Conceptual Capture

The most direct form of capture occurs when one conceptual vocabulary begins to dominate the description of heterogeneous problems.

Suppose a learner has recently acquired a powerful grammar Γ_i . The learner may begin to observe

$$Q_1 \xrightarrow{\Gamma_i} Q'_1, \quad Q_2 \xrightarrow{\Gamma_i} Q'_2, \quad \dots, \quad Q_n \xrightarrow{\Gamma_i} Q'_n. \quad (73)$$

Such generalization can be productive. Powerful concepts often reveal relations across domains.

A possible capture signal appears when the learner becomes unable to produce a serious redescription without the currently dominant vocabulary.

This suggests a simple diagnostic operation:

$$\mathcal{D}_{-\Gamma_i}(Q) = \text{redescribe } Q \text{ without the characteristic vocabulary of } \Gamma_i. \quad (74)$$

The operation is not intended to establish that specialized terminology is undesirable. Technical vocabulary permits precision that ordinary language cannot reproduce. The diagnostic question is whether temporary suspension of that vocabulary reveals another intelligible organization of the problem.

If

$$\mathcal{D}_{-\Gamma_i}(Q) \approx \emptyset, \quad (75)$$

the result may indicate that Γ_i has become deeply integrated into the learner's epistemic organization.

Such integration may represent expertise. It becomes relevant to criticality learning when the learner also loses the ability to reconstruct competing organizations.

For example, after sustained study of nonlinear dynamics, a learner may increasingly describe heterogeneous phenomena through attractors, bifurcations, criticality, metastability, and path dependence. These concepts may be genuinely useful. Attractor awareness asks whether the learner can still describe the same phenomenon historically, phenomenologically, legally, institutionally, or narratively without treating those descriptions as merely incomplete versions of the dynamical one.

The purpose of the exercise is therefore diagnostic rather than purificatory. The learner does not seek a vocabulary-free description. The learner seeks evidence that alternative grammars remain cognitively alive.

4.5 Comparative Asymmetry

Attractor capture can also appear as an asymmetry in comparative inquiry.

Let

$$\Gamma_i(\Gamma_j)$$

represent an inquiry in which framework i is used to examine framework j .

Such directional comparison is methodologically legitimate. Comparative religious studies, philosophy, international relations, law, and intellectual history frequently employ one conceptual system to illuminate tensions, omissions, or possibilities in another.

The relevant problem arises when

$$\Gamma_i(\Gamma_j) \tag{76}$$

remains available while

$$\Gamma_j(\Gamma_i) \tag{77}$$

becomes epistemically unavailable or unintelligible.

This produces a form of *comparative asymmetry*:

$$\text{Access} [\Gamma_i(\Gamma_j)] \gg \text{Access} [\Gamma_j(\Gamma_i)]. \tag{78}$$

The asymmetry itself need not be eliminated. One direction may be more relevant to a specific research question. The diagnostic concern is whether the learner can still reverse the relation when doing so is conceptually useful.

This motivates a *reversal operation*:

$$\mathcal{V}_{ij} : \Gamma_i(\Gamma_j) \longrightarrow \Gamma_j(\Gamma_i). \tag{79}$$

The operation asks what becomes visible when the object and the evaluative framework exchange roles.

In comparative religion, a scholar may ask how Buddhist concepts illuminate Christian theology. Criticality learning permits this inquiry. Attractor awareness adds a second question: can Christian conceptual structures also reorganize how Buddhist claims are perceived?

Likewise, a realist account of international politics may illuminate the security constraints ignored by a legal or normative account. The reverse comparison may reveal dimensions of legitimacy, obligation, or institutional construction obscured by a security-centered grammar.

The value of reversal is not that every framework receives equal authority. Its value lies in making the direction of comparison visible.

$$\boxed{\text{directional comparison} \neq \text{unexamined permanent meta-language.}} \tag{80}$$

4.6 Identity-Based Capture

Epistemic attractors are not sustained by concepts alone.

A framework may become connected to professional identity, religious commitment, political belonging, institutional membership, biography, social recognition, or accumulated investment.

The return cost from A_i can therefore be represented as

$$C_R(A_i, t) = C_{\text{concept}} + C_{\text{identity}} + C_{\text{social}} + C_{\text{institutional}} + C_{\text{affective}} + C_{\text{historical}}. \tag{81}$$

Equation (81) is schematic rather than additive in a strict empirical sense. Its purpose is to make explicit that epistemic mobility is relationally embedded.

Identity capture can occur when the relation

I use Γ_i

becomes increasingly difficult to distinguish from

I am Γ_i .

Professional identities provide an obvious example. A researcher may become socially and institutionally embedded within a disciplinary community. Changing frameworks can then threaten accumulated expertise, publication networks, professional recognition, or belonging.

Religious and political commitments can involve still stronger forms of existential identification. A framework may organize not only explanations but also moral orientation, community, ritual, memory, and conceptions of selfhood.

Criticality learning does not treat these commitments as pathologies. Commitment can generate forms of knowledge that detached observation cannot produce. The issue is whether commitment raises the cost of re-recognition to the point that alternative frameworks can no longer be entered seriously.

The relevant awareness question is therefore broader than

Is this theory correct?

It also includes

What is making it difficult for me to move away from this framework?

The answer may include evidence and explanatory adequacy. It may also include belonging, identity, fear of inconsistency, sunk investment, or anticipated social cost.

Attractor awareness seeks to distinguish these forces without presuming that they can or should be eliminated.

4.7 Affective Capture

Emotional states can also reorganize epistemic accessibility.

A framework may become associated with reassurance, threat, moral disgust, admiration, fear, hope, resentment, or existential security. These affective relations can influence which alternatives remain available for serious consideration.

A learner may therefore experience

$$A_i \longleftrightarrow E_i, \tag{82}$$

where E_i denotes an affective configuration coupled to the epistemic attractor.

This coupling is not intrinsically irrational. Emotional salience can direct attention toward genuine features of a problem, and meaningful learning often has affective dimensions.

The criticality-learning concern begins when affective responses operate as automatic barriers to re-entry into alternative frameworks.

For example,

$$\Gamma_j \rightarrow \text{threat response} \rightarrow \text{premature rejection}$$

may prevent the learner from reconstructing Γ_j far enough to evaluate it.

Attractor awareness therefore includes awareness of the emotional conditions under which frameworks become easier or harder to approach.

This does not require the learner to become affectively neutral. It requires the capacity to distinguish

I experience this framework as threatening
from

this framework is therefore unintelligible or false.

The distinction creates additional room for inquiry.

4.8 Social and Institutional Capture

Framework mobility can also be constrained by social structures outside the individual learner.

Disciplinary communities provide language, standards, mentorship, archives, peer review, funding, and recognition. These structures are essential to deep learning. The same structures may also generate path dependence.

Let

$$R_i(t)$$

denote the learner's relational embedding in the community associated with A_i . Increasing $R_i(t)$ may reduce the cost of generation inside the framework:

$$C_{\text{internal}}(A_i, t) \downarrow. \quad (83)$$

At the same time, under some conditions, the cost of leaving may rise:

$$C_R(A_i, t) \uparrow. \quad (84)$$

Institutional rewards can reinforce the same process. Publication systems, professional credentials, funding structures, curricula, disciplinary departments, and career paths can make certain epistemic trajectories easier to sustain than others.

Attractor awareness therefore cannot be reduced to introspection. A learner may accurately recognize personal cognitive habits while remaining unable to identify the social conditions maintaining them.

Criticality learning requires a relational form of awareness:

$$\text{self-observation} + \text{framework observation} + \text{condition observation}. \quad (85)$$

The learner asks not only what is being thought, but what social and institutional relations make some forms of thought easier to continue than others.

4.9 Perspective Transformation and Capture

Transformative learning provides another important complication. A deep learning episode may change the meaning structures through which experience is organized [12]. Such transformation can be one of the most valuable outcomes of education.

Criticality learning therefore cannot use the magnitude of transformation as a measure of capture. A learner may undergo

$$x_t \rightarrow x_{t+1}, \quad \|x_{t+1} - x_t\| \gg 0, \quad (86)$$

while maintaining substantial returnability.

Another learner may undergo only modest conceptual change while becoming strongly attached to a new identity or social group, thereby reducing epistemic mobility.

The important distinction is

$$\boxed{\text{transformation intensity} \neq \text{capture intensity.}} \quad (87)$$

Criticality learning therefore welcomes transformative encounters when they remain compatible with later re-recognition.

A religious experience, philosophical conversion, scientific discovery, or political awakening may reorganize a learner's world. The ethical question is not whether the learner has been deeply changed. The question concerns whether the transformed learner retains a meaningful capacity to encounter other possible worlds.

4.10 Attractor Awareness Indicators

Because attractor capture cannot presently be measured through a complete epistemic state-space reconstruction, criticality learning requires provisional indicators.

These indicators should be treated as prompts for reflection rather than diagnostic criteria.

A learner may have reason to examine possible attractor capture when several of the following patterns appear.

Vocabulary monopolization. Heterogeneous problems are increasingly described through the same limited conceptual vocabulary.

Problem homogenization. Different questions are repeatedly transformed into the characteristic problem form of one framework.

Framework invisibility. The learner can identify the assumptions of alternative frameworks more readily than the assumptions of the currently preferred framework.

Comparative irreversibility. One framework can be used to analyze another, while the reverse operation becomes difficult to perform seriously.

Alternative trivialization. Competing frameworks are increasingly represented as naive, incomplete, or irrational before their internal grammar has been reconstructed.

Identity fusion. Criticism of a framework is experienced primarily as criticism of the learner's identity or belonging.

Affective exclusion. Some frameworks produce automatic rejection before conceptual reconstruction is attempted.

Social exit cost. Leaving or suspending a framework threatens professional, communal, or institutional relations strongly enough to constrain inquiry.

Question loss. The learner can no longer recover the question that existed before it was reformulated by the preferred framework.

No single indicator establishes capture. Some may accompany legitimate expertise or commitment. Their importance lies in making possible a more specific reflective question:

Has one framework become difficult to distinguish from the conditions of intelligibility themselves?
--

(88)

4.11 Awareness without Premature Decentering

Attractor awareness should not be confused with a requirement to leave a framework immediately after recognizing its influence.

A learner may become fully aware that a mathematical grammar is organizing a problem and nevertheless decide that continued mathematical immersion is appropriate.

A scholar may recognize that a religious tradition has become central to the interpretation of experience and continue to practice within that tradition.

A political analyst may recognize a realist framing and conclude that the security structure of the case makes that framing especially useful.

Awareness therefore creates a decision point:

$$A_i \xrightarrow{\text{awareness}} \begin{cases} \text{continued immersion,} \\ \text{comparative testing,} \\ \text{decentering,} \\ \text{return.} \end{cases} \quad (89)$$

This distinction prevents criticality learning from becoming compulsory framework switching.

Criticality is not maximized by leaving every attractor as quickly as possible. Some tasks require long residence inside a specialized structure. The role of awareness is to make residence increasingly intentional.

awareness transforms attraction from an invisible condition into a potentially governable relation.

(90)

4.12 Limits of Self-Awareness

Attractor awareness itself has epistemic limits.

A framework that organizes the criteria by which reflection is performed may also organize the reflection intended to detect that framework. The learner can therefore remain inside an attractor while believing that the attractor has already been critically examined.

This produces a recursive difficulty:

$$\Gamma_i [\text{Reflection}(\Gamma_i)]. \quad (91)$$

The framework can structure its own apparent critique.

For this reason, self-reflection alone cannot guarantee criticality.

External perturbation remains important. Another discipline, interlocutor, language, historical case, empirical anomaly, cultural context, or practical failure can reveal assumptions that remain difficult to detect from inside a stable framework.

A more adequate model of awareness is therefore relational:

$$\mathcal{A}_t = \Phi(\text{self-reflection, alternative frameworks, interlocutors, experience, anomaly}), \quad (92)$$

where $\mathcal{A}_t$ denotes attractor awareness.

This model also places limits on claims of complete reflexivity. No learner occupies a position from which all active grammars become simultaneously visible.

Attractor awareness is consequently a revisable achievement rather than a final state.

4.13 Awareness and Epistemic Humility

The impossibility of complete attractor awareness gives criticality learning an epistemic-humility requirement.

A learner may recognize several active frameworks while remaining organized by others that have not yet become visible.

The relevant stance is therefore not

I have escaped all frameworks

,

but

I can identify some of the frameworks organizing my present inquiry, while remaining open to the discovery of others.

This distinction is especially important in value-heterogeneous research. Claims of neutrality can themselves become attractor structures. Secularism, pluralism, scientific naturalism, liberalism, or methodological neutrality may function as local grammars while appearing to the researcher as an absence of grammar.

Attractor awareness therefore applies reflexively to neutrality itself.

A comparatively neutral position in criticality learning is not a view from nowhere. It is a metastable position characterized by sufficient awareness and mobility to permit several frameworks to become locally operative without one of them becoming permanently invisible as a framework.

4.14 Attractor Awareness within Criticality Learning

Attractor awareness occupies the first regulatory position within the criticality-learning process.

The relationship can be represented as

$$\text{attraction} \longrightarrow \text{awareness} \longrightarrow \text{possible regulation}. \quad (93)$$

Without awareness, increasing attraction can continue toward capture without becoming available for deliberate intervention:

$$A_i \rightarrow \text{reinforcement} \rightarrow \text{capture}. \quad (94)$$

With sufficient awareness, another family of trajectories becomes possible:

$$A_i \rightarrow \text{awareness} \rightarrow \begin{cases} \text{continued immersion,} \\ \text{framework reversal,} \\ \text{alternative perturbation,} \\ \text{return.} \end{cases} \quad (95)$$

The present section can therefore be summarized in the following proposition.

Proposition 4.1 (Attractor Awareness). *Attractor awareness is the learner's revisable capacity to identify the disciplinary, conceptual, affective, identity-based, social, or institutional structures that are organizing present inquiry, and to detect when their increasing dominance is reducing the meaningful accessibility of alternative epistemic organizations.*

The proposition contains two components.

The first is *recognition*:

Which framework is active?

The second is *mobility sensitivity*:

What is happening to the accessibility of alternatives?

The second component distinguishes attractor awareness from simple self-description. A learner can know that a framework is being used while remaining unaware that its use is gradually changing the future epistemic landscape.

Attractor awareness therefore concerns not only the present grammar of thought but also the direction in which that grammar is moving the learner.

The next section examines the complementary requirement of *immersion*. Criticality learning depends upon the capacity to detect capture, but it equally depends upon sufficiently deep entry into epistemic attractors for their internal grammars to become genuinely generative. Awareness without immersion would preserve mobility at the cost of depth.

5 Immersion and Disciplinary Depth

Attractor awareness prevents a learner from treating a locally dominant framework as an invisible background condition. Awareness alone, however, is insufficient for criticality learning. A learner who continually observes frameworks from a distance may preserve mobility while failing to acquire the internal generative competence required to understand any of them seriously.

This section therefore develops the complementary requirement of *immersion*. Criticality learning depends upon sufficiently sustained entry into an epistemic attractor-like structure for its concepts, distinctions, inferential habits, exemplars, evaluative standards, and problem-forming practices to become locally operational. The educational problem is not to avoid attraction. It is to permit attraction to produce depth while preserving the conditions for later movement.

The basic tension can be written as

$$\boxed{\text{insufficient immersion} \longrightarrow \text{shallow multiplicity}} \quad (96)$$

and

$$\boxed{\text{unregulated immersion} \longrightarrow \text{capture risk.}} \quad (97)$$

Criticality learning occupies neither extreme.

5.1 Immersion as Entry into a Generative Grammar

A discipline cannot be reduced to a list of conclusions. As discussed in Sections 2 and 3, disciplinary competence includes ways of forming questions, identifying relevant distinctions, selecting evidence, performing transformations, and evaluating possible answers [11, 13].

Let

$$\Gamma_i$$

denote the generative grammar associated with attractor-like structure A_i . Exposure to disciplinary content may provide a collection of propositions

$$\mathcal{K}_i = \{k_1, k_2, \dots, k_n\},$$

without yet providing operational access to Γ_i .

This distinction can be represented as

$$\text{content exposure} \not\Rightarrow \text{grammar acquisition.} \quad (98)$$

A learner may know that general relativity concerns curved spacetime without being able to formulate a geometrical problem. A learner may know the vocabulary of legal interpretation without being able to reason through the relation among authority, precedent, procedure, and institutional competence. A learner may summarize doctrines of a religious tradition without being able to reconstruct why its internal distinctions make certain questions meaningful.

Immersion begins when the learner moves beyond the reception of disciplinary outputs and becomes able to perform transformations generated from within the framework.

Let Q denote an initial problem. Sufficient acquisition of Γ_i permits operations such as

$$\Gamma_i(Q) = \{Q_i^{(1)}, Q_i^{(2)}, \dots, M_i, I_i\}, \quad (99)$$

where $Q_i^{(k)}$ are newly generated questions, M_i are framework-specific representations, and I_i are inferential operations.

The transition from content reception to generative use is central to the present account:

$$\boxed{\text{knowing statements within a discipline} \longrightarrow \text{thinking generatively with the discipline.}} \quad (100)$$

Criticality learning requires the second condition.

5.2 Disciplinary Dwell Time

Generative grammar acquisition requires time.

Let

$$\tau_i \quad (101)$$

denote the duration of effective immersion within framework i . The relevant duration is not identical to clock time. Ten hours of passive reading and ten hours of active problem solving may produce substantially different degrees of disciplinary organization. The notation therefore represents effective engagement rather than a simple temporal quantity.

For an initial range, increasing τ_i can support increasing disciplinary depth:

$$\frac{\partial D_i}{\partial \tau_i} > 0, \quad (102)$$

where D_i denotes the degree to which Γ_i has become operational.

Equation (102) is local rather than universal. Learning may plateau, become repetitive, or reorganize qualitatively. Its purpose is to express a minimal condition: disciplinary depth normally requires sustained engagement.

Bruner's account of learning emphasizes the importance of structured development and repeated encounters with fundamental ideas [1]. Cognitive Flexibility Theory similarly rejects the expectation that complex and ill-structured knowledge can be mastered through a single simplified traversal, emphasizing repeated encounters from multiple directions [17]. These traditions support the broader claim that complex knowledge requires temporal persistence and revisitation.

Criticality learning adds that dwell time has two simultaneous effects.

First,

$$\tau_i \uparrow \Rightarrow \text{Operationality}(\Gamma_i) \uparrow \quad (103)$$

under suitable conditions.

Second, sustained residence may also alter the cost of leaving the framework:

$$\tau_i \uparrow \Rightarrow C_R(A_i, t) \text{ may increase.} \quad (104)$$

The learning problem is therefore inherently dynamical. The same process that makes a framework intellectually useful may increase its organizational stability.

5.3 Depth and Internal Reconstruction

Criticality learning requires more than familiarity with a framework from an external standpoint. The learner must sometimes permit the framework to reorganize the problem on its own terms.

This requirement can be expressed as a distinction between external description and internal reconstruction.

An external description may take the form

$$O(\Gamma_i) = \text{description of framework } i \text{ from framework } O. \quad (105)$$

Internal reconstruction instead attempts to generate

$$\Gamma_i(Q) \quad (106)$$

without immediately translating the result into the learner's preferred external grammar.

This distinction becomes particularly important in cross-framework inquiry. Consider comparative religion. A learner may know that a Buddhist tradition uses concepts such as dependent origination, emptiness, suffering, and liberation. Such knowledge does not yet establish that the learner can temporarily allow these relations to organize a problem.

Likewise, a researcher can memorize the vocabulary of realism in international relations while remaining unable to reconstruct how security uncertainty and strategic interaction reorganize a political event from within a realist grammar.

Internal reconstruction therefore requires temporary suspension of immediate reduction:

$$\Gamma_i(Q) \not\Rightarrow \Gamma_j[\Gamma_i(Q)] \quad \text{at the first moment of entry.} \quad (107)$$

The learner allows Γ_i sufficient local autonomy to disclose what it makes visible.

This condition does not imply agreement. Understanding a grammar and accepting its conclusions are different acts.

$$\boxed{\text{internal intelligibility} \neq \text{normative or epistemic endorsement.}} \quad (108)$$

Criticality learning depends upon preserving this distinction.

5.4 The Productive Suspension of Immediate Comparison

Comparative learning can fail when comparison begins too early.

Suppose a learner enters framework Γ_i while retaining a highly dominant framework Γ_j . Every unfamiliar concept may immediately be translated:

$$\Gamma_i \longrightarrow \Gamma_j(\Gamma_i). \quad (109)$$

If this translation occurs before the internal relations of Γ_i become operational, the learner may never encounter Γ_i as a generative organization.

Criticality learning therefore requires a temporary period in which comparison is partially suspended:

$$\text{entry} \longrightarrow \text{local reconstruction} \longrightarrow \text{comparison.} \quad (110)$$

The suspension is methodological rather than ideological. It does not require the learner to abandon prior commitments. It provides sufficient space for the new framework to form an intelligible local structure before being subjected to external evaluation.

This principle is especially important in value-heterogeneous inquiry. Religious, ethical, political, and cultural grammars may organize not only propositions but also practices, affective relations, symbolic distinctions, and forms of life. Immediate translation into an external evaluative system can remove precisely the relations that make the framework intelligible.

The appropriate question during early immersion is therefore often

$$\boxed{\text{What becomes intelligible if this grammar is provisionally allowed to organize the problem?}} \quad (111)$$

Only after this question has been explored does reversal become fully productive.

5.5 Shallow Multiplicity

The principal failure mode on the low-immersion side is *shallow multiplicity*.

Let the learner encounter frameworks

$$A_1, A_2, \dots, A_n.$$

A sequence of very brief encounters may produce

$$K_0 \rightarrow A_1 \rightarrow A_2 \rightarrow A_3 \rightarrow \dots \rightarrow A_n \quad (112)$$

without any A_i becoming sufficiently developed to support internally generated reasoning.

The learner may then possess a large vocabulary:

$$|\mathcal{K}| \uparrow,$$

while the number of operational grammars remains small:

$$|\mathcal{G}_{\text{operational}}| \ll |\mathcal{G}_{\text{encountered}}|. \quad (113)$$

This distinction is important for interdisciplinary education. Breadth can produce an appearance of integration while each disciplinary contribution remains externally reconstructed through one dominant home grammar.

A learner may say:

Physics says this, philosophy says that, religion says another thing.

Yet the learner may still lack the capacity to perform the internal moves by which each field arrives at its questions and judgments.

Criticality learning therefore rejects the equation

$$\text{number of disciplines encountered} = \text{interdisciplinary depth}. \quad (114)$$

The educational aim is not maximal disciplinary variety.

5.6 Immersion and Temporary Asymmetry

Serious immersion necessarily produces temporary asymmetry.

During a period of mathematical study, mathematical concepts may become more salient:

$$P_t(\Gamma_{\text{math}}) \uparrow. \quad (115)$$

During intensive historical research, historical relations may dominate attention:

$$P_t(\Gamma_{\text{history}}) \uparrow.$$

Criticality learning should not interpret these temporary asymmetries as failures.

Indeed, preventing local asymmetry would make deep learning nearly impossible. If the learner were required continuously to maintain equal use of every available framework,

$$P(\Gamma_1) = P(\Gamma_2) = \dots = P(\Gamma_n), \quad (116)$$

disciplinary grammar acquisition would be severely constrained.

The relevant distinction is therefore

$$\boxed{\text{temporary epistemic asymmetry} \neq \text{epistemic foreclosure}}. \quad (117)$$

Criticality learning permits, and often requires, temporary attraction strong enough to reorganize the learner.

The normative concern arises when temporary asymmetry becomes difficult to revise even after the learning purpose that justified the immersion has changed.

5.7 Immersion as Controlled Vulnerability

Deep learning requires a form of epistemic vulnerability.

To learn a framework seriously, the learner must permit the possibility that the framework will change what appears plausible, relevant, or valuable.

If the learner enters with the condition

$$x_{t+1} = x_t,$$

then no transformative learning is possible.

A more realistic condition is

$$x_{t+1} = \Phi_i(x_t), \quad \Phi_i(x_t) \neq x_t. \quad (118)$$

The learner therefore accepts some uncertainty regarding the state that will emerge after immersion.

This vulnerability distinguishes serious learning from informational consumption. A book, lecture, ritual, proof, field experience, or conversation can become educationally significant when the learner permits it to alter the relations through which subsequent inquiry proceeds.

Criticality learning nevertheless qualifies this vulnerability with returnability.

The ideal is

$$\boxed{\text{openness to transformation} + \text{preservation of later movement.}} \quad (119)$$

The learner does not demand immunity from change. Nor does the learner surrender the future possibility of re-evaluation.

This combination is one reason that criticality learning requires both cognitive and ethical regulation.

5.8 Immersion and Commitment

Immersion can deepen into commitment.

A learner may conclude that a theory is especially compelling, adopt a professional disciplinary identity, enter a religious practice, or orient long-term research around one framework.

Criticality learning does not require these commitments to remain weak.

Let

$$W_i(t) \quad (120)$$

denote the practical or epistemic weight assigned to framework i . A strong commitment may involve

$$W_i(t) \gg W_j(t).$$

This inequality is compatible with criticality learning.

The relevant condition is not equal weighting but continued revisability:

$$W_i(t) \gg W_j(t) \quad \text{and} \quad C_R(A_i, t) < C_{\text{prohibitive}}. \quad (121)$$

A committed learner may still possess sufficient capacity to reconstruct, compare, and re-recognize alternative frameworks.

This distinction becomes especially important in religious or philosophical learning. A person may enter deeply into a tradition and eventually affirm it as a central orientation. Criticality learning does not require the person to treat competing traditions as equally convincing.

The relevant ethical question is whether commitment has been generated in a way that preserves the capacity for future reconsideration.

5.9 Depth without Universalization

A powerful disciplinary grammar often acquires explanatory reach beyond its original domain. This reach can be one sign of intellectual depth.

The risk appears when local explanatory success becomes universal ontological privilege.

Suppose Γ_i performs well across problems

$$Q_1, Q_2, \dots, Q_m.$$

The learner may infer

$$\Gamma_i \text{ is useful across many domains} \tag{122}$$

and then move, without sufficient justification, toward

$$\Gamma_i \text{ provides the fundamental grammar of all domains.} \tag{123}$$

Criticality learning treats this transition as a point requiring attractor awareness.

The purpose is not to prohibit universal theories. Some theories legitimately make claims of wide scope. The relevant issue is whether the expansion of scope has been argued or merely generated by growing familiarity and fluency.

The learner should therefore distinguish

breadth of successful application

from

exclusive ontological authority.

This distinction preserves the possibility that a deeply learned framework remains one highly productive grammar among several irreducible forms of inquiry.

5.10 Signs of Insufficient Immersion

Criticality learning requires indicators of insufficient depth as well as indicators of capture.

A learner may have reason to continue immersion when several of the following patterns remain present.

Vocabulary without operation. The learner can define central terms but cannot use them to generate a new question or analysis.

External paraphrase. The framework can be summarized only through another preferred vocabulary.

Example dependence. The learner can reproduce canonical examples but cannot recognize structurally related cases.

Inference dependence. The learner repeatedly requires an external authority to determine what follows from the framework.

Question dependence. The learner can answer disciplinary questions but cannot formulate new ones.

Premature evaluation. The learner evaluates the framework before reconstructing the relations that make its claims intelligible.

Translation collapse. Every unfamiliar concept is immediately translated into a familiar concept from another field.

These indicators do not establish a measurable threshold of mastery. They identify conditions under which return may be premature because the learner has not yet acquired enough of the framework to carry anything substantial back to the critical region.

5.11 Signs of Sufficient Local Depth

Conversely, an excursion may have reached sufficient local depth when the learner can perform several framework-internal operations.

The learner can generate new questions using Γ_i :

$$Q \xrightarrow{\Gamma_i} Q_i^{\text{new}}. \quad (124)$$

The learner can identify why some evidence becomes relevant inside the framework.

The learner can distinguish strong from weak arguments without relying entirely upon external authority.

The learner can identify internal tensions or unresolved problems.

The learner can recognize when an external criticism misses the framework's actual claim.

The learner can also identify limitations from inside the framework rather than only from outside it.

These capacities suggest that Γ_i has become sufficiently operational to participate in later comparison and recombination.

This condition can be written schematically as

$$D_i \geq D_i^{\text{generative}}, \quad (125)$$

where $D_i^{\text{generative}}$ denotes an unspecified threshold at which the framework begins to support autonomous generation.

The threshold is conceptual rather than empirically fixed. Different tasks require different levels of depth.

5.12 Task-Relative Depth

Criticality learning does not require expert-level mastery of every framework.

Such a requirement would make interdisciplinary inquiry impossible.

The relevant depth depends upon the task.

Let

$$D_i^*(Q)$$

denote the depth in framework i required for inquiry Q . Then

$$D_i^*(Q_1) \neq D_i^*(Q_2). \quad (126)$$

A philosophical comparison of concepts may require substantial conceptual depth but little experimental technique.

An empirical interdisciplinary project may require detailed methodological competence.

A preliminary creative inquiry may need only enough disciplinary structure to generate a new analogy or question, provided the limits of the analogy remain explicit.

Criticality learning therefore seeks

$$D_i \geq D_i^*(Q) \quad (127)$$

rather than maximal D_i for every field.

This principle protects limited cognitive resources while preventing superficial interdisciplinarity.

5.13 The Immersion–Capture Tension

The central difficulty can now be expressed more precisely.

Let disciplinary depth be

$$D_i(\tau),$$

and effective return cost be

$$C_R(A_i, \tau).$$

Criticality learning benefits from increasing D_i while seeking to avoid a region in which increasing depth is accompanied by prohibitively increasing return cost.

A purely schematic objective is

$$\max_{\tau} D_i(\tau) \quad \text{subject to} \quad C_R(A_i, \tau) < C_{\text{prohibitive}}. \quad (128)$$

Equation (128) should not be interpreted as an optimization algorithm. Neither D_i nor C_R is presently available as a numerical quantity. The expression identifies the structure of the educational judgment.

The learner asks two questions simultaneously:

Have I entered deeply enough for this framework to become generative?
Am I still capable of leaving it as a framework?

(129)

Neither question is sufficient alone.

5.14 Immersion within the Criticality-Learning Cycle

The role of immersion within criticality learning can now be stated.

Starting from a comparatively open region K_t , the learner encounters a framework through some perturbation δ_i :

$$K_t \xrightarrow{\delta_i} \mathcal{B}_i. \quad (130)$$

Sustained engagement permits movement toward a locally coherent epistemic organization:

$$\mathcal{B}_i \xrightarrow{\tau_i} A_i. \quad (131)$$

Attractor awareness continues during this process:

$$\mathcal{A}_t = \mathcal{A}(A_i, C_R, \mathcal{G}_{\text{accessible}}), \quad (132)$$

where the learner monitors both increasing disciplinary organization and the changing accessibility of alternatives.

Return becomes educationally useful when the framework has reached sufficient local generativity and the learner has something structurally meaningful to carry back:

$$A_i \xrightarrow{\mathcal{R}_i} K_{t+1}. \quad (133)$$

The excursion therefore has the form

$$\boxed{K_t \rightarrow \text{entry} \rightarrow \text{immersion} \rightarrow \text{local generativity} \rightarrow \text{return}.} \quad (134)$$

This sequence clarifies why criticality learning is distinct from continuous framework switching.

5.15 Immersion and the Ethics of Epistemic Exposure

The requirement of immersion also has an ethical dimension.

To understand another framework seriously, the learner must sometimes permit it to become more than an external object. This can be demanding when the framework concerns religion, politics, morality, identity, or existential orientation.

An educational system could attempt to eliminate this difficulty by teaching every framework from a supposedly neutral external vocabulary. Such an approach may increase administrative comparability while decreasing internal intelligibility.

Criticality learning instead permits controlled epistemic exposure:

$$\text{exposure} \rightarrow \text{internal reconstruction} \rightarrow \text{reflexive return}. \quad (135)$$

The learner is neither required to convert to every framework nor protected from every possibility of transformation.

The ethical condition lies in preserving sufficient agency and future revisability.

This distinction becomes especially important for education involving children or other learners whose capacities for consent, resistance, or future-oriented judgment remain developing. The stronger the transformative power of an educational environment and the greater the difficulty of later revision, the more carefully the conditions of immersion should be governed.

The present paper does not develop a complete ethics of educational intervention. It establishes a principle that will become important for re-recognition:

deep entry is educationally valuable when transformation remains compatible with meaningful future re-access.

5.16 Immersion as a Condition of Recombination

Criticality learning is ultimately concerned with generation across heterogeneous frameworks. Such generation requires more than the juxtaposition of labels.

Suppose a learner has operational access to grammars Γ_i and Γ_j . Recombination can then take forms such as

$$\Gamma_i \otimes \Gamma_j \longrightarrow \Gamma_{ij}^{\text{new}}, \quad (136)$$

where $\otimes$ denotes a provisional relation of interaction rather than a specific algebraic operation. The resulting structure may generate questions that neither grammar produced alone.

If either Γ_i or Γ_j has been acquired only superficially, however, the apparent recombination may consist primarily of metaphorical borrowing.

Criticality learning therefore places immersion before strong recombination:

recombination quality depends partly upon the internal depth of the grammars being recombined.
--

(137)

This requirement protects interdisciplinary creativity from becoming terminological collage.

5.17 Immersion as a Core Capacity

The present section can be summarized in the following proposition.

Proposition 5.1 (Generative Immersion). *Generative immersion is a sufficiently sustained and internally reconstructive engagement with an epistemic attractor-like structure such that the learner acquires the capacity to generate questions, distinctions, representations, and inferences through its local grammar, while retaining awareness of the framework as a framework and preserving reasonable conditions for later epistemic return.*

The proposition contains three conditions.

First, immersion must be sufficiently deep:

$$D_i \geq D_i^*. \quad (138)$$

Second, the framework must become generative rather than merely descriptive:

$$\Gamma_i : Q \mapsto Q_i^{\text{new}}. \quad (139)$$

Third, disciplinary fluency must remain compatible with framework awareness:

$$\text{Operationality}(\Gamma_i) \uparrow \quad \text{without requiring} \quad \text{Visibility}(\Gamma_i) \rightarrow 0. \quad (140)$$

Criticality learning therefore rejects both shallow interdisciplinarity and compulsory epistemic symmetry.

Its ideal is a learner who can enter a framework deeply enough for it to become a real source of thought, remain long enough for its generative grammar to become operational, and still recognize that the grammar represents one historically situated organization of inquiry.

The next section turns to the transition that makes repeated criticality learning possible: *epistemic returnability*. The problem is no longer whether the learner can enter an attractor deeply enough, but whether a learner who has already been transformed by that attractor can subsequently leave its locally dominant organization without erasing the knowledge gained within it.

6 Epistemic Returnability

The preceding sections established two requirements of criticality learning. The learner must be able to recognize the epistemic structures organizing inquiry, and must also be able to enter those structures deeply enough for their internal grammars to become generative. The present section examines the transition that allows these capacities to participate in repeated learning: *epistemic returnability*.

Returnability concerns the learner's capacity to move away from a locally dominant epistemic organization while retaining the knowledge, distinctions, and transformations acquired through immersion. The return process therefore does not erase the excursion. It changes the relation between the acquired framework and the learner's wider epistemic field.

Let A_i denote an attractor-like epistemic structure and K_t a comparatively open region from which several frameworks remain meaningfully accessible. A return process can be represented by an operator

$$\mathcal{R}_i : A_i \rightarrow K_{t+1}. \quad (141)$$

Because immersion changes the learner, the returned region generally differs from the region that preceded immersion:

$$K_{t+1} \neq K_t. \quad (142)$$

Returnability therefore concerns movement after transformation rather than restoration of an earlier epistemic state.

6.1 Return after Transformation

A learner who has acquired a disciplinary grammar cannot simply become the learner who had never acquired it. Concepts alter salience. New distinctions create new possible questions. Experiences reorganize expectations. Practices create habits of attention and inference. Transformative learning can alter the meaning structures through which later experience is interpreted [12].

The history of learning therefore remains present after return.

Let an immersion process be represented by

$$\mathcal{I}_i : K_t \rightarrow A_i.$$

If return restored the exact earlier state, one would require

$$\mathcal{R}_i \circ \mathcal{I}_i(K_t) = K_t. \quad (143)$$

Criticality learning does not assume this condition. The more general relation is

$$\mathcal{R}_i \circ \mathcal{I}_i(K_t) = K_{t+1}, \quad K_{t+1} \neq K_t. \quad (144)$$

The significance of return lies precisely in this inequality. What has been learned remains capable of participating in subsequent inquiry, while the learner regains sufficient distance from the framework for other grammars to become operative again.

This makes return a generative transition. It can increase the number and quality of relations among previously separated forms of knowledge. The framework carried back from immersion may become an additional resource rather than the exclusive background of thought.

6.2 Returnability and Forgetting

Returnability should be distinguished from forgetting.

Forgetting reduces the availability of acquired knowledge. Returnability changes the position of acquired knowledge within a larger epistemic organization.

Suppose the learner has acquired grammar Γ_i . Successful return does not require

$$\Gamma_i \rightarrow \emptyset.$$

The desired condition is that Γ_i remains available without monopolizing the organization of subsequent inquiry.

Let

$$\mathcal{G}_{t+1} = \{\Gamma_i, \Gamma_j, \Gamma_k, \dots\}$$

denote the learner's accessible epistemic grammars after return. The important change concerns their relation. Framework Γ_i becomes one accessible resource within a wider repertoire.

This distinction is educationally important because a model that equates return with detachment may inadvertently treat disciplinary depth as something that must later be undone. Criticality learning instead seeks durable acquisition combined with renewed mobility.

A learner who has studied formal logic should remain capable of using formal logic after return. A learner who has studied Buddhist philosophy should retain the distinctions acquired through that study. A learner who has become competent in a realist analysis of international politics should remain able to deploy realism when appropriate.

Returnability is present when these acquired capacities can coexist with renewed access to other frameworks.

6.3 Returnability and Neutrality

Returnability also differs from recovery of a neutral standpoint.

Hermeneutic philosophy provides an important background for this distinction. Understanding is historically situated, and encounters with texts, traditions, and others alter the horizon through which later understanding occurs [7]. Criticality learning therefore does not presuppose an epistemically empty location outside all frameworks.

The returned region K_{t+1} is better understood as a comparatively open configuration. Several epistemic organizations remain accessible, while none has become completely invisible as an organization.

A learner may return with strong commitments. The learner may regard one framework as especially convincing, useful, beautiful, or ethically important. Returnability requires mobility rather than indifference.

This distinction allows criticality learning to accommodate serious religious, philosophical, scientific, and political commitments. A learner can inhabit a tradition deeply while retaining

a meaningful capacity to reconstruct other traditions and revisit the conditions of the present commitment.

Neutrality, in this framework, is therefore better treated as a relational achievement of mobility. It is historically produced, revisable, and susceptible to further transformation.

6.4 Dimensions of Returnability

Epistemic returnability has several dimensions. A learner may retain mobility along one dimension while experiencing substantial closure along another. Separating these dimensions makes the concept more analytically useful.

6.4.1 Conceptual Returnability

Conceptual returnability concerns the capacity to describe or investigate a problem without requiring the vocabulary of the currently dominant framework.

A practical test is temporary de-jargonization. The learner attempts to reconstruct the object without immediately invoking the concepts most strongly associated with Γ_i .

Successful de-jargonization does not establish that technical language is dispensable. It shows that the learner can temporarily loosen the connection between the object and one preferred conceptual encoding.

Conceptual returnability is especially relevant after acquiring powerful general vocabularies. Terms such as system, discourse, rationality, power, utility, attractor, structure, subject, information, or generativity can become so productive that heterogeneous phenomena begin to appear immediately through them. The learner benefits from periodically testing whether the phenomenon can still appear under another description.

6.4.2 Problem Returnability

Framework immersion often transforms the original question.

Let Q_0 denote the question that initiated inquiry. Under grammar Γ_i , the question may become

$$Q_i = \Gamma_i(Q_0). \quad (145)$$

This transformation is often productive. A vague initial problem can become precise once a discipline reorganizes it.

A risk appears when Q_i completely replaces Q_0 in the learner's memory of the inquiry. The learner may then forget that the disciplinary problem was one transformation of an earlier question.

Problem returnability is the capacity to recover the earlier problem and compare it with its disciplinary reformulations.

This capacity supports a useful reflective practice: preserving an *original-question anchor*. Before entering a framework, the learner records the problem in relatively framework-light language. After immersion, the learner revisits the earlier formulation and asks what became visible, what disappeared, and what changed.

The earlier formulation need not be privileged. It serves as a historical reference point for observing the effects of immersion.

6.4.3 Representational Returnability

Frameworks often stabilize particular forms of representation. Mathematics may privilege equations and formal structures. Law may organize inquiry through statutes, cases, doctrines, and institutional competences. Historical work may privilege sequences, archives, provenance, and contextual relations.

Representational returnability concerns the capacity to shift among such formats.

A phenomenon represented through a graph may reveal relations that disappear in narrative description. A narrative can reveal temporal and experiential structure suppressed by a graph. A legal classification can clarify institutional responsibility while leaving phenomenological experience largely unrepresented.

Returnability therefore includes the capacity to change representational medium when the present form has begun to constrain the available questions.

6.4.4 Identity Returnability

Identity returnability concerns the learner's ability to distinguish participation in a framework from total identification with it.

The distinction between

I work through this framework

and

I am this framework

can become difficult to sustain after long immersion.

Professional formation, religious practice, political membership, and philosophical commitment can all create strong identities. These identities may be valuable sources of continuity, responsibility, and community. Returnability asks whether temporary epistemic distance remains possible without requiring the learner to experience that distance as complete self-negation.

Identity returnability is therefore related to the capacity to suspend local identification for the purpose of inquiry while retaining the possibility of later re-entry.

6.4.5 Social Returnability

Epistemic mobility depends partly upon relationships.

A learner may be conceptually capable of reconsidering a framework while facing substantial social penalties for doing so. Communities can reward certain interpretations, identities, research programs, or forms of commitment. Institutional recognition can strengthen the same effects.

Social returnability concerns the availability of relationships and spaces in which framework transition remains socially possible.

This dimension helps explain why returnability cannot be reduced to a private cognitive skill. Educational environments contribute to returnability by making revision, dissent, exploration, and interdisciplinary movement legitimate activities.

6.4.6 Temporal Returnability

Return costs can change with duration.

Longer immersion can increase competence, deepen identity, expand social embedding, and stabilize habitual attention. These developments can make later return more demanding.

Let $C_R(A_i, t)$ denote the effective cost of return from A_i . A possible learning trajectory may satisfy

$$\frac{\partial C_R(A_i, t)}{\partial t} > 0 \quad (146)$$

over some interval.

Equation (146) does not imply that return cost always increases with time. Mature expertise can sometimes make comparison easier because the learner becomes sufficiently secure within a discipline to engage alternatives without threat. The relation is therefore empirical and context-dependent.

Temporal returnability nevertheless draws attention to the timing of return. A learner may benefit from occasional excursions outside a dominant framework before the costs of movement become unnecessarily high.

6.5 Return Cost

The concept of return cost provides a way to integrate the dimensions above.

Let

$$C_R(A_i, t) = F(C_c, C_p, C_r, C_{id}, C_s, C_a), \quad (147)$$

where C_c denotes conceptual cost, C_p problem-reframing cost, C_r representational cost, C_{id} identity cost, C_s social and institutional cost, and C_a affective cost.

The function F is schematic. The components may interact nonlinearly. Strong social pressure may amplify affective cost. Identity attachment may increase conceptual resistance. Conceptual insecurity may make social belonging more important.

Returnability decreases when these coupled costs become sufficiently large that alternative frameworks cease to function as serious possibilities.

The relevant threshold should be understood pragmatically. No universal numerical value separates ordinary commitment from epistemic capture. The question is whether movement remains feasible under conditions that a learner could reasonably encounter.

6.6 Partial Return

Return need not occur simultaneously across all dimensions.

A learner may achieve conceptual return while retaining strong professional identity. Another may leave a social community while continuing to organize problems through its conceptual grammar. A third may adopt a new theoretical framework while continuing to experience affective attraction toward the old one.

Return is therefore often partial.

Let the state of returnability be represented by a vector

$$\mathbf{r}_i(t) = (r_c, r_p, r_r, r_{id}, r_s, r_a), \quad (148)$$

where the components correspond to the dimensions identified above.

This representation allows different return profiles. Two learners may have similar overall mobility while the structure of that mobility differs substantially.

The vector is conceptual rather than psychometric at this stage. Future empirical research could investigate whether observable proxies for these dimensions can be developed.

6.7 Return Operators

Returnability becomes educationally useful when the learner has practical means of exercising it. The present framework therefore distinguishes returnability as a capacity from *return operators* as actions that can increase the probability of transition away from a locally dominant grammar.

Several return operators can be identified provisionally.

Recovery of the original question. The learner revisits the problem formulation that preceded disciplinary immersion and compares it with the framework-specific version.

De-jargonization. The learner temporarily redescribes the object without the characteristic technical vocabulary of the dominant framework.

Alternative description. The learner attempts to describe the same object through another disciplinary, historical, cultural, phenomenological, legal, artistic, or practical vocabulary.

Framework reversal. In a comparative inquiry, the learner reverses the direction of analysis and allows the previously examined framework to become the standpoint from which the preferred framework is examined.

Scale change. The learner changes temporal, spatial, institutional, or analytical scale. A pattern that appears compelling at one scale may become less explanatory at another.

Return to primary material. The learner revisits observations, texts, cases, experiences, or data before the current theoretical encoding and asks which aspects have been neglected.

Unstructured encounter. The learner temporarily suspends a defined theoretical task and returns to observation, walking, conversation, artistic experience, or another relatively open encounter from which unexpected salience can emerge.

Interlocutor perturbation. The learner engages a person whose conceptual history differs substantially from the dominant framework and allows their questions to disturb the present organization.

Temporal separation. The learner introduces an interval between immersion and evaluation. Reflection after a period of distance may reveal assumptions that remained transparent during intensive engagement.

These operators do not guarantee return. Their role is perturbative. They create conditions under which a locally stabilized epistemic organization may become visible and alternative transitions may regain accessibility.

6.8 Return as Reframing

Schön's account of reflective practice is particularly relevant to return because professional inquiry often develops through reframing [15]. A problematic situation can be reorganized by changing the frame through which its elements are related.

Criticality learning treats reframing as one possible return mechanism.

Suppose framework Γ_i produces a problem formulation Q_i . Return may involve applying an alternative transformation Γ_j :

$$Q_i \rightarrow Q_0 \rightarrow Q_j. \quad (149)$$

The intermediate recovery of Q_0 is conceptually useful because direct translation from Q_i to Q_j may carry hidden assumptions from Γ_i into the new representation.

In practice, complete recovery of a framework-independent Q_0 may be impossible. The original question was already historically and linguistically situated. The operation should therefore be understood as an attempt to loosen the most recently dominant organization rather than to reach a pure pre-theoretical object.

6.9 Returnability and Commitment

Strong commitment and high returnability can coexist.

A scientist may be deeply committed to a research program while remaining capable of reconstructing competing explanations. A religious practitioner may affirm one tradition while preserving the capacity to understand another tradition on its own terms. A political theorist may maintain a clear normative position while continuing to revisit the assumptions through which that position is generated.

The relevant structure is asymmetric but revisable.

Let W_i denote the learner's weight of commitment to framework i . Criticality learning permits

$$W_i \gg W_j \quad (150)$$

while requiring that the effective cost of examining A_j remains within a range that allows serious re-entry.

This point protects criticality learning from collapsing into permanent suspension of judgment. Epistemic mobility has value precisely because it allows commitment to remain capable of learning.

6.10 Returnability and Expertise

Expertise creates a special returnability problem.

Experts possess highly efficient disciplinary grammars. They can identify patterns, eliminate implausible possibilities, and generate solutions with speed unavailable to novices. Such compression is one source of expertise.

At the same time, efficiency can reduce the visibility of alternative problem formulations. What appears obvious to an expert may depend upon a long history of disciplinary training.

Criticality learning therefore does not ask experts to suspend expertise continuously. It asks them to retain practices through which expertise can occasionally become an object of inquiry.

One such practice is deliberate novice reconstruction. The expert asks which assumptions a learner from another field would need in order for the problem to appear in its current form.

Another is cross-disciplinary translation. The expert attempts to explain the problem to an interlocutor whose field does not share the same inferential shortcuts.

A third is anomaly preservation. Observations that do not fit the dominant grammar are recorded rather than immediately normalized or discarded.

These practices create local opportunities for return while preserving the advantages of expertise.

6.11 Failure Modes of Return

Return can fail in several distinct ways.

Nominal return. The learner changes vocabulary while preserving the same underlying grammar. The apparent move produces little change in problem structure.

Premature return. The learner leaves a framework before acquiring enough internal depth for its generative grammar to become operational.

Defensive return. The learner encounters discomfort during immersion and retreats primarily to restore a familiar identity or worldview.

Asymmetric return. The learner can leave one framework but treats another preferred framework as the permanent location to which every excursion must return.

Erasure return. The learner attempts to regain mobility by suppressing or disowning what was learned during immersion.

Fragmented return. The learner accumulates several partially learned frameworks without forming relations among them.

Institutionally blocked return. The learner becomes capable of conceptual movement while institutional or social conditions make such movement prohibitively costly.

These failure modes indicate that returnability is more demanding than switching topics.

A learner can change subject matter while remaining inside the same epistemic grammar. Conversely, a learner can remain with the same object while substantially changing the framework through which it is approached.

6.12 Returnability Indicators

A complete empirical measure of returnability remains unavailable. Several provisional indicators can nevertheless guide reflection and future operationalization.

A learner demonstrates stronger returnability when the learner can recover an earlier formulation of the problem after disciplinary reframing; describe the object without relying exclusively on the preferred vocabulary; reconstruct a competing framework with sufficient internal coherence; identify assumptions that became invisible during immersion; reverse the direction of comparison; distinguish evidential commitment from identity attachment; and re-enter the preferred framework after temporary decentering without losing acquired competence.

The last condition is important. Returnability includes re-entry.

A framework from which the learner can exit only by abandoning it completely may remain weakly integrated into the learner's broader epistemic structure. Mature returnability permits movement in both directions:

$$K_t \xrightarrow{\mathcal{I}_i} A_i \xrightarrow{\mathcal{R}_i} K_{t+1} \xrightarrow{\mathcal{I}'_i} A'_i. \quad (151)$$

The re-entered attractor A'_i may differ from the earlier A_i because the learner now approaches the framework from a changed epistemic history.

Returnability therefore supports repeated, increasingly reflexive immersion.

6.13 Returnability as a Learnable Capacity

Criticality learning treats returnability as a capacity that can be cultivated.

Metacognitive monitoring provides one part of this capacity [5]. Reflective reframing provides another [15]. Interdisciplinary learning adds experience in perspective change and integration [16]. Cognitive Flexibility Theory provides practices of repeated traversal and multiple representation [17].

Criticality learning reorganizes these practices around a temporal question: after a framework has become locally generative, what practices preserve the possibility of later movement?

A minimal training cycle may involve the following sequence:

1. record the initial question before intensive immersion;
2. enter one framework deeply enough to generate new questions through its grammar;
3. identify the concepts and distinctions that have become newly salient;
4. temporarily redescribe the problem without the dominant vocabulary;
5. reconstruct at least one alternative framework;
6. compare the transformed question with the initial question;
7. retain both the acquired grammar and the revised field of alternatives.

The sequence should be adapted to the domain. Mathematical study, religious practice, historical interpretation, legal education, and artistic training generate different return conditions.

The general principle concerns the preservation of transition capacity.

6.14 Returnability and Epistemic Freedom

Returnability also has a normative dimension.

A learner's epistemic freedom cannot be reduced to the number of available books, courses, or formal choices. A framework may remain formally accessible while the learner has lost the conceptual, affective, linguistic, social, or identity conditions required to encounter it seriously.

Effective epistemic freedom therefore depends partly upon the accessibility of transitions.

Let A_i and A_j both remain formally available. The practical possibility of movement from A_i to A_j depends upon the effective transition cost

$$C(A_i \rightarrow A_j). \tag{152}$$

Formal availability can coexist with a transition cost so high that the alternative has little practical epistemic reality.

Returnability makes this difference visible. Educational freedom includes a reasonable capacity to revise, revisit, reinterpret, and re-enter.

This claim becomes especially important when educational practices produce long-term commitments before learners possess substantial capacity to understand alternatives. The ethical concern is strongest when a mode of learning simultaneously deepens one attractor and systematically raises the future cost of recognizing others.

6.15 Returnability within Criticality Learning

Returnability connects immersion to repeated critical learning.

Without immersion, there is little substantive structure to return from. Without returnability, immersion can become epistemic lock-in. Together they produce a repeatable learning dynamic:

$$K_0 \xrightarrow{\mathcal{I}_i} A_i \xrightarrow{\mathcal{R}_i} K_1 \xrightarrow{\mathcal{I}_j} A_j \xrightarrow{\mathcal{R}_j} K_2. \quad (153)$$

Each return changes the conditions of the next excursion.

The learner who enters A_j after A_i carries distinctions acquired from A_i . The next framework may confirm, disturb, reinterpret, or reorganize them. The resulting learning history is cumulative while remaining open.

This structure supports the following proposition.

Proposition 6.1 (Epistemic Returnability). *Epistemic returnability is the learner's capacity, after sufficiently deep engagement with an epistemic attractor-like structure, to reduce its local organizational dominance enough for alternative frameworks to become meaningfully accessible again, while retaining the knowledge and generative capacities acquired through the original immersion.*

Three elements are central to this definition.

First, return follows meaningful immersion. It therefore presupposes transformation.

Second, return changes relative dominance rather than requiring erasure of the acquired framework.

Third, return restores access to further epistemic movement.

The resulting learner occupies a historically transformed region from which new encounters become possible.

The next section develops the concept that gives this movement its strongest temporal and normative significance: *re-recognition*. Returnability concerns the capacity to reopen epistemic movement. Re-recognition concerns whether alternative conceptual systems, values, and possible worlds can become genuinely intelligible again after the learner has already been transformed by earlier learning.

7 Epistemic Re-recognition and Revisability

Epistemic returnability reopens movement after disciplinary or conceptual immersion. Return alone, however, does not guarantee that alternative frameworks will again become genuinely intelligible. A learner may succeed in loosening the dominance of one grammar while continuing to encounter every alternative through categories produced by the earlier immersion.

The present section introduces *epistemic re-recognition* to describe a stronger capacity. Re-recognition concerns the renewed intelligibility of a concept, framework, value system, or possible world after the learner has already been transformed by prior learning.

The relevant structure is historical. Let x_{t_0} denote the learner's state before sustained engagement with framework A_i , and let x_{t_1} denote the transformed state after immersion and return. In general,

$$x_{t_1} \neq x_{t_0}. \quad (154)$$

If another framework A_j is encountered again at t_1 , the encounter cannot reproduce the earlier relation. The object may remain nominally the same while the conditions of recognition have changed.

Re-recognition therefore concerns neither restoration of an original perspective nor repetition of an earlier judgment. It concerns whether an alternative can become epistemically alive again from within a changed history.

7.1 Recognition after Epistemic Transformation

Learning has temporal consequences. Dewey's principle of continuity emphasizes that experience enters into the conditions of subsequent experience [4]. Transformative learning likewise treats learning as capable of reorganizing the meaning perspectives through which later experience is interpreted [12]. Criticality learning takes these observations seriously at the level of cross-framework movement.

Suppose a learner encounters framework A_j at time t_0 . The meaning generated in that encounter may be represented schematically as

$$M_{j,t_0} = M(A_j, x_{t_0}). \quad (155)$$

After substantial learning through another framework A_i , the learner encounters A_j again:

$$M_{j,t_1} = M(A_j, x_{t_1}). \quad (156)$$

Because $x_{t_1} \neq x_{t_0}$, there is no reason to expect

$$M_{j,t_1} = M_{j,t_0}. \quad (157)$$

The later encounter may become richer, more critical, less sympathetic, more precise, or differently structured. Re-recognition does not require continuity of judgment. It requires continuity of meaningful accessibility.

This distinction allows learning to be transformative without requiring the learner to preserve an earlier interpretation unchanged.

7.2 Re-recognition and Memory

Re-recognition should be distinguished from memory.

A learner may remember the name, propositions, vocabulary, or historical features of a framework while losing the capacity to enter its internal organization.

For example, a person may accurately remember the doctrines of a religious tradition while no longer being able to understand why those doctrines form a coherent world for practitioners. A scholar may remember the claims of a theoretical school while encountering them only as errors already classified by a preferred framework.

Memory therefore establishes informational persistence. Re-recognition requires renewed epistemic access.

Let K_j denote stored information concerning framework A_j , while G_j denotes operational access to its generative grammar. It is possible that

$$K_j(t_1) > 0 \quad \text{while} \quad G_j(t_1) \approx 0. \quad (158)$$

Such a learner remembers the framework but can no longer seriously inhabit its mode of inquiry. Criticality learning therefore evaluates more than information retention.

7.3 Re-recognition and Internal Intelligibility

A stronger form of re-recognition requires the learner to reconstruct at least part of the internal relation among a framework's concepts.

Let Γ_j denote the grammar associated with framework A_j . Re-recognition is present when the transformed learner can again permit

$$Q \xrightarrow{\Gamma_j} Q_j \quad (159)$$

without immediately replacing the transformation with one generated by the currently preferred grammar.

This requirement parallels the internal reconstruction discussed in Section 5. The difference is temporal. In re-recognition, the learner returns to a framework after intervening learning has altered the epistemic conditions of access.

The framework may now appear differently. Concepts previously accepted may become problematic. Claims previously dismissed may acquire new significance. The learner may recognize internal tensions that were previously invisible.

Re-recognition therefore does not preserve the earlier framework in a frozen form. It preserves the possibility of renewed encounter.

7.4 Re-recognition and Hermeneutic Historicity

Philosophical hermeneutics provides an important background for this historical structure. Gadamer's account of understanding emphasizes that the interpreter approaches texts, traditions, and others from historically formed horizons, and that understanding itself can transform those horizons [7].

Criticality learning therefore rejects the idea that re-recognition requires recovery of a neutral standpoint that existed before learning.

The learner cannot remove the effects of history. The relevant task is to permit another horizon to become effective within the transformed present.

This can be described as a relation among three moments:

1. an earlier encounter with framework A_j ;
2. an intervening history of transformation through other encounters;
3. a renewed encounter in which A_j becomes intelligible under changed conditions.

The third moment is neither a repetition of the first nor a wholly new encounter. It is historically mediated re-recognition.

This structure also limits claims of complete neutrality. Every later recognition carries the history of prior learning. Criticality learning seeks mobility within this historical condition rather than escape from it.

7.5 Re-recognition and Revisability

Re-recognition gives revisability a stronger meaning.

A belief or framework may be formally revisable if the learner is permitted to change it. Formal permission, however, does not establish that the learner retains the epistemic conditions required for serious reconsideration.

Let A_j remain formally available. The learner's practical capacity to reconsider it depends upon effective accessibility:

$$\alpha_j(t) = \alpha(A_j, x_t, C_t), \quad (160)$$

where C_t denotes relevant conceptual, social, linguistic, affective, and institutional conditions. A framework may remain formally accessible while

$$\alpha_j(t) \rightarrow 0. \quad (161)$$

In this condition, revisability survives procedurally while disappearing epistemically.

Criticality learning therefore treats revisability as partly dependent upon the preservation of re-recognition.

A learner can seriously revise a judgment only if relevant alternatives can still become sufficiently intelligible to participate in the revision.

7.6 Commitment and Re-recognition

Re-recognition does not require weak commitment.

A learner may judge one framework to be more adequate than another. A religious practitioner may hold exclusive theological commitments. A scientist may strongly reject a superseded theory. A political thinker may maintain a clear normative position.

The relevant question is whether the rejected or less preferred alternative can still be reconstructed when there is a reason to reconsider it.

Strong commitment and re-recognition can therefore coexist.

A learner may maintain

$$W_i \gg W_j, \quad (162)$$

where W_i and W_j denote relative commitment weights, while $\alpha_j(t)$ remains sufficiently large for serious re-entry.

This distinction is particularly important in religious education. Doctrinal exclusivity does not by itself establish epistemic foreclosure. A tradition may affirm its own claims strongly while still cultivating knowledge of alternatives, reflective awareness, and the capacity for renewed encounter.

Conversely, explicit pluralism does not guarantee re-recognition. A learner who assumes that all traditions ultimately express the same underlying truth may eliminate the very differences that make their internal grammars intelligible.

Re-recognition therefore requires neither relativism nor symmetrical commitment.

7.7 Pluralism and Epistemic Flattening

An important failure mode occurs when the preservation of openness is pursued through premature equivalence.

Suppose several frameworks are represented as

$$A_1, A_2, \dots, A_n.$$

A learner may attempt to preserve openness by translating all of them into a single generalized vocabulary Γ_P . The translation can support comparison, but it can also remove framework-specific relations.

If

$$\Gamma_P(A_i) \approx \Gamma_P(A_j) \quad (163)$$

for frameworks whose internal organizations differ substantially, comparison may become easier precisely because the differences requiring serious re-recognition have been erased.

Criticality learning therefore distinguishes plural accessibility from epistemic flattening.

The aim is to preserve the possibility that heterogeneous frameworks remain heterogeneous.

7.8 Re-recognition and Possible Worlds

The concept of re-recognition can be extended beyond disciplines and theories to possible worlds.

A framework does more than produce propositions. It can structure what kinds of persons, relations, futures, obligations, institutions, or forms of life appear imaginable.

Learning therefore modifies a learner's epistemic possibility space.

Let

$$\mathcal{P}_t = \{P_1, P_2, \dots, P_m\} \quad (164)$$

denote a set of currently recognizable possible worlds.

A strongly transformative learning process may alter this set:

$$\mathcal{P}_{t+1} = T_i(\mathcal{P}_t). \quad (165)$$

Some possibilities may become newly visible. Others may become less plausible or less salient. Such changes are ordinary effects of learning.

The ethical concern arises when the mode of acquisition systematically makes alternative worlds practically unrecognizable in ways that are highly difficult to revise.

The relevant loss is therefore deeper than disagreement. A learner may cease to possess the conceptual or experiential conditions required even to understand what an alternative possibility would mean.

7.9 Epistemic Foreclosure

The limiting failure of re-recognition is *epistemic foreclosure*.

Epistemic foreclosure occurs when prior learning has transformed the learner's epistemic organization such that one or more previously meaningful alternatives become practically inaccessible as serious objects of understanding.

Let $\alpha_j(t)$ denote accessibility of framework A_j . A foreclosure condition can be represented schematically when

$$\alpha_j(t_0) > 0 \quad \text{and} \quad \alpha_j(t_1) \approx 0, \quad (166)$$

while restoration requires substantial cost or remains practically unavailable.

The change may result from conceptual habit, institutional isolation, linguistic loss, social sanctions, identity formation, affective barriers, or combinations of these conditions.

Foreclosure is therefore relational. It cannot be inferred merely from what a learner believes.

Two learners may hold the same conclusion while differing greatly in epistemic openness. One may have examined alternatives and retain the capacity to revisit them. The other may possess the same conclusion because competing frameworks have become unrecognizable.

Criticality learning treats these as different educational states.

7.10 Irreversibility and Degrees of Closure

Epistemic foreclosure should not be represented as an all-or-nothing event.

Most learning changes accessibility gradually. Some alternatives become more difficult to enter without becoming impossible.

Let

$$C_{ij}(t)$$

denote the effective transition cost from A_i to A_j . Increasing closure may appear as

$$C_{ij}(t_1) > C_{ij}(t_0). \quad (167)$$

The normative concern increases when several conditions coincide:

1. the increase in transition cost is substantial;
2. the process is difficult to reverse;
3. the learner had limited capacity to understand the long-term consequences of the acquisition process;
4. the lost alternative may have significant future epistemic or practical value;
5. the closure was unnecessary for acquiring the knowledge or competence in question.

This graded account avoids treating every specialization as an ethical problem.

Learning French may make some French conceptual distinctions increasingly salient without destroying the capacity to learn Chinese. Mathematical training may strongly orient attention toward formal structure without making historical reasoning inaccessible. Deep religious practice may reorganize a person's life without preventing serious understanding of another tradition.

The stronger concern arises when learning is organized through mechanisms that depend upon the destruction of future re-entry.

7.11 A Principle of Epistemic Re-recognizability

The preceding analysis supports a provisional normative principle.

Proposition 7.1 (Principle of Epistemic Re-recognizability). *Any knowledge, theory, or educational practice whose mode of acquisition irreversibly, or with substantial difficulty of revision, diminishes a subject's capacity to re-recognize alternative conceptual systems, value frameworks, or possible worlds warrants ethical scrutiny.*

The proposition is deliberately formulated in terms of ethical scrutiny rather than automatic prohibition.

There may be cases in which some forms of closure are unavoidable. Expertise requires specialization. Language acquisition changes patterns of attention. Professional formation creates habits. Moral education seeks to stabilize certain judgments. A person may voluntarily organize life around commitments that make some alternatives less salient.

The principle therefore does not require maximal re-recognizability.

Its function is diagnostic. It asks whether the loss of future epistemic access is necessary, proportionate, revisable, and generated under conditions that respect the learner's future capacity for inquiry.

7.12 Re-recognizability and Educational Design

The principle has several implications for educational design.

First, education should distinguish mastery from closure. A curriculum can seek deep competence without requiring students to treat its disciplinary grammar as exhaustive.

Second, competing frameworks should sometimes be presented with enough internal structure to permit genuine reconstruction. Listing alternatives as names or simplified positions preserves formal diversity without preserving re-recognizability.

Third, educational systems should preserve opportunities for later return. Courses, archives, languages, records, and explanatory resources can function as infrastructures of future re-entry.

Fourth, students should be allowed to revisit concepts at different stages of development. Bruner's emphasis on repeated encounter is relevant here [1]. A framework dismissed at one stage may become newly intelligible after later experience.

Fifth, learners should periodically encounter alternative representations of complex problems. Cognitive Flexibility Theory provides an important precedent for repeated traversal through multiple representations in ill-structured domains [17].

The distinctive concern of criticality learning is that these practices also preserve the learner's future capacity to reopen frameworks after strong immersion elsewhere.

7.13 Re-recognition and Comparative Inquiry

Comparative inquiry provides a direct application.

Suppose a learner has studied frameworks A_i and A_j . After prolonged immersion in A_i , the learner returns to A_j .

Weak comparison may ask whether the claims of A_j can be translated into the vocabulary of A_i .

Strong re-recognition asks whether A_j can again reorganize the problem.

This requires a temporary restoration of framework-level susceptibility.

In comparative religion, the question is not merely whether one remembers the doctrines of another tradition. It is whether the distinctions through which that tradition organizes suffering, personhood, transcendence, ritual, or liberation can again become intellectually effective.

In international relations, a scholar deeply formed by one theoretical school may ask whether another school can again alter what counts as the primary problem rather than merely supplying additional variables.

In philosophy, a learner may revisit a thinker previously regarded as obsolete and discover that an intervening intellectual history has created new conditions for understanding the earlier text.

Re-recognition therefore supports comparison across time as well as across frameworks.

7.14 Re-recognition and the Order of Learning

The path dependence developed in Section 3 implies that re-recognition is sensitive to learning order.

Let $\mathcal{E}_i$ and $\mathcal{E}_j$ denote learning episodes involving frameworks i and j . In general,

$$\mathcal{E}_j \circ \mathcal{E}_i(x_0) \neq \mathcal{E}_i \circ \mathcal{E}_j(x_0). \quad (168)$$

A learner who encounters Marx after neoclassical economics does not encounter the same Marx as a learner who encounters neoclassical economics after Marx. A learner who studies Buddhism after Christianity enters a different comparative history from one whose order is reversed.

Re-recognition makes this asymmetry explicit.

Later encounters can also alter the meaning of earlier ones. Learning does not merely accumulate forward. New frameworks can reorganize memories and interpretations of previous learning.

The epistemic history is therefore recursively revisable.

7.15 Retrospective Re-recognition

A particularly important case occurs when a teaching or framework that was previously encountered without substantial understanding becomes meaningful only after later experience.

At t_0 , the learner may encounter an idea Q and generate little meaning:

$$M(Q, x_{t_0}) \approx 0. \quad (169)$$

After later experience and conceptual development,

$$M(Q, x_{t_1}) > M(Q, x_{t_0}). \quad (170)$$

The earlier encounter was therefore not necessarily educationally inert. It may have created a trace that later becomes available for re-recognition.

This structure helps explain why educational effects cannot always be judged at the moment of instruction. A learner may initially reject, misunderstand, or ignore an idea that later becomes significant under changed life conditions.

Re-recognizability consequently includes the preservation of traces, texts, questions, and return paths that allow earlier encounters to become active again.

7.16 Re-recognition and Epistemic Humility

Re-recognition also requires epistemic humility.

A learner who regards the present framework as final may see little reason to preserve access to alternatives. Yet the learner's present judgment is itself historically situated.

Mezirow's account of perspective transformation demonstrates that meaning structures can themselves become objects of revision [12]. Gadamer's hermeneutics similarly rejects the idea of an ahistorical standpoint from which understanding is completed [7].

Criticality learning therefore treats present commitment as compatible with future revisability.

The learner may reasonably say that a framework is presently the most convincing one available while also recognizing that later experience may alter the conditions under which that judgment is made.

Epistemic humility does not weaken inquiry. It preserves the temporal horizon within which inquiry can continue.

7.17 Re-recognition Indicators

A complete operational measure of re-recognizability remains a task for future research. Several provisional indicators can nevertheless be identified.

A learner shows stronger re-recognition when the learner can reconstruct a previously rejected framework without relying exclusively upon the preferred framework's categories; identify changes in how the framework now appears; distinguish disagreement from unintelligibility; recover questions that once made the framework meaningful; reverse the direction of comparison; recognize new significance in previously encountered material; and revise earlier interpretations without requiring erasure of the intervening learning history.

A particularly strong indicator is the ability to say:

I still reject this framework, but I can now see more clearly what kind of world makes it intelligible.

Another is:

I once accepted this framework, but I can now reconstruct both what made it persuasive and why my present judgment differs.

These statements express historically informed recognition rather than simple agreement or disagreement.

7.18 Re-recognition within Criticality Learning

Re-recognition completes an important part of the criticality-learning cycle.

Attractor awareness makes the active grammar visible.

Immersion permits the grammar to become sufficiently generative.

Returnability reopens movement after transformation.

Re-recognition allows other grammars to become genuinely intelligible again from the transformed position.

The resulting sequence can be represented as

$$K_t \xrightarrow{\mathcal{I}_i} A_i \xrightarrow{\mathcal{R}_i} K_{t+1} \xrightarrow{\mathcal{J}_j} A'_j, \quad (171)$$

where $\mathcal{J}_j$ denotes renewed entry into framework j , and A'_j indicates that the framework is now encountered through a different learning history.

In general,

$$A'_j \neq A_j \quad (172)$$

at the level of the learner's effective epistemic relation to the framework.

The framework itself may not have changed. The relation through which it is recognized has.

This supports the following definition.

Proposition 7.2 (Epistemic Re-recognition). *Epistemic re-recognition is the historically situated capacity of a learner, after transformation through prior learning, to permit a previously known or alternative conceptual system, value framework, or possible world to become meaningfully intelligible again without requiring restoration of the learner's earlier epistemic state.*

Re-recognition therefore preserves difference across time.

It allows the learner to be changed without making every earlier or alternative world disappear.

Within criticality learning, this capacity provides the normative bridge between learning and future inquiry. Education can legitimately transform the epistemic landscape. The stronger ethical question concerns whether the mode of transformation unnecessarily destroys the conditions under which the learner may later recognize that other landscapes remain possible.

The next section examines the consequences of this structure for *comparative and value-heterogeneous inquiry*. Religious traditions, political theories, international relations, and cross-cultural research provide settings in which deep immersion, directional comparison, commitment, and re-recognition must coexist without presupposing a framework-independent view from nowhere.

8 Comparative and Value-Heterogeneous Inquiry

The preceding sections developed criticality learning through four capacities: attractor awareness, generative immersion, epistemic returnability, and re-recognition. These capacities become especially important when inquiry moves among frameworks that differ in their concepts, standards of evidence, normative commitments, historical formation, or forms of life.

This section examines such value-heterogeneous and cross-framework inquiry. The central problem is methodological. Serious comparison requires temporary entry into locally organized epistemic worlds, while the act of comparison itself requires sufficient mobility to move among them. A researcher must sometimes allow one framework to organize the inquiry without allowing that temporary organization to become an invisible and permanent meta-language.

This problem appears prominently in comparative religious study, international relations, political and moral inquiry, cross-cultural research, and interdisciplinary philosophy. In each case, frameworks may overlap while remaining partly irreducible to one another.

Criticality learning approaches comparison as a sequence of situated entries, returns, reversals, and recombinations rather than as observation from a framework-independent standpoint.

8.1 Heterogeneous Epistemic Grammars

Cross-framework inquiry becomes difficult when the participating systems organize meaning differently.

Let Γ_i and Γ_j denote two epistemic grammars. Their difference may concern several dimensions:

- characteristic objects of attention;
- legitimate forms of evidence;
- accepted inferential procedures;
- temporal and causal organization;
- conceptions of agency and subjecthood;
- normative distinctions;
- linguistic and symbolic resources;
- relations among knowledge, practice, and experience.

The existence of common vocabulary does not establish equivalence between the underlying grammars. Two traditions may use words translated as *self*, *law*, *freedom*, *reason*, or *salvation* while organizing those terms through substantially different relations.

Likewise, two theories may examine the same empirical event while treating different structures as causally or normatively primary.

Kuhn's account of disciplinary matrices provides one philosophical precedent for treating frameworks as historically organized practices of inquiry rather than collections of detachable propositions [11]. Gadamer's hermeneutic account further emphasizes that understanding occurs from historically formed horizons and that genuine encounter may transform the horizon from which interpretation proceeds [7].

Criticality learning therefore begins comparative inquiry with an assumption of possible heterogeneity. Translation, integration, and synthesis become achievements of inquiry rather than conditions assumed in advance.

8.2 Local Centering

Comparison requires a standpoint.

A researcher cannot activate every epistemic grammar with equal intensity at every moment. Inquiry therefore develops through temporary local centers.

Suppose framework Γ_i is selected as the active standpoint. A directional comparison may then be represented as

$$\Gamma_i(\Gamma_j), \quad (173)$$

where Γ_j is examined through distinctions generated by Γ_i .

Such local centering is methodologically legitimate. A Buddhist philosophical framework may be used to examine a Christian conception of personhood. A Christian theological framework may be used to examine Buddhist accounts of salvation or liberation. A realist theory of international relations may be used to examine the assumptions of liberal institutionalism. International law may be used to evaluate political practices that realism would organize differently.

Criticality learning does not require that comparison begin from an empty position.

The relevant requirement is that the local center remain visible as a local center.

A researcher should therefore be able to identify at least provisionally

- which grammar is organizing the comparison;
- which concepts are being imported from that grammar;
- which aspects of the examined framework may become less visible under this organization;
- whether another direction of comparison remains possible.

Local centering becomes problematic when its locality disappears from awareness.

8.3 Directional Comparison

Cross-framework comparison is often asymmetric for good reasons.

A research question may explicitly ask what one framework reveals about another. Historical circumstance, practical urgency, disciplinary competence, or the object of inquiry may justify a particular direction.

Criticality learning therefore does not require reciprocal comparison in every instance.

The important distinction lies between *directional comparison* and *irreversible comparative privilege*.

Directional comparison temporarily assigns framework Γ_i a privileged analytic role. Irreversible privilege occurs when Γ_i can no longer itself become an object of comparable reorganization.

The difference can be examined through the availability of the reverse relation:

$$\Gamma_j(\Gamma_i). \quad (174)$$

The reverse relation need not produce the same conclusions, and it need not be equally useful for the current research question. Its availability indicates that the original direction has not become the only intelligible geometry of comparison.

This distinction permits strong and even critical comparative arguments while preserving reflexivity.

8.4 Framework Reversal

Framework reversal is a practical operation for testing comparative mobility.

Suppose an inquiry has developed through

$$\Gamma_i(\Gamma_j).$$

A reversal temporarily reconstructs the relation as

$$\Gamma_j(\Gamma_i).$$

The purpose is to observe which assumptions, omissions, and asymmetries become visible when the direction changes.

The result may reveal that the initial framework remains more adequate for the research purpose. Reversal therefore does not imply epistemic equivalence.

Its methodological value lies in exposing relations that remain difficult to observe from only one direction.

A useful reversal procedure contains three stages.

First, reconstruct Γ_j with enough internal depth that the framework can generate questions rather than merely supply terminology.

Second, permit Γ_j to reorganize the relevant object or the assumptions of Γ_i .

Third, compare the two directional relations without requiring immediate synthesis.

The result can be represented as a pair

$$(\Gamma_i(\Gamma_j), \Gamma_j(\Gamma_i)). \quad (175)$$

This pair is more informative than either direction considered alone when the research problem concerns heterogeneous systems.

8.5 Comparative Depth

Framework reversal depends upon sufficient immersion.

A comparison can appear balanced while remaining epistemically asymmetric if one framework has been reconstructed from primary concepts and practices while the other is represented by a few secondary summaries.

Let D_i and D_j denote task-relative depth in two frameworks. Comparative adequacy does not require

$$D_i = D_j.$$

Different research questions justify different levels of specialization.

A minimal condition is that each framework reach enough local depth to perform the role assigned to it in the comparison.

If framework j is expected to generate a serious reversal of framework i , then D_j must be sufficient for internal reconstruction.

This observation is especially important for interdisciplinary and cross-cultural research. Formal inclusion of multiple perspectives does not guarantee substantive plurality.

Spelt and colleagues identify disciplinary knowledge, perspective taking, and integration as important elements of interdisciplinary learning [16]. Criticality learning adds a temporal requirement: the researcher must remain in each relevant framework long enough for its local grammar to become operational before judging the quality of cross-framework movement.

8.6 Metastable Neutrality

Value-heterogeneous inquiry frequently invokes neutrality. The meaning of neutrality requires care.

A framework-independent view from nowhere is unavailable to a historically situated learner. The researcher approaches every object through accumulated languages, practices, concepts, experiences, and institutional relations. Hermeneutic situatedness therefore remains even when the researcher intends to be neutral [7].

Criticality learning treats neutrality as a dynamic condition of *metastable mobility*.

A comparatively neutral epistemic region N_t can be understood as a state in which several relevant frameworks remain accessible and the researcher can move among them without one becoming permanently invisible as a framework.

Neutrality may evolve through inquiry:

$$N_t \rightarrow N_{t+1}. \quad (176)$$

The change is expected because every serious encounter alters the researcher.

The researcher who has studied realism, constructivism, international law, and political economy cannot return to the epistemic configuration that preceded those encounters. Likewise, a scholar who has seriously entered several religious traditions does not recover an untouched position outside religion.

Metastable neutrality therefore preserves movement while allowing history to accumulate.

8.7 Neutrality and Commitment

Metastable neutrality is compatible with local commitment.

A researcher may reach a clear conclusion after comparison. A practitioner may inhabit one religious tradition. A scholar may regard one political theory as more explanatory for a particular case.

Criticality learning does not require these judgments to be weakened merely to preserve a symmetrical appearance.

The relevant capacity is framework mobility. A committed position remains capable of being made visible, interrogated, temporarily decentered, and reconsidered when new relations justify doing so.

This distinction is important because neutrality understood as permanent non-commitment can itself become an epistemic attractor. The learner may become attached to being “above” every framework and consequently refuse the depth required to understand any framework from within.

Attractor awareness must therefore apply to neutrality itself.

Pluralism, neutrality, and interdisciplinarity can all become local grammars with characteristic assumptions. Their methodological value depends partly on their continued revisability.

8.8 Comparative Religious Inquiry

Comparative religion provides a particularly clear case of heterogeneous epistemic grammars.

Religious traditions may organize relations among doctrine, ritual, experience, authority, community, language, history, transcendence, ethics, and forms of life in substantially different ways. A comparison limited to propositional doctrine may therefore omit dimensions that are internally central to one or more traditions.

Criticality learning approaches such inquiry through alternating local immersion and return.

A learner may first enter tradition A_i sufficiently deeply to understand some of its internal distinctions. After return, the learner may enter tradition A_j under similarly serious conditions. Comparison then occurs between historically transformed encounters rather than between simplified lists of doctrines.

One possible sequence is

$$K_0 \rightarrow A_i \rightarrow K_1 \rightarrow A_j \rightarrow K_2. \quad (177)$$

The states K_1 and K_2 preserve the effects of prior immersion.

This structure has two implications.

First, later religious understanding is path-dependent. A learner's encounter with Christianity after sustained Buddhist study will differ from an encounter that precedes such study. The reverse ordering generates another historical relation.

Second, comparison should preserve the possibility of reversal. The learner may legitimately ask what Buddhist concepts reveal about Christian theology. A later inquiry may ask what Christian theological categories reveal about Buddhist claims. Each direction can disclose different relations.

The purpose is neither to establish that the traditions are equivalent nor to force them into a common theology. The objective is to preserve enough framework mobility that heterogeneous structures remain capable of addressing one another.

8.9 Religious Commitment and Re-recognition

Religious commitment provides a strong test for re-recognition because religious learning may involve doctrine, practice, community, identity, affect, and existential orientation simultaneously.

A learner may therefore become deeply situated within one tradition. Such situatedness can support forms of understanding unavailable to detached observation.

The criticality-learning concern lies in the future accessibility of other traditions.

Doctrinal exclusivity and epistemic foreclosure should be analytically distinguished. A religious tradition can claim unique truth while still allowing adherents to study, reconstruct, and understand alternatives. Conversely, a nominally pluralist approach can flatten differences so strongly that distinct religious grammars cease to be recognizable.

The relevant question concerns the conditions of acquisition.

An educational practice becomes more ethically concerning when commitment is generated through mechanisms that make the serious future recognition of alternatives increasingly difficult and when such closure is unnecessary for the practice itself.

This is one application of the Principle of Epistemic Re-recognizability formulated in Proposition 7.1.

8.10 International Relations and Theoretical Plurality

International relations provides another useful domain because the same event can be organized through substantially different theoretical grammars.

A military alliance may appear through one framework as a response to security uncertainty, through another as an institution that changes incentives, through another as a historically constructed identity relation, through another as a legal structure, and through another as an expression of political-economic organization.

These descriptions need not be mutually exclusive. They may nevertheless select different primary relations and imply different research questions.

Criticality learning encourages temporary entry into each relevant grammar before synthesis.

A researcher may therefore move through a sequence of local questions:

- Which relations become salient under a security-centered grammar?
- Which relations become salient under an institutional grammar?
- Which relations become salient under a constructivist or historical grammar?
- Which relations become salient under a legal grammar?
- Which relations become salient under a political-economic grammar?

The value of this procedure lies in allowing the research object itself to change under each framework.

If every framework is introduced only as an additional variable inside the first framework, theoretical plurality remains superficial.

Criticality learning therefore separates *variable addition* from *framework transition*.

Variable addition preserves the organizing grammar while extending its contents. Framework transition allows the organization of the problem itself to change.

8.11 Framework Mobility in International Relations

Theoretical plurality becomes useful when the researcher can move among frameworks without requiring premature integration.

Suppose an event Q is successively organized through grammars Γ_R , Γ_L , and Γ_C . The resulting representations can be written as

$$Q_R = \Gamma_R(Q), \quad Q_L = \Gamma_L(Q), \quad Q_C = \Gamma_C(Q). \quad (178)$$

The research problem then includes relations among Q_R , Q_L , and Q_C .

Some claims may be compatible. Others may operate at different scales. Some may conflict because they assign different causal priority or define the relevant actors differently.

Criticality learning does not require immediate reduction of these representations to one common model.

A period of maintained heterogeneity may itself be epistemically productive. Contradictions can identify assumptions. Missing relations can become visible. One framework may reveal the boundary conditions of another.

Recombination becomes more valuable after these differences have been preserved long enough to be understood.

8.12 Cross-Cultural Inquiry

Cross-cultural inquiry extends the same problem beyond formal disciplines.

Languages and cultural-historical systems can organize distinctions in ways that lack exact counterparts elsewhere. Translation therefore creates new relations while also risking premature equivalence.

Criticality learning treats translation as an epistemic transition rather than a transparent transfer.

Let L_i and L_j denote two linguistic or cultural-symbolic systems. A translated concept can be represented schematically as

$$T_{ij}(c_i) = c'_j, \quad (179)$$

where c'_j is a reconstruction within L_j .

The prime indicates that translation generally produces a new relational object. Exact identity cannot be assumed.

Repeated movement across languages can therefore alter the learner's epistemic state. A concept encountered in one language may become newly recognizable after learning another language, while a familiar concept may lose its previous apparent simplicity.

Re-recognition becomes important because later translation occurs from a changed linguistic history.

This structure supports a cautious form of cross-cultural comparison. The researcher preserves terms in their local relations long enough to understand their generative role, then explores mappings without assuming that the map exhausts the source structure.

8.13 Power and Comparative Accessibility

Framework accessibility is also shaped by power.

Some languages, disciplines, institutions, religions, or theoretical schools possess greater material and symbolic resources than others. Their concepts may dominate curricula, publishing systems, professional credentials, and public discourse.

As a result, apparent framework preference may partly reflect unequal conditions of exposure and recognition.

Critical pedagogy provides an important neighboring tradition because it places education within relations of domination, dialogue, and emancipatory praxis [6]. Criticality learning approaches a narrower but related issue: whether unequal social conditions alter which epistemic frameworks a learner can seriously enter, leave, and re-recognize.

A formally open intellectual environment may therefore remain dynamically asymmetric.

One framework may have abundant teachers, translations, archives, funding, and institutional legitimacy. Another may remain accessible only through fragmented or externally interpreted sources.

Such asymmetry affects immersion quality and returnability.

Comparative inquiry should therefore examine the conditions through which frameworks become available, rather than treating all observed differences in uptake as purely individual preference.

8.14 Translation and Reduction

Cross-framework inquiry frequently requires translation. Translation is valuable because complete non-communication would make comparison impossible.

The difficulty lies in preserving the difference between translation and reduction.

A translation attempts to construct relations between grammars. Reduction treats one grammar as fully representable within another without significant remainder.

Suppose a mapping exists:

$$T_{ij} : \Gamma_i \rightarrow \Gamma_j. \quad (180)$$

The existence of T_{ij} does not imply that the map is invertible or lossless.

A useful comparative practice therefore records translation remainder: concepts, practices, relations, or normative structures that become difficult to preserve under the mapping.

The remainder is not automatically evidence of radical incommensurability. It is evidence that the comparison has a boundary.

Criticality learning treats such boundaries as generative objects of inquiry. They identify locations where additional immersion, alternative translation, or a new relational vocabulary may be required.

8.15 Premature Synthesis

One recurring failure mode in heterogeneous inquiry is premature synthesis.

The learner encounters several frameworks and rapidly seeks a common theory that reconciles them.

Synthesis can be highly productive. Its timing matters.

If synthesis begins before the participating grammars have reached sufficient local depth, differences may be erased before their significance is understood.

Premature synthesis can take several forms:

- treating similar vocabulary as conceptual identity;
- converting one framework into variables inside another;
- identifying a vague common principle that removes substantive disagreements;
- retaining only the elements compatible with the researcher's preferred framework;
- treating irreducible differences as temporary terminological confusion.

Criticality learning therefore permits a phase of sustained heterogeneity.

Frameworks may remain in tension while the learner develops enough mobility to move among them.

Recombination follows after rather than before this period of differentiated immersion.

8.16 Strong Comparison

The preceding discussion supports a distinction between weak and strong forms of comparison.

Weak comparison places externally described features side by side. It may be useful for classification or introductory survey.

Strong comparison requires deeper movement.

A strong comparative process includes:

1. task-relative immersion in each relevant framework;
2. reconstruction of framework-specific problem formation;
3. explicit identification of the current local center;
4. directional comparison;
5. at least provisional framework reversal when appropriate;
6. preservation of translation remainder;
7. return to a transformed comparative region;

8. delayed recombination or judgment.

This process does not guarantee objectivity. It creates more demanding conditions for reflexive comparison.

The researcher remains historically situated throughout.

8.17 A Comparative Mobility Criterion

The quality of cross-framework inquiry can therefore be examined partly through *comparative mobility*.

Let A_i and A_j be relevant frameworks. Comparative mobility is stronger when the learner can move in both directions with enough depth for each framework to reorganize the object:

$$A_i \rightleftharpoons A_j. \quad (181)$$

The double arrow represents accessibility rather than equality.

The transition costs may differ substantially:

$$C(A_i \rightarrow A_j) \neq C(A_j \rightarrow A_i). \quad (182)$$

Criticality learning therefore does not require symmetrical trajectories. It requires that relevant transitions remain meaningfully possible.

This leads to a provisional proposition.

Proposition 8.1 (Comparative Framework Mobility). *Comparative framework mobility is the learner's capacity to permit more than one sufficiently reconstructed epistemic grammar to reorganize a shared object of inquiry, while retaining awareness of the direction, asymmetry, and historical conditions of the comparison.*

The proposition places mobility at the level of problem organization. A researcher who can summarize several theories while allowing only one to define the problem exhibits informational plurality with limited framework mobility.

8.18 Value Heterogeneity and Judgment

Framework mobility does not suspend judgment indefinitely.

Comparative inquiry eventually requires decisions about explanatory adequacy, ethical acceptability, legal validity, historical plausibility, or practical action.

Criticality learning modifies the conditions under which such judgment is formed.

Judgment follows encounters in which relevant alternatives have been permitted to become sufficiently intelligible. The resulting conclusion may remain asymmetric and decisive.

The learner may reject one framework after understanding it more deeply. Re-recognition remains valuable because future conditions may justify renewed examination.

This structure gives judgment a temporal character. A conclusion can be firm at the present stage of inquiry while remaining historically revisable.

Such revisability is compatible with responsible action. International politics, law, ethics, and public policy often require decisions before every framework can be fully reconciled. Criticality learning does not remove this constraint.

Its contribution is to preserve awareness that decision closes some immediate possibilities without necessarily requiring permanent epistemic closure.

8.19 Comparative Inquiry within Criticality Learning

Comparative and value-heterogeneous inquiry brings the principal elements of criticality learning together.

A learner begins from a historically situated region of inquiry. One framework becomes locally active. Immersion allows its grammar to become generative. Attractor awareness keeps the locality of that grammar visible. Returnability permits movement away from its dominance. Re-recognition allows another framework to become intelligible under changed conditions. Framework reversal tests whether comparative direction has become rigid. Recombination becomes possible after differentiated structures have been preserved long enough to interact meaningfully.

A representative sequence is

$$K_0 \rightarrow A_i \rightarrow K_1 \rightarrow A_j \rightarrow K_2 \rightarrow A'_i \rightarrow K_3. \quad (183)$$

The return to A'_i illustrates a central feature of the model. The learner does not encounter the first framework in exactly the same way after serious immersion in the second. Comparison changes both the understanding of the alternative and the understanding of the initial framework.

Criticality learning therefore treats comparative inquiry as recursively transformative.

The principal methodological orientation can be stated in ordinary language: enter a framework deeply enough for its internal distinctions to become generative, retain awareness of its local position, preserve the capacity to reverse the comparative relation, and allow later encounters to revise the meaning of earlier ones.

The next section turns from comparison to *recombination and creative generation*. Once several epistemic grammars have become sufficiently deep, returnable, and re-recognizable, the learner may generate relations that are not contained within any one framework considered separately.

9 Recombination and Creative Generation

The preceding sections treated criticality learning primarily as a problem of movement: entering an epistemic framework, becoming sufficiently immersed in its generative grammar, returning from its local dominance, and preserving the capacity to re-recognize alternatives. These movements create the conditions for a further process: *recombination*.

Recombination concerns the generation of questions, representations, relations, distinctions, or conceptual structures that become possible through the interaction of previously acquired epistemic grammars. It is therefore different from the simple accumulation of disciplinary contents. A learner may possess knowledge from several fields without generating any new relation among them. Criticality learning becomes creatively productive when heterogeneous grammars remain sufficiently distinct to contribute different operations while also becoming sufficiently accessible to interact.

This section develops recombination as a relational consequence of epistemic mobility. The emphasis remains modest. Criticality learning does not provide a general theory of creativity, nor does it imply that creative insight can be reduced to a deterministic operation over disciplinary representations. The present claim is narrower: preserved mobility among sufficiently developed epistemic grammars can create conditions under which previously unavailable relations become generable.

9.1 Recombination after Differentiated Immersion

Recombination presupposes differentiation.

Suppose a learner has acquired two epistemic grammars, Γ_i and Γ_j . If both have been reduced in advance to a single common vocabulary, their interaction may contribute little beyond the dominant grammar already organizing the comparison. If neither has been learned with sufficient depth, recombination may amount to the juxtaposition of terminology.

Criticality learning therefore places differentiated immersion before strong recombination.

Let D_i and D_j denote task-relative depth in two frameworks. A minimal condition for substantive recombination is that both exceed the depth required for the intended inquiry:

$$D_i \geq D_i^*, \quad D_j \geq D_j^*. \quad (184)$$

The thresholds D_i^* and D_j^* remain task-dependent. They do not imply expert mastery. They indicate that each grammar has become sufficiently operational to generate distinctions and transformations rather than merely labels.

This requirement is compatible with Cognitive Flexibility Theory, which emphasizes the value of multiple representations and repeated traversal in complex and ill-structured domains [17]. Criticality learning adds that the participating representations may themselves be historically stabilized epistemic structures whose interaction depends upon the learner's capacity to enter and leave them without premature reduction.

9.2 Juxtaposition and Generative Interaction

Several frameworks can coexist in a learner's repertoire without interacting generatively.

A weak interdisciplinary configuration may contain

$$\Gamma_i, \quad \Gamma_j, \quad \Gamma_k,$$

while each remains isolated from the others. The learner knows which framework to invoke for which conventional problem but does not generate relations across them.

Generative recombination begins when an operation available in one grammar changes how another grammar, object, or question can be organized.

For two grammars, this can be represented schematically by an interaction operator

$$\mathcal{C}_{ij} : (\Gamma_i, \Gamma_j, Q) \mapsto Q'_{ij}, \quad (185)$$

where Q is an initial object of inquiry and Q'_{ij} is a newly generated question or representation made possible by the relation between the two grammars.

The operator $\mathcal{C}_{ij}$ is conceptual. It does not denote a fixed algorithm. Different recombinations may involve analogy, translation, formalization, scale transfer, reversal of assumptions, comparison of invariants, reinterpretation of evidence, or the creation of new vocabulary.

The important feature is that the output is not reducible to the independent application of either grammar alone.

9.3 Non-commutativity of Recombination

Recombination inherits the path dependence of learning.

The sequence in which frameworks are acquired and activated can affect the relations that become visible. A learner who first acquires a mathematical grammar and later enters political theory may generate different questions from a learner whose historical sequence is reversed.

If $\mathcal{C}_{ij}$ denotes recombination initiated from Γ_i toward Γ_j , and $\mathcal{C}_{ji}$ the reverse direction, there is no general reason to expect

$$\mathcal{C}_{ij}(Q) = \mathcal{C}_{ji}(Q). \quad (186)$$

This asymmetry is intellectually productive. One framework may contribute the initial problem structure while another contributes a perturbing concept. In a different ordering, the roles may reverse.

The resulting insight is therefore partly historical. Creativity emerges from a learner whose repertoire has been formed through a particular sequence of encounters.

Criticality learning does not seek to remove this dependence. Attractor awareness makes the direction of generation more visible, while framework reversal creates opportunities to explore alternative orderings.

9.4 Perturbation across Frameworks

A framework can function as a perturbation to another framework.

Suppose Γ_i has produced a relatively stable representation Q_i . A concept, distinction, or operation from Γ_j may disturb this organization:

$$Q_i \xrightarrow{\delta_j} Q'_{ij}, \quad (187)$$

where δ_j denotes a perturbation generated from framework j .

The value of the perturbation does not depend upon complete transfer of Γ_j into Γ_i . A relatively small conceptual intervention may reveal an assumption that had remained invisible inside the stable organization of Q_i .

For example, a dynamical-systems concept may lead a political theorist to ask whether a phenomenon previously treated as a stable category is better understood through transition, path dependence, or basin structure. Historical analysis may then reveal that the mathematical analogy conceals institutional or symbolic contingencies. The second framework can therefore perturb the first, while the first remains capable of responding.

Generative recombination develops through this reciprocal disturbance rather than through unilateral translation.

9.5 Preserved Difference

Recombination requires sufficient relation, but it also requires sufficient difference.

If two frameworks become completely assimilated before interaction, little remains to generate tension or novelty. The relation becomes redundant.

Let $d(\Gamma_i, \Gamma_j)$ denote a conceptual measure of effective difference between two grammars. The present framework does not define a numerical metric for d , but the notation makes one structural point explicit: generative interaction requires neither zero difference nor complete disconnection.

A useful region can be described qualitatively as one in which

$$0 < d(\Gamma_i, \Gamma_j) < d_{\text{inaccessible}}. \quad (188)$$

The first inequality preserves heterogeneity. The second indicates that the grammars remain sufficiently accessible for relation to be generated.

This structure parallels the metastable orientation of criticality learning. Creative inquiry benefits from frameworks that are differentiated enough to produce distinct organizations and connected enough to perturb one another.

Premature synthesis can reduce the first condition. Epistemic foreclosure can destroy the second.

9.6 Translation Remainders as Generative Sites

Section 8 treated translation remainder as a boundary of cross-framework mapping. Such remainders can also become sources of generation.

Suppose a mapping

$$T_{ij} : \Gamma_i \rightarrow \Gamma_j$$

fails to preserve some relation r_i . Instead of treating the failure merely as a defect in translation, the learner may examine why r_i lacks an adequate counterpart.

Several possibilities arise.

The receiving framework may lack a required distinction. The source framework may contain an assumption that does not survive outside its original context. The apparent mismatch may reveal that two concepts previously treated as equivalent perform different generative roles. A new intermediary concept may be required.

Translation failure can therefore produce a new research object.

In this sense, the residue left by incomplete mapping is epistemically valuable. It marks a relation that has resisted absorption into the current comparative grammar.

9.7 Recombination without Reduction

A common response to interdisciplinary complexity is to seek a unified framework. Such unification can be productive when the participating structures genuinely support it. Criticality learning does not assume that every successful recombination should terminate in a unified grammar.

Some relations may remain heterogeneous.

A new conceptual structure Γ'_{ij} may arise from the interaction of Γ_i and Γ_j :

$$\mathcal{C}_{ij}(\Gamma_i, \Gamma_j) = \Gamma'_{ij}. \quad (189)$$

The emergence of Γ'_{ij} does not require the disappearance of the contributing grammars. The learner may retain

$$\Gamma_i, \quad \Gamma_j, \quad \Gamma'_{ij}$$

as distinct but related resources.

This multiplicity is important because the newly generated framework may itself become an attractor. Once stabilized, it can acquire a vocabulary, preferred questions, inferential habits, and characteristic blind spots.

Criticality learning therefore applies recursively to its own products.

A successful interdisciplinary synthesis should eventually become available for attractor awareness, return, and re-recognition in the same way as the frameworks from which it emerged.

9.8 The Formation of New Attractors

Creative recombination can alter the epistemic landscape.

Suppose a recurrent relation between Γ_i and Γ_j generates a new grammar Γ'_{ij} . Repeated use may stabilize this grammar into a new attractor-like structure A_{ij} .

The process can be represented as

$$(\Gamma_i, \Gamma_j) \xrightarrow{\mathcal{C}_{ij}} \Gamma'_{ij} \xrightarrow{\text{repeated use}} A_{ij}. \quad (190)$$

This possibility is especially important for interdisciplinary research. Novel fields, methods, and theoretical programs often begin through relations among previously separate domains and later acquire their own institutional and conceptual stability.

Once stabilization occurs, the benefits and risks described earlier return. The new framework can support depth and accumulated generation. It can also become sufficiently familiar that its contingent origins disappear from awareness.

Criticality learning therefore has no final synthesis.

Every generated framework may later become another object of immersion, awareness, comparison, return, and recombination.

9.9 Recombination and the Evolution of the Epistemic State Space

Creative learning may change more than the learner's position within an existing space. It may create previously unavailable dimensions of inquiry.

Section 3 introduced the possibility that the effective epistemic state space evolves through learning:

$$\mathcal{M}_{t+1} \neq \mathcal{M}_t. \quad (191)$$

Recombination provides one mechanism for such evolution.

If a new relation cannot be represented adequately through the learner's existing grammars, the learner may need to construct a new distinction or representational axis. The result is an expansion or reorganization of the effective space of possible inquiry.

Let $\Delta\mathcal{M}_{ij}$ denote the structural change associated with a recombination event. The later epistemic space may then be represented schematically as

$$\mathcal{M}_{t+1} = \mathcal{T}_{ij}(\mathcal{M}_t), \quad (192)$$

where $\mathcal{T}_{ij}$ denotes the transformation generated through the interaction of frameworks i and j .

The significance of this formulation is conceptual. Creative learning need not consist only of selecting a previously available answer. It may alter the set of questions and relations that can subsequently be generated.

9.10 Recombination and Serendipitous Encounter

Not every productive recombination is planned.

A concept acquired in one field may remain inactive until an unrelated encounter makes a new relation salient. A historical observation, artistic experience, conversation, empirical anomaly, unfamiliar place, or forgotten text may reactivate a dormant grammar.

The learner's accumulated repertoire therefore creates latent possibilities for future recombination.

Suppose grammars Γ_i and Γ_j are both available but have not previously interacted. An external encounter e_t may create a new relation:

$$(\Gamma_i, \Gamma_j, e_t) \mapsto Q'_{ij}. \quad (193)$$

The encounter does not generate the result independently. Its effect depends upon the learner's prior epistemic history.

This observation connects recombination with Dewey's emphasis on continuity of experience [4]. Earlier learning changes the conditions under which later encounters become meaningful. A

seemingly minor event can become generative because the learner already possesses structures that can be brought into relation through it.

Criticality learning can therefore increase the generative value of serendipity by maintaining several grammars in a state of reasonable accessibility.

9.11 Incubation and Delayed Recombination

Recombination may also be temporally delayed.

A learner can complete an immersion episode without producing an immediate cross-framework insight. The acquired grammar remains available and later participates in another relation.

The time between acquisition and recombination can be educationally important. Immediate synthesis may preserve the organization dominant during immersion. Temporal distance can reduce local attraction and permit different relations to become salient.

This provides another reason that criticality learning should not evaluate every excursion solely by its immediate output.

An encounter may contribute to the learner's repertoire before its generative role becomes visible.

The resulting epistemic history contains latent relations whose later activation cannot always be predicted at the time of learning.

9.12 Recombination and Original Questions

The original-question anchor introduced in Section 6 can become an important site of recombination.

Suppose an inquiry begins with Q_0 . Immersion in two frameworks produces

$$Q_i = \Gamma_i(Q_0), \quad Q_j = \Gamma_j(Q_0). \quad (194)$$

After return, the learner can compare not only the answers generated by the two frameworks but also the transformations applied to the original question.

A new question may emerge from the difference between Q_i and Q_j .

This form of recombination is especially valuable because it preserves the history of problem formation. Instead of asking which framework gives the correct answer to an assumed common question, the learner examines how the frameworks generated different questions from the same initial concern.

The divergence itself can become the object of inquiry.

9.13 Conceptual Hybridization

Some recombinations generate hybrid concepts.

A concept from one framework may be modified through constraints imported from another. The resulting concept cannot be understood as a direct transfer from either source.

Let $c_i \in \Gamma_i$ and $c_j \in \Gamma_j$. A hybrid concept may be represented by

$$c'_{ij} = H(c_i, c_j), \quad (195)$$

where H denotes a generative transformation.

Hybridization can be productive when the new concept clarifies relations that were previously difficult to articulate.

It can also create conceptual confusion when incompatible assumptions are combined without recognition.

Criticality learning therefore requires genealogical awareness of hybrid concepts. The learner should remain capable of asking which elements came from which framework, which relations changed during recombination, and which source assumptions were retained or discarded.

The resulting concept should eventually become available for independent evaluation.

9.14 Analogy and Structural Transfer

Cross-disciplinary creativity frequently involves analogy.

A structure recognized in one domain is used to generate a question in another. Criticality learning treats analogy as a perturbative operation whose value lies in generation rather than automatic equivalence.

Suppose relation R_i is identified in framework i . An analogical mapping to domain j can be written as

$$\mathcal{A}_{ij}(R_i) = R_j^*, \quad (196)$$

where R_j^* is a candidate relation to be investigated.

The asterisk is important. The mapped relation is a hypothesis-producing object. It does not establish structural identity.

For example, concepts such as attractor, landscape, phase transition, or resonance can generate questions in social and cultural inquiry. Their productive use depends upon identifying which relations transfer, which do not, and where the analogy breaks.

Criticality learning therefore separates analogy as a generative operation from analogy as evidence.

This distinction permits strong exploratory creativity while maintaining disciplinary caution.

9.15 Recombination and Framework Critique

Recombination can also generate critique.

An alternative grammar may reveal assumptions or omissions that remain difficult to perceive from inside a stabilized framework.

The critique need not replace the original framework. It may identify a boundary condition, missing relation, or domain in which another form of description is required.

This is one reason framework mobility has epistemic value even for strongly specialized researchers. An external grammar can function as a perturbation that makes the home discipline more reflexive.

The resulting critique is strongest when the alternative framework has been learned with enough depth to generate its own questions. Superficial borrowing may produce rhetorical critique without structural understanding.

Recombination therefore depends upon the same generative immersion that supports comparison.

9.16 Recombination and Creative Risk

Creative recombination carries epistemic risks.

Relations generated across distant frameworks may be attractive precisely because they are novel. Novelty can conceal weak correspondence, category errors, unsupported universalization, or metaphorical overextension.

Criticality learning cannot eliminate these risks. It can introduce several forms of discipline.

First, the learner can return to each source framework and test whether the borrowed concept has been represented adequately.

Second, the learner can identify where the recombination is exploratory, analogical, formal, empirical, or normative.

Third, the learner can preserve the distinction between a generative question and a supported conclusion.

Fourth, framework reversal can test whether the proposed relation remains meaningful when examined from the other side.

Fifth, the newly generated structure can be treated as provisional and revisable.

These practices allow creativity to remain generative without granting novelty automatic epistemic authority.

9.17 Creative Criticality

The interaction between metastability and recombination can now be stated more precisely.

A learner fixed entirely within one attractor may possess substantial depth but limited access to heterogeneous perturbations. A learner moving continuously among many frameworks may possess diversity but insufficient internal structure for strong generation.

Creative criticality occupies a region in which several sufficiently developed grammars remain accessible and can be activated without requiring permanent capture by any one of them.

Let

$$\mathcal{G}_t^* = \{\Gamma_1, \Gamma_2, \dots, \Gamma_m\}$$

denote the subset of grammars that are both operational and meaningfully accessible at time t .

The learner's recombinational possibilities depend partly upon the relations available among elements of $\mathcal{G}_t^*$.

The framework does not imply that maximizing the number of accessible grammars maximizes creativity. Too many weakly developed frameworks can increase fragmentation. The relevant property is the quality and diversity of relations among sufficiently generative structures.

9.18 Recombination as a Historical Process

Recombination is cumulative.

A newly generated grammar can participate in later interactions. Let Γ'_{ij} emerge from an earlier relation between Γ_i and Γ_j . A later encounter with Γ_k may produce

$$\mathcal{C}(\Gamma'_{ij}, \Gamma_k) = \Gamma''_{ijk}. \quad (197)$$

The learner's conceptual history therefore develops through recursive generation.

This process also explains why re-recognition remains important after successful synthesis. A new framework may alter the learner's interpretation of the original sources. Returning to Γ_i after the generation of Γ'_{ij} may reveal aspects that were previously invisible.

Generation and re-recognition consequently form a feedback relation.

New combinations change the learner, and the changed learner can return to older frameworks under new conditions.

9.19 Generative Failure Modes

Several failure modes can limit recombination.

Terminological collage. Concepts from several disciplines are placed together without operational understanding of their source grammars.

Decorative formalization. Mathematical or scientific vocabulary is introduced without contributing a genuine structural constraint or generative operation.

Premature unification. Heterogeneous frameworks are collapsed into a common model before their differences have been reconstructed.

One-way assimilation. One framework supplies the organizing grammar while others contribute only examples or vocabulary.

Analogy inflation. A productive analogy is treated as evidence that two domains possess the same underlying structure.

Novelty attachment. The learner becomes invested in a newly generated framework and loses sensitivity to counterexamples or alternative interpretations.

Genealogical erasure. The historical contributions of source frameworks disappear, making the new concept difficult to examine or revise.

These failure modes show why creativity requires the earlier capacities of criticality learning. Attractor awareness, returnability, and re-recognition remain active during generation.

9.20 Recombination Indicators

A recombination is more substantively generative when several conditions are present.

The contributing frameworks can be reconstructed independently of the new proposal. The relation among them generates a question or distinction that was previously difficult to formulate. The new structure makes identifiable constraints or predictions about what should follow. The limits of translation or analogy remain visible. The learner can return to the source frameworks and identify what changed during the combination. The new framework remains revisable and does not automatically erase the heterogeneity from which it emerged.

These indicators do not provide a metric of creativity. They help distinguish generative interaction from superficial interdisciplinarity.

9.21 Recombination within Criticality Learning

Recombination completes the basic cycle developed in the paper.

Attractor awareness makes the current grammar visible. Generative immersion provides local depth. Epistemic returnability reopens movement. Re-recognition allows other frameworks to become meaningful after transformation. Comparative mobility creates relations among heterogeneous grammars. Recombination generates new questions and structures from those relations.

A minimal multi-framework trajectory can be represented as

$$K_0 \xrightarrow{\mathcal{I}_i} A_i \xrightarrow{\mathcal{R}_i} K_1 \xrightarrow{\mathcal{I}_j} A_j \xrightarrow{\mathcal{R}_j} K_2 \xrightarrow{\mathcal{C}_{ij}} K_3. \quad (198)$$

The state K_3 may contain relations unavailable at K_0 . It can also contain a newly stabilizing framework that later becomes an object of further criticality learning.

This supports the following proposition.

Proposition 9.1 (Generative Recombination). *Generative recombination occurs when two or more sufficiently developed and meaningfully accessible epistemic grammars interact to produce questions, representations, distinctions, or relational structures that were not readily generable through the isolated operation of the participating grammars.*

The definition emphasizes three conditions: sufficient disciplinary depth, continued accessibility, and genuinely relational generation.

Criticality learning therefore treats creativity as compatible with disciplinary seriousness. Deep immersion provides the structures from which new relations can be generated, while returnability prevents those structures from becoming mutually inaccessible.

The next section turns to the practical and methodological implications of the framework. It examines how criticality learning might be cultivated without requiring complete reconstruction of a learner's epistemic state space, how local indicators may support learning design, and where the present conceptual model requires empirical development.

10 Learning Design and Practical Cultivation

The preceding sections developed criticality learning as a conceptual model of epistemic movement. The framework would remain incomplete, however, if its practical use depended upon reconstructing a learner's entire epistemic state space, identifying every attractor, or numerically measuring the cost of every possible transition. Such information is unavailable in ordinary learning situations and may remain unavailable even under substantially improved empirical methods.

The practical problem is therefore one of learning design under epistemic uncertainty. A learner or educator must make locally useful judgments without possessing a complete model of the learner.

This section develops a provisional approach based on local observation, small perturbations, reversible interventions, periodic return, and repeated reassessment. The objective is to cultivate the conditions of criticality learning rather than to prescribe a universally optimal learning trajectory.

10.1 Local Governance without Complete Reconstruction

Criticality learning does not require a complete answer to the question

What is the learner's full epistemic state?

A more practical set of questions concerns local changes:

- Which grammar is currently organizing the inquiry?
- Has that grammar become sufficiently deep to generate new questions?
- Are alternative descriptions still meaningfully available?
- Has the learner become unable to recover the original problem?
- Does another framework still have the capacity to reorganize the object?
- Is continued immersion producing new generativity or mainly repetition?

These questions do not reconstruct the full geometry of the learner's epistemic landscape. They estimate local directionality.

Suppose a learner's epistemic trajectory is represented by $x(t)$. A local intervention changes the learning condition by a small perturbation δC . The resulting response can be observed schematically as

$$\Delta x = x(t + \Delta t; C + \delta C) - x(t + \Delta t; C). \quad (199)$$

The practical significance of Equation (199) is limited but useful. One need not know the entire function governing development in order to observe whether a small change in learning conditions increases depth, mobility, confusion, resistance, or generative questioning.

This suggests a local learning process:

probe, observe, interpret, adjust, and probe again.

The sequence resembles reflective and adaptive approaches already present in metacognitive and reflective-practice traditions [5, 15]. Criticality learning specifies epistemic mobility as one of the variables to be observed.

10.2 Task Mode Selection

Criticality learning should not govern every learning episode.

Different tasks require different dynamical modes. A learner preparing for a mathematics examination may benefit from sustained residence within one formal grammar. A musician acquiring a difficult technique may require repeated practice with minimal framework switching. A language learner developing basic fluency may need stable repetition.

Other tasks benefit more directly from criticality learning. These include comparative inquiry, theoretical synthesis, exploratory research, creative problem formation, cross-cultural interpretation, and problems for which the relevant framework remains uncertain.

Learning design should therefore begin by identifying the dominant task mode.

A useful distinction is among:

Mastery mode. The immediate objective is reliable performance within an established grammar.

Exploratory mode. The learner is investigating which grammar, representation, or problem formulation may be useful.

Comparative mode. Several frameworks must be reconstructed and examined in relation.

Generative mode. The learner seeks new questions, concepts, or relations across existing structures.

Criticality learning is expected to play a larger role in the latter three modes.

The modes can alternate. A learner may temporarily enter mastery mode within a discipline in order to acquire enough depth for later comparison. Criticality learning therefore regulates transitions among learning modes rather than replacing disciplinary mastery.

10.3 The Original-Question Anchor

One of the simplest practical tools is preservation of the question that preceded intensive framework immersion.

Before beginning a disciplinary excursion, the learner records an initial question Q_0 in relatively ordinary language. During immersion, the framework may transform the problem:

$$Q_i = \Gamma_i(Q_0). \quad (200)$$

After the excursion, the learner returns to both Q_0 and Q_i .

The comparison asks:

- What became newly visible?
- What became more precise?
- What disappeared from attention?
- Which assumptions entered through the framework?
- Does the transformed question still address the concern that initiated the inquiry?

The purpose of Q_0 is historical rather than foundational. The initial question is itself situated and may be poorly formulated. It functions as a record of epistemic transformation.

This practice is particularly useful in long research projects, where a discipline can gradually redefine the research question until the learner no longer remembers which problem originally motivated the inquiry.

10.4 Framework Journaling

Attractor awareness can be cultivated through a lightweight record of framework use.

A framework journal does not require extensive diary writing. After a learning session, the learner records several short observations:

- the framework primarily used;
- the concepts that became unusually salient;
- questions newly generated by the framework;
- alternative descriptions that became harder to access;
- unresolved tensions or anomalies;
- possible frameworks for a later reversal.

Over time, such records can reveal patterns that remain difficult to notice within a single session.

For example, a learner may discover that nearly every new social problem has been reformulated through a dynamical-systems vocabulary during several consecutive weeks. This pattern does not establish misuse. It creates a reason to perform a return test.

Framework journaling operationalizes a specific form of metacognitive monitoring [5]: the object being monitored is the changing distribution of epistemic grammars.

10.5 De-jargonization as a Return Practice

Technical vocabulary is necessary for disciplinary precision. It can also make the organizational effect of a framework difficult to perceive.

A practical return exercise is therefore temporary de-jargonization.

The learner selects an object currently described through a preferred framework and attempts to explain it without several characteristic terms from that framework.

The goal is not to produce a superior nontechnical description. The exercise tests whether the learner can loosen the automatic connection between the object and one vocabulary.

Several outcomes are possible.

The learner may discover that the technical vocabulary was genuinely indispensable for a specific distinction. The exercise may reveal an implicit assumption that ordinary language makes easier to notice. It may also expose that the learner has been using a technical term where a simpler relation would suffice.

De-jargonization is therefore a diagnostic perturbation.

It becomes particularly useful when a learner notices that the same small set of theoretical terms appears across increasingly heterogeneous topics.

10.6 Alternative Description Exercises

A stronger return practice requires the learner to generate more than one serious description of the same object.

Suppose an object Q has been organized through grammar Γ_i . The learner deliberately selects a different grammar Γ_j and constructs

$$Q_i = \Gamma_i(Q), \quad Q_j = \Gamma_j(Q). \quad (201)$$

The exercise then compares the two representations.

The relevant question is not immediately which one is correct. The learner first identifies changes in salience, scale, agency, evidence, and problem formation.

For example, a political conflict may be described strategically, historically, legally, economically, and phenomenologically. The descriptions need not be assigned equal authority. Their temporary coexistence makes the effect of each grammar more visible.

Repeated alternative-description practice can cultivate framework mobility without requiring constant abandonment of disciplinary expertise.

10.7 Framework Reversal Exercises

The reversal operation developed in Section 8 can be used as a practical learning exercise.

If a learner has developed an analysis of Γ_j through Γ_i , the learner attempts the reverse direction:

$$\Gamma_i(\Gamma_j) \longrightarrow \Gamma_j(\Gamma_i).$$

The reversed comparison does not need to become the final interpretation. Its value lies in identifying asymmetries.

A learner may discover that the second framework cannot yet be reconstructed with enough depth. This result indicates a need for further immersion rather than a failure of the method.

Alternatively, the learner may discover that the preferred framework contains assumptions that became visible only when treated as an object rather than a meta-language.

Reversal therefore combines attractor awareness, immersion, and returnability within one exercise.

10.8 Periodic Return

Long immersion episodes may benefit from deliberate return intervals.

The purpose is not to maintain a fixed schedule such as changing fields every day or every week. The appropriate interval depends upon the task and the rate at which the grammar is becoming operational.

A return interval becomes useful when the learner observes signs such as:

- rapidly diminishing novelty within the current framework;
- difficulty describing the problem without its vocabulary;
- loss of the original question;
- automatic dismissal of alternative approaches;
- increasing identity attachment to the framework;
- repeated application of the same explanation across unrelated objects.

A return interval may involve a different discipline, a primary source, an unstructured observation period, conversation with someone from another background, or simply temporary suspension of the theoretical task.

The duration need not be long. The purpose is to test whether transition capacity remains available.

10.9 Open Intervals and Unstructured Attention

Criticality learning also benefits from intervals in which no disciplinary task is assigned in advance.

Highly structured study increases the probability that attention will follow known disciplinary paths. Open intervals allow environmental encounters to generate perturbations whose relevance was not predictable beforehand.

Walking, observing public space, listening to music, visiting an unfamiliar institution, reading outside the current research problem, or engaging in unstructured conversation can all function as sources of perturbation.

The educational significance of such activities depends upon prior learning. An observation that appears trivial to one learner may activate several latent grammars in another.

The value of open intervals is therefore relational rather than inherent. Their role is to provide opportunities for salience to emerge outside the currently dominant task structure.

They should not replace systematic study. Their value becomes stronger when combined with sufficiently developed disciplinary grammars that can later participate in recombination.

10.10 Rest and Delayed Integration

Immediate cognitive activity is not always required for generation.

After intensive immersion, a learner may benefit from a period during which explicit problem solving is reduced. Concepts acquired during the learning episode remain part of the learner's epistemic history and can participate in later re-recognition or recombination.

Criticality learning therefore does not assume that every productive learning cycle must conclude with an immediate synthesis.

A practical learning design may deliberately separate:

acquisition, return, and later recombination.

This separation can reduce pressure toward premature synthesis and allows later experiences to supply additional perturbations.

The relevant educational record should therefore preserve unresolved questions rather than treating the absence of an immediate conclusion as failure.

10.11 Preserving Unresolved Questions

Criticality learning benefits from an archive of unresolved questions.

A question that cannot be answered within the current epistemic configuration may become generative after later learning.

The learner can maintain a small collection containing:

- unresolved conceptual tensions;
- failed translations;
- unexplained observations;
- analogies whose validity remains uncertain;
- apparent contradictions across frameworks;
- questions that feel significant despite lacking an available method.

Such an archive protects inquiry from the pressure to force every problem into the grammar currently available.

It also supports re-recognition. A later framework may transform the meaning of an earlier unresolved question.

The practice therefore preserves epistemic seeds without assuming when or whether they will become productive.

10.12 Small and Reversible Perturbations

When the learner or educator is uncertain about the appropriate direction of development, small interventions are preferable to irreversible commitments.

A perturbation can include assigning a contrasting text, introducing a new representation, changing the scale of analysis, inviting another interlocutor, or temporarily changing the learning environment.

The learner's response provides additional information.

This approach is compatible with nonlinear pedagogy's emphasis on the role of constraints and learner-environment interaction [2]. Criticality learning applies the same broad sensibility to epistemic organization.

A small perturbation is especially valuable when it can be reversed easily. If the intervention produces confusion without new generativity, the previous learning structure remains available. If it reveals a new direction, further immersion can follow.

The practical principle is conservative under uncertainty: irreversible epistemic intervention should require stronger justification than reversible exploration.

10.13 Criticality-Sensitive Learning Periods

Some learning decisions have greater path-dependent consequences than others.

Choosing a university major, entering a professional field, joining an intensive intellectual community, adopting a research identity, or beginning long-term training can substantially alter later epistemic accessibility.

Criticality learning treats such periods as requiring increased attention to returnability.

The issue is not that early specialization should be prohibited. The issue is that high-impact transitions should be accompanied, where feasible, by mechanisms that preserve re-entry and revision.

Examples include:

- maintaining access to neighboring fields;
- allowing changes of specialization without excessive penalty;
- preserving records of earlier interests and questions;
- designing curricula with genuine elective space;
- permitting interdisciplinary movement;
- avoiding premature identity classification of learners.

The more difficult a decision is to reverse, the more important it becomes to examine the epistemic conditions under which it is made.

10.14 Learning Portfolios as Epistemic Histories

Conventional assessment frequently emphasizes what a learner can currently produce. Criticality learning also requires some record of how the learner's epistemic organization has changed.

A learning portfolio can therefore include more than completed outputs.

Useful elements may include:

- initial and transformed research questions;
- competing descriptions of the same object;
- records of framework reversals;
- unresolved questions;
- conceptual maps before and after immersion;
- reflections on changed assumptions;
- examples of later re-recognition of earlier material.

Such a portfolio makes the learning trajectory itself available for reflection.

The objective is not to reward constant change. A learner may discover that a framework remains robust after repeated comparison. That stability is itself informative when it results from reflective inquiry rather than lack of alternatives.

10.15 Assessment beyond Content Accumulation

If criticality learning is educationally valuable, assessment should not measure only the quantity of disciplinary content acquired.

Several additional capacities become relevant:

Internal reconstruction. Can the learner explain a framework through its own distinctions?

Attractor awareness. Can the learner identify the grammar currently organizing the problem?

Alternative generation. Can the learner construct another serious representation?

Returnability. Can the learner loosen the dominance of a preferred framework without losing its useful content?

Re-recognition. Can a previously rejected or unfamiliar framework become intelligible again?

Recombination. Can the learner generate a new question or relation through interaction among several grammars?

These capacities should not be collapsed into a single score.

A learner may be strong in disciplinary immersion while still developing returnability. Another may possess high comparative mobility but insufficient depth. The profiles suggest different learning interventions.

10.16 Collaborative Criticality Learning

Framework mobility need not occur entirely within one individual.

Groups can distribute epistemic grammars across members. An interdisciplinary team may contain researchers who each possess substantial depth in different fields.

The collective problem then becomes one of relational mobility.

If each member remains confined to a disciplinary attractor and communication consists only of exchanging conclusions, the group may achieve multidisciplinary without strong recombination.

A more generative group process requires members to make disciplinary problem formation partially visible to one another.

Practical mechanisms include:

- asking each participant to formulate the common problem through the home discipline;
- identifying concepts that resist translation;
- rotating which discipline temporarily provides the local center;
- allowing another member to restate the home discipline's argument before critique;
- preserving disagreements that reveal genuinely different problem structures.

Spelt and colleagues emphasize perspective change and integration in interdisciplinary learning [16]. Criticality learning adds attention to the transition conditions through which those perspectives become mutually available.

10.17 The Role of the Teacher

Criticality learning changes the role of the teacher.

The teacher cannot determine the learner's full epistemic trajectory. Nor can the teacher know in advance which encounter will later become generative.

The teacher can, however, alter learning conditions.

Several roles become especially important.

Providing entry. The teacher supplies enough structure, examples, language, and practice for a framework to become internally intelligible.

Protecting depth. The teacher prevents premature switching when a learner has encountered a framework but has not yet acquired its grammar.

Introducing perturbation. The teacher presents alternative cases, theories, or representations when one grammar has become overly stable.

Supporting return. The teacher allows learners to revisit earlier questions and compare how those questions changed.

Preserving revisability. The teacher avoids treating present performance or preference as a permanent classification of the learner.

Maintaining archives of return. Texts, questions, examples, and conceptual records can remain available for later re-entry.

The teacher therefore acts partly as a steward of learning conditions rather than as a producer of understanding.

This orientation is compatible with the broader developmental and mediated accounts associated with Vygotsky and Bruner [18, 1]. Criticality learning places particular emphasis on the temporal preservation of future epistemic movement.

10.18 Minimal Learning Cycle

The practical elements developed above can be combined into a minimal criticality-learning cycle.

1. **Anchor.** Record the initial question and current framing.
2. **Enter.** Select a framework and reconstruct enough of its internal grammar for serious inquiry.
3. **Immerse.** Remain long enough for the framework to generate new questions, distinctions, or representations.
4. **Observe.** Identify what has become newly salient and what alternatives have become less accessible.
5. **Return.** Apply one or more return practices, such as de-jargonization, original-question recovery, alternative description, or temporal distance.
6. **Re-recognize.** Permit another framework or an earlier object to become intelligible from the transformed position.

7. **Reverse.** Where appropriate, change the direction of comparison.
8. **Recombine.** Explore relations among sufficiently developed grammars without requiring immediate synthesis.
9. **Record.** Preserve new questions, unresolved remainders, and changes in the learner's framing.
10. **Re-enter.** Begin another excursion when the next learning purpose becomes sufficiently clear.

The sequence is heuristic rather than prescriptive. Steps may overlap, repeat, or occur in another order.

Its purpose is to make epistemic movement more deliberate.

10.19 A Local Regulation Principle

The practical approach developed in this section can be summarized through a principle of local regulation.

Proposition 10.1 (Local Regulation of Criticality Learning). *When the learner's complete epistemic dynamics are unavailable, criticality learning can be cultivated through local observation of framework dominance, generative depth, alternative accessibility, and response to small reversible perturbations, followed by iterative adjustment of immersion and return.*

The proposition deliberately avoids requiring accurate prediction of a learner's distant future. The relevant practical question is often local:

Given what is presently observable, which intervention preserves or increases the learner's capacity for meaningful next movement?

This orientation also places limits on educational control. A teacher or learner may influence conditions without knowing the complete trajectory that will emerge from them.

10.20 Practical Boundaries

Several limitations remain.

First, excessive self-monitoring can interfere with immersion. A learner who continuously asks whether capture is occurring may never acquire sufficient disciplinary fluency. Awareness should therefore sometimes remain in the background during concentrated practice.

Second, framework switching consumes cognitive resources. Return exercises should be used when they serve the learning task rather than as compulsory rituals.

Third, some alternatives are not worth preserving with equal effort. Limited time requires selection.

Fourth, learners differ in prior knowledge, available languages, social conditions, and tolerance for ambiguity. A single learning schedule cannot serve every learner.

Fifth, educational institutions operate under coordination constraints. Curricula, examinations, qualifications, and professional standards require some common structures.

Criticality learning therefore offers a regulatory orientation rather than a complete institutional design.

Its practical value lies in introducing a neglected variable into learning design: the future mobility produced or constrained by present learning.

The next section examines the theoretical and empirical limitations of the framework more systematically. It considers the status of the attractor metaphor, problems of operationalization, scale, normative indeterminacy, and the risk that criticality itself could become another dominant epistemic grammar.

11 Limitations and Open Problems

Criticality learning has been developed in this paper as a preliminary conceptual framework for understanding epistemic movement across heterogeneous disciplinary, theoretical, religious, and value structures. The framework introduces a dynamical vocabulary of attraction, immersion, returnability, re-recognition, and recombination. Its usefulness depends, however, upon maintaining clear limits around what this vocabulary presently establishes.

This section examines those limits. The principal issues concern the methodological status of epistemic attractors, the absence of a complete operational state space, the problem of scale, the difficulty of measuring returnability, the distinction between educational value and maximal mobility, the normative indeterminacy of re-recognizability, institutional constraints, the possibility of harmful frameworks, and the recursive risk that criticality learning itself becomes an epistemic attractor.

The discussion also identifies several directions for theoretical and empirical development.

11.1 The Status of Epistemic Attractors

The concept of an epistemic attractor is central to the framework and also one of its most significant methodological vulnerabilities.

In nonlinear dynamics, an attractor has a mathematically specified meaning. Its identification requires a state space, dynamical evolution, and a structure toward which trajectories exhibit appropriate asymptotic or long-term behavior. The present paper has not established that disciplines, religious traditions, or conceptual frameworks satisfy these mathematical conditions.

The expression *attractor-like structure* is therefore intentionally weaker.

Its purpose is to describe several recurrent features of learning:

- repeated use of a framework increases the ease of using it again;
- some questions are increasingly reformulated through familiar disciplinary distinctions;
- local epistemic organization can become relatively stable;
- transitions away from a highly stabilized framework can become more difficult;
- alternative perturbations can reorganize the learner under some conditions.

These properties justify a dynamical analogy. They do not yet justify identifying an empirical cognitive attractor in the mathematical sense.

Future work should therefore distinguish at least three levels of claim.

The first is *descriptive analogy*. Attractor language organizes familiar educational observations.

The second is *formal conceptual modeling*. Attractor language generates relations among variables such as depth, stability, transition cost, and framework accessibility.

The third is *empirical dynamical modeling*. Observable learner data are used to infer state-space structure, transition patterns, or attractor-like regimes.

The present paper operates primarily at the first two levels.

11.2 The Epistemic State-Space Problem

The notation

$$x_t \in \mathcal{M}_t$$

has allowed the paper to reason formally about learning history and transitions. The effective epistemic state space $\mathcal{M}_t$, however, has not been operationally specified.

Human epistemic organization includes conceptual knowledge, embodied habits, language, affect, memory, social relations, identity, institutional context, and practical experience. It is unclear whether these dimensions can or should be represented within a single state space.

Several problems follow.

First, the relevant dimensionality is unknown.

Second, some dimensions may be latent or inaccessible to introspection.

Third, the effective dimensions may change through development.

Fourth, variables that appear independent at one scale may become strongly coupled at another.

Fifth, the learner's environment is itself changing, making a fixed autonomous state-space representation inadequate.

The assumption

$$\mathcal{M}_{t+1} \neq \mathcal{M}_t \tag{202}$$

addresses part of this problem conceptually while making empirical reconstruction more difficult.

Criticality learning therefore should not depend upon complete state-space recovery for practical use. Section 10 proposed local observation and reversible perturbation precisely because global modeling may remain infeasible.

11.3 Observer Dependence

Any identification of an epistemic framework depends partly upon the observer.

A learner may experience two theories as distinct attractors while another researcher treats them as variants within one larger tradition. A historian may distinguish several schools where a novice sees only one discipline. Conversely, an insider may perceive subtle internal boundaries invisible to an external observer.

The partition of epistemic space is therefore not given independently of description.

Let

$$\Pi_O(\mathcal{M}) \tag{203}$$

denote a partition or organization of an epistemic domain produced relative to observer O .

Different observers may generate

$$\Pi_{O_1}(\mathcal{M}) \neq \Pi_{O_2}(\mathcal{M}). \tag{204}$$

This does not make framework distinctions arbitrary. Some distinctions may be historically, institutionally, linguistically, or empirically robust. It does mean that the analyst should remain reflexive about the level at which an attractor-like structure is being identified.

The problem is especially important in comparative religion and cross-cultural inquiry, where externally imposed categories may themselves distort the structures being compared.

11.4 The Problem of Scale

Epistemic dynamics operate across multiple temporal and organizational scales.

A learner may move among concepts within seconds, among theories within hours, among disciplines over months, and among professional or religious identities over years.

An apparent attractor at one scale may be a transient state at another.

Let τ denote the observational time scale. The effective stability of a framework can depend upon τ :

$$S_i = S_i(\tau). \quad (205)$$

A framework that appears stable over a one-hour seminar may be highly unstable over several years of research.

Scale also affects the interpretation of return. Leaving a concept temporarily during one conversation differs from leaving a professional identity developed over decades.

Future empirical work must therefore specify the temporal scale of any claim about attraction, stability, capture, or returnability.

The same problem applies spatially and socially. Individual cognition, classroom interaction, disciplinary institutions, and broader knowledge systems may exhibit related but non-identical dynamics.

Criticality learning currently moves among these scales conceptually. A more developed theory will require clearer rules for when such movement is legitimate.

11.5 The Measurement of Returnability

Epistemic returnability is one of the central concepts of the framework, but its direct measurement remains unresolved.

The paper has represented return cost through a schematic function

$$C_R(A_i, t).$$

No validated metric currently corresponds to this quantity.

Several observable proxies may eventually be useful:

- ability to generate an alternative description;
- quality of reconstruction of a competing framework;
- time required to shift between representations;
- recovery of earlier questions after disciplinary reframing;
- affective response to framework reversal;
- willingness to revise identity-linked beliefs;
- successful re-entry into a previously suspended framework.

These indicators measure different aspects of returnability and should not be assumed to form a single latent variable.

A learner may shift conceptual vocabulary rapidly while retaining strong identity-based closure. Another learner may require substantial time to change frameworks while nevertheless retaining deep openness to alternatives.

The multidimensional representation introduced earlier,

$$\mathbf{r}_i(t) = (r_c, r_p, r_r, r_{id}, r_s, r_a),$$

should therefore remain a conceptual decomposition until empirical work establishes whether the dimensions can be measured reliably.

11.6 The Measurement of Criticality

The term *criticality* itself presents a further operational difficulty.

In physical and computational systems, criticality can be associated with specific statistical or dynamical signatures. The present framework does not claim that epistemic criticality has been shown to exhibit those same signatures.

A learner positioned between several frameworks may display high cognitive flexibility without satisfying any formal criterion of critical phenomena.

The paper therefore uses criticality to denote a structured region of enhanced transition possibility among epistemic attractor-like organizations.

Future research should examine whether this concept can be operationalized through behavioral or longitudinal indicators without importing inappropriate physical assumptions.

Possible research questions include:

- whether transitions among conceptual framings exhibit identifiable stability regimes;
- whether some learning configurations show heightened susceptibility to small conceptual perturbations;
- whether return costs display hysteresis after prolonged immersion;
- whether interdisciplinary expertise changes the transition structure among representations;
- whether periods of increased epistemic mobility correlate with creative recombination.

The answers cannot be assumed from the conceptual model.

11.7 Metastability and Productive Instability

The framework places substantial value on metastability. This raises the risk of romanticizing instability.

A learner who is unable to maintain any framework long enough to acquire depth does not thereby occupy an educationally desirable critical state.

Continual doubt, fragmentation, indecision, or rapid switching can reduce learning quality.

Likewise, some learners may require extended periods of stable structure before productive cross-framework mobility becomes possible.

The distinction between metastability and instability is therefore essential. Metastability combines local coherence with transition capacity. Unstructured instability may provide neither.

Criticality learning should consequently avoid treating movement itself as a measure of educational success.

11.8 Mobility and Educational Value

Higher epistemic mobility is not always better.

A learner may benefit from reducing access to irrelevant alternatives during tasks requiring concentrated performance. Expertise often depends upon rapid elimination of unproductive possibilities. Moral and professional responsibility can require stable commitments. Long-term projects require persistence.

The framework therefore does not seek to maximize the number of accessible epistemic trajectories.

The more limited aim is to prevent unnecessary or unjustified foreclosure in contexts where later movement retains substantial value.

This creates a normative judgment problem. Determining which alternatives should remain accessible depends upon the learner, the task, available resources, possible harms, developmental stage, and wider social conditions.

Criticality learning can identify a loss of mobility. It cannot by itself determine whether that loss is justified.

11.9 Re-recognizability and Normative Indeterminacy

The Principle of Epistemic Re-recognizability introduced earlier provides a normative orientation rather than a complete ethical theory.

The principle states that modes of knowledge acquisition warrant scrutiny when they irreversibly or with substantial difficulty reduce the capacity to re-recognize alternative conceptual systems, value frameworks, or possible worlds.

Several unresolved questions remain.

How much loss of re-recognizability is ethically acceptable?

How should present educational benefit be weighed against future epistemic optionality?

Can a learner voluntarily choose substantial epistemic closure?

How should such choices be treated when made by children?

Are there frameworks for which reducing future accessibility is itself educationally desirable?

How should harmful, deceptive, or demonstrably false frameworks be handled?

The present paper does not derive answers to these questions from the dynamical model.

A dynamical description can show that a trajectory has become difficult to reverse. The ethical evaluation of that irreversibility requires further normative premises.

Criticality learning therefore should remain compatible with multiple ethical frameworks while making the temporal consequences of educational intervention more visible.

11.10 Harmful Frameworks and the Limits of Openness

The value placed upon re-recognition creates an obvious challenge. Some frameworks may support violence, systematic deception, dehumanization, or other serious harms.

Criticality learning cannot require indefinite openness to every possible framework.

Re-recognizability concerns epistemic capacity, not an obligation to treat all frameworks as equally legitimate or to expose learners repeatedly to harmful material.

A learner may understand a framework sufficiently to reject it while retaining the capacity to explain why it is rejected.

The distinction between understanding and endorsement developed earlier is therefore essential.

Educational design must also consider the costs and risks of immersion. Internal reconstruction of a framework may sometimes be unnecessary or ethically inappropriate when the learning objective can be achieved through less intensive engagement.

The framework consequently requires a principle of proportionality between the epistemic value of immersion and its potential harms.

A complete formulation of this principle remains outside the scope of the present paper.

11.11 Developmental Asymmetry

Criticality learning places substantial demands upon metacognition, perspective taking, linguistic competence, and tolerance of ambiguity. These capacities vary across developmental stages.

Children cannot be assumed to possess the same ability as adults to recognize attractor capture, evaluate long-term return costs, or deliberately maintain framework mobility.

This creates a governance problem.

The weaker the learner's capacity for reflective regulation, the greater the responsibility placed upon teachers, caregivers, curricula, and institutions to preserve reasonable conditions of future revisability.

At the same time, excessive protection can prevent meaningful immersion and development.

Educational design must therefore balance entry and option preservation under developmental uncertainty.

Vygotsky's emphasis on socially mediated development and Bruner's concern with developmentally appropriate forms of representation provide important background for this problem [18, 1]. Criticality learning adds attention to the future transition conditions generated by those mediated encounters.

11.12 Resource Constraints

Criticality learning is cognitively and materially expensive.

Serious immersion in several disciplines requires time. Framework reversal requires additional learning. Re-recognition may require language competence, access to primary materials, interlocutors, or institutional resources.

A learner cannot preserve equally deep access to every possible framework.

This means that epistemic closure can result from scarcity rather than deliberate capture.

Limited attention, time, money, language access, educational opportunity, and social support all constrain the feasible set of epistemic trajectories.

Any practical account of criticality learning must therefore include selection.

The question becomes which transitions are worth preserving under limited resources.

The present paper has not developed a complete allocation theory for these resources.

11.13 Institutional Coordination

Formal education cannot be organized entirely around individualized epistemic trajectories.

Schools and universities require common calendars, examinations, curricula, credits, professional standards, and administrative classifications.

These structures reduce complexity and permit coordination at scale.

Criticality learning therefore should not treat institutional standardization as intrinsically opposed to generative development.

The practical issue is whether common structures leave sufficient local space for differentiated depth, return, re-entry, and revision.

A standardized course may still permit several representations, optional projects, later re-entry, and interdisciplinary movement.

Conversely, a formally flexible curriculum may generate strong practical lock-in through prerequisites, cost structures, or professional incentives.

Institutional analysis must therefore distinguish formal flexibility from effective returnability.

11.14 Social Inequality and Unequal Mobility

The ability to maintain epistemic mobility is unevenly distributed.

Some learners have access to multiple languages, disciplines, institutions, travel, archives, mentors, and communities. Others face narrow educational pathways and high costs of experimentation.

Criticality learning could therefore become socially selective if presented as an individual cognitive virtue without attention to enabling conditions.

A learner with abundant resources can afford exploratory excursions and failed transitions. Another learner may face substantial economic costs for changing specialization even when the educational value of return is clear.

The concept of return cost must therefore include structural conditions.

Future work should investigate how institutional and socioeconomic inequality shape the practical accessibility of epistemic alternatives.

11.15 The Risk of Endless Deferral

A framework that values revisability can produce another failure mode: indefinite postponement of judgment.

The learner may repeatedly seek another framework, another reversal, or another comparison while avoiding commitment.

This is especially problematic in domains requiring action.

Law, medicine, public policy, and international affairs frequently require decisions under incomplete information. Ethical life also requires choices that cannot wait for unlimited epistemic exploration.

Criticality learning therefore requires a stopping condition at the level of action even when epistemic revisability remains open.

A learner may conclude that the present evidence supports one course strongly enough for action while retaining the capacity to revisit the judgment later.

Revisability should support responsible decision rather than replace it.

11.16 The Risk of Hyper-Reflexivity

Attractor awareness can itself become excessive.

A learner who continually monitors every conceptual move may disrupt the automaticity required for expert performance or creative immersion.

Reflection consumes attention.

Some epistemic operations become productive precisely because they can proceed without continuous explicit supervision.

Criticality learning therefore requires temporal differentiation between immersion and reflection.

During some phases, the learner should permit the grammar to operate with minimal interruption. Attractor awareness can return at transition points, during review, or when indicators of capture become salient.

The aim is reflective availability rather than permanent self-surveillance.

11.17 Framework Proliferation

Another risk lies in treating every conceptual distinction as a separate framework or attractor.

If the analysis proliferates attractors without restraint, the model loses explanatory value.

A useful epistemic attractor-like structure should display some degree of organized persistence. It should shape several related operations, such as problem formation, salience, evidence, inference, or evaluation, across more than one isolated moment.

The appropriate granularity remains context-dependent.

A research tradition may be treated as one attractor for one analysis and as several sub-attractors for another.

Future formalization should therefore include criteria for model granularity.

11.18 Framework Interaction beyond Pairwise Comparison

Much of the paper has used two-framework comparisons because they are easier to represent.

Real epistemic systems are rarely pairwise.

A learner may simultaneously draw upon several disciplines, identities, languages, affective structures, and social contexts.

Let

$$\mathcal{G}_t = \{\Gamma_1, \Gamma_2, \dots, \Gamma_n\}.$$

The resulting dynamics may involve higher-order interactions among several grammars.

A relation generated by Γ_1 and Γ_2 may alter the accessibility of Γ_3 . Three frameworks together may generate a structure unavailable in every pairwise comparison.

The present framework has not developed a formal theory of such higher-order epistemic interactions.

This limitation becomes particularly important for genuinely interdisciplinary research and multicultural environments.

11.19 Collective and Institutional Attractors

The paper has focused primarily on the learner. Many epistemic attractors, however, are collective.

Disciplines are maintained by journals, departments, conferences, textbooks, funding systems, professional associations, and shared evaluative practices. Religious traditions are maintained through institutions, communities, rituals, texts, and authority structures.

Individual returnability can therefore remain limited even when cognitive flexibility is high.

A more complete theory should distinguish at least:

- individual epistemic attractors;
- interpersonal coordination patterns;
- disciplinary or communal attractors;
- institutional incentive structures;
- wider cultural-symbolic landscapes.

Transitions at one level can alter those at another.

The present model acknowledges these relations but does not formalize their cross-scale dynamics.

11.20 Criticality Learning as an Attractor

The framework must also be applied reflexively to itself.

Once a learner becomes familiar with the vocabulary of attractors, metastability, returnability, re-recognition, and criticality, that vocabulary can begin to organize an increasingly wide range of problems.

Criticality learning can therefore become another attractor.

A researcher may begin to interpret every intellectual commitment as capture, every specialization as loss of mobility, every disagreement as framework difference, or every productive insight as criticality.

Such use would contradict the framework's own methodological commitments.

Criticality learning should periodically undergo its own de-jargonization and framework reversal.

A learner should be able to describe a phenomenon without the language of criticality and ask whether another educational, historical, sociological, psychological, or philosophical account explains the case more adequately.

The theory's success should increase the learner's repertoire rather than make its own vocabulary unavoidable.

11.21 Re-recognizability of Criticality Learning

The principle of re-recognition also applies reflexively.

A learner who adopts criticality learning should remain capable of re-recognizing theories that place greater value on stable disciplinary formation, apprenticeship, repetition, authority, tradition, or cumulative expertise.

The framework should not classify these approaches as failures simply because they generate stronger attraction.

The relevant question remains contextual: what kinds of stability and mobility serve the learning task, and what future possibilities are being created or closed?

This reflexive application provides an internal check against theoretical self-exemption.

11.22 Empirical Research Directions

The conceptual model generates several empirical research directions.

One line of work could examine framework-switching tasks. Participants might be taught several structured approaches to the same problem and later tested on their ability to reconstruct, reverse, and recombine them.

Another line could study disciplinary experts and novices. Researchers could compare the speed and quality of transitions among disciplinary framings and investigate whether expertise increases or decreases different dimensions of returnability.

Longitudinal research could examine how professional training changes the accessibility of alternative problem representations over time.

Comparative education studies could investigate whether curricula that include structured return and framework reversal produce stronger re-recognition than curricula that merely expose students to multiple disciplines.

Qualitative research could examine learner narratives of intellectual conversion, disciplinary migration, religious transition, or major theoretical change.

Collaborative research could examine interdisciplinary teams and identify conditions under which disciplinary differences produce recombination rather than parallel work or assimilation.

These studies would not require acceptance of the full dynamical vocabulary in advance. Their results could support, revise, or reject parts of the model.

11.23 Formal Research Directions

Further formal development is also possible.

A more explicit model could represent epistemic grammars as operators over problem representations and study changes in transition probabilities among them.

Returnability could be modeled through weighted transition graphs in which nodes represent locally coherent epistemic organizations and edge weights represent effective transition costs.

If the set of epistemic states is represented by a graph $G = (V, E)$, a returnability problem could be expressed through changes in edge weights

$$w_{ij}(t) = C(A_i \rightarrow A_j, t). \quad (206)$$

Learning could then alter both node structure and edge weights.

A more ambitious formulation might permit the graph itself to evolve:

$$G_t \rightarrow G_{t+1}. \quad (207)$$

Such models may eventually clarify path dependence, hysteresis, closure, and re-entry.

Their usefulness will depend upon whether the formal objects can be connected to observable educational phenomena.

Formal elegance alone would not validate the epistemic interpretation.

11.24 Philosophical Research Directions

Several philosophical questions also remain open.

The ontology of an epistemic framework requires further clarification. It is uncertain whether attractor-like structures should be attributed primarily to individual cognition, social practices, linguistic systems, institutions, or relations among them.

The concept of epistemic freedom requires additional normative analysis. The relationship between freedom, commitment, expertise, and self-formation cannot be derived from transition cost alone.

Re-recognition raises questions about personal continuity. A sufficiently transformed learner may reconstruct a past framework while no longer experiencing it as a genuine existential possibility.

The role of truth also requires further treatment. Criticality learning protects access to competing frameworks, but epistemic mobility cannot replace standards for evaluating their claims.

Finally, the relation between criticality and generativity requires additional conceptual work. A highly mobile state may generate novelty without generating valuable knowledge, while a highly stable framework may generate profound results over a long period.

These issues indicate that criticality learning is a theory of one dimension of epistemic development rather than a complete epistemology.

11.25 Scope of the Preliminary Proposal

The limitations developed above define the appropriate scope of the present paper.

Criticality learning currently provides:

- a vocabulary for attraction and movement among epistemic frameworks;

- a distinction between immersion and capture;
- a concept of epistemic returnability;
- a historically situated concept of re-recognition;
- an account of recombination across sufficiently developed grammars;
- a set of provisional learning practices and diagnostic indicators;
- a family of empirical, formal, and normative research questions.

It does not currently provide:

- a validated psychological model of epistemic attractors;
- a complete measurable state space of learning;
- a numerical measure of criticality or returnability;
- a universal criterion for optimal disciplinary dwell time;
- a complete ethics of epistemic openness;
- a general theory of creativity;
- a universal replacement for disciplinary learning.

The distinction is important for the methodological status of the proposal.

Criticality learning should be evaluated initially by whether it clarifies recognizable learning problems, generates useful distinctions, and supports productive empirical and philosophical questions.

Its concepts should remain revisable as those questions are investigated.

11.26 A Reflexivity Requirement

The limitations of the framework can be condensed into a final methodological requirement.

Proposition 11.1 (Reflexivity Requirement). *A theory of criticality learning should remain itself returnable and re-recognizable: its vocabulary should support inquiry without becoming a necessary meta-language through which every learning process must be interpreted.*

This requirement follows directly from the theory's own account of epistemic capture.

Criticality learning is useful only while learners remain able to leave it, compare it with alternative accounts, identify its limits, and return to it when it again becomes generative.

The final section draws together the preliminary argument and summarizes the conceptual architecture of criticality learning without converting that architecture into a closed theory of learning.

12 Conclusion

This paper has introduced *criticality learning* as a preliminary framework for examining how learners move among disciplinary, theoretical, religious, and value-laden epistemic structures. The motivating problem is neither disciplinary depth nor interdisciplinarity considered separately. It is the relation between them: how a learner can enter a framework deeply enough for its internal grammar to become generative while preserving the capacity to move again after that learning has transformed the learner.

The framework begins from the observation that learning changes more than the amount of information available to a subject. Sustained engagement with a discipline can alter salience, problem formation, inferential habits, representational preferences, evaluative standards, and the questions that appear worth asking. Such stabilization was represented in this paper through the provisional language of epistemic attractor-like structures.

Attraction has an essential educational function. Without sufficient attraction, disciplinary grammar remains external to the learner. Concepts can be repeated without becoming generative. Comparative inquiry then risks becoming a juxtaposition of summaries rather than an encounter among operational forms of thought.

Criticality learning therefore does not seek continuous detachment from disciplines. It requires immersion.

The concept of *generative immersion* was introduced to describe sustained engagement through which a learner becomes capable of generating questions, distinctions, representations, and inferences from within a framework. Such immersion necessarily produces temporary epistemic asymmetry. One grammar may become more salient than others, and a learner may develop strong commitments or specialization.

Temporary asymmetry does not itself constitute epistemic closure.

The problem emerges when an acquired grammar becomes increasingly difficult to perceive as a grammar and begins to function as an invisible background for all subsequent inquiry. Criticality learning therefore places *attractor awareness* alongside immersion. Attractor awareness concerns the learner's capacity to recognize which conceptual, disciplinary, affective, identity-based, social, or institutional structures are currently organizing inquiry and whether their increasing dominance is reducing the meaningful accessibility of alternatives.

Awareness does not require immediate departure. Its function is to make the relation between learner and framework available for reflection. A learner may recognize an attractor and reasonably choose to remain within it. Long periods of disciplinary concentration can be appropriate. What changes is that the attraction can become increasingly intentional rather than remaining entirely transparent.

The third central concept developed in the paper was *epistemic returnability*. Returnability describes the capacity to move away from a locally dominant epistemic structure without erasing the knowledge and generative competence acquired through immersion. Return is therefore different from forgetting, repudiation, or restoration of an earlier untouched state.

A learner who has seriously entered a framework cannot simply become the learner who existed before the encounter. Learning history remains active. Return produces a transformed region of inquiry in which the acquired grammar remains available while alternative organizations can again become meaningfully accessible.

This non-restorative character of return leads directly to *re-recognition*. Re-recognition concerns the possibility of encountering a previously known or alternative framework again after intervening learning has altered the learner's epistemic position.

The framework may appear differently on the second encounter. The learner may reject what

was once accepted, understand what was once dismissed, or discover new tensions in what previously appeared obvious. Re-recognition therefore does not preserve earlier judgments. It preserves the possibility of renewed intelligibility.

This distinction has a normative consequence. Educational openness cannot be reduced to the formal availability of alternative information. A book may remain on a shelf while the learner has lost the linguistic, conceptual, affective, social, or identity conditions required to encounter its framework seriously. Formal permission to reconsider a view therefore does not always amount to effective revisability.

The paper consequently proposed a Principle of Epistemic Re-recognizability. Modes of knowledge acquisition warrant ethical scrutiny when they diminish, irreversibly or with substantial difficulty of revision, the learner's future capacity to re-recognize alternative conceptual systems, value frameworks, or possible worlds.

The principle does not require the preservation of every possible epistemic trajectory. Expertise requires selection. Commitment creates asymmetry. Education operates under limited time and resources. Some frameworks deserve rejection, and some activities require stable mastery rather than continuous comparison.

The relevant distinction is between transformation and unnecessary foreclosure.

Criticality learning accepts that education transforms the epistemic landscape. Its normative concern lies in how that transformation changes the conditions of later inquiry.

The same structure becomes especially important in comparative and value-heterogeneous research. Comparative inquiry cannot proceed from a perfectly framework-independent location. Researchers enter comparison from historically formed positions and frequently adopt a temporary local center.

Criticality learning therefore does not prohibit directional comparison. One framework may legitimately be used to interrogate another. The methodological concern arises when the direction of comparison becomes invisible and effectively irreversible.

Framework reversal was introduced as one way to test this condition. The researcher asks whether the previously examined framework can itself become a standpoint from which the preferred framework is reorganized. Reversal need not establish equivalence between the frameworks. Its function is to test whether comparative direction remains an available choice rather than an unnoticed necessity.

This approach also produces a different interpretation of neutrality. Neutrality does not require absence of commitment or a position outside all frameworks. Within criticality learning, a more plausible form of neutrality is metastable and historically evolving. It consists in maintaining enough framework mobility that several positions can become genuinely operative without any one position becoming permanently invisible as a position.

Such neutrality can change through learning. Indeed, serious inquiry should be expected to change it.

The framework was then extended from comparison toward *generative recombination*. If several epistemic grammars have been learned with sufficient depth and remain accessible after return, relations can emerge among them that were unavailable within any one grammar considered in isolation.

Recombination is distinct from terminological collage. It requires enough internal reconstruction of the participating frameworks for their differences to become generatively consequential. Translation failures, incompatible problem formulations, differences of scale, analogies, and unresolved remainders can all become sites at which new questions are generated.

The output of recombination may itself stabilize into a new epistemic attractor. Criticality learning therefore has no final position of synthesis. A newly generated theory can later become

sufficiently familiar to require its own attractor awareness, return, comparison, and re-recognition.

The framework is recursively applicable to its own products.

Section 10 translated these ideas into a preliminary learning-design orientation. Because the complete epistemic state of a learner cannot presently be reconstructed, practical criticality learning should rely on local observations rather than comprehensive prediction.

Several practices were proposed: preserving the original question before disciplinary immersion, framework journaling, temporary de-jargonization, alternative-description exercises, framework reversal, periodic return, unstructured encounters, preservation of unresolved questions, and small reversible perturbations.

These practices share a common logic. They seek information about local epistemic direction without requiring a complete model of the learner.

Criticality learning therefore favors iterative regulation over long-range control. The learner or educator observes what becomes more generative, what becomes less accessible, and how the system responds to modest changes in conditions.

The practical objective is not to determine the learner's final trajectory. It is to preserve meaningful next movements while allowing sufficiently deep local development.

The limitations of this proposal remain substantial. Epistemic attractors have not been established as empirically measurable dynamical attractors. Returnability currently lacks a validated metric. The effective epistemic state space is uncertain, potentially high-dimensional, historically changing, and socially embedded. The appropriate scale of analysis varies across tasks. The normative value of mobility cannot be derived from dynamics alone.

Criticality learning therefore remains a conceptual framework and research program rather than an empirically complete theory.

These limitations are also methodologically important. The language of criticality, attractors, metastability, and returnability should not become decorative formalism. Dynamical concepts are useful only when they clarify relations that ordinary descriptions leave insufficiently explicit.

Likewise, criticality learning should not become a universal vocabulary through which every educational process is interpreted.

The framework must remain subject to its own principle of returnability.

If another theory explains a learning process more adequately, the learner should be capable of leaving the criticality-learning vocabulary. If disciplinary stability is appropriate for a task, criticality learning should not force unnecessary mobility. If its concepts obscure rather than clarify a phenomenon, they should be revised or abandoned.

This reflexivity is part of the proposal rather than an external qualification.

The preliminary architecture developed throughout the paper can be summarized in ordinary language.

A learner first needs sufficient openness for more than one epistemic path to remain possible. The learner then enters a framework deeply enough to acquire its internal generative capacities. During and after this immersion, the learner develops awareness of how the framework is reorganizing perception, questions, and judgment. The learner preserves enough returnability to move again without erasing what has been learned. From the transformed position, alternative frameworks can become recognizable again. Their renewed encounter can produce comparison, reversal, and eventually recombination. Newly generated structures then enter the same historical process.

Criticality learning is therefore a learning process of repeated transformation without requiring irreversible epistemic capture.

Its deepest educational question is not simply how much a learner knows, nor how many disciplines a learner has encountered. It concerns the relation between present learning and future possibilities of knowing.

A successful learning episode may give the learner a powerful grammar. A generative learning history should also leave open the possibility that the learner may later encounter another grammar, revisit the first one, recognize something previously invisible, and generate another relation.

The proposal can consequently be condensed into a final orientation:

Enter deeply enough to be transformed. Learn to perceive the framework that is transforming you. Preserve enough returnability for other worlds to become recognizable again. Let later encounters revise the meaning of earlier ones.

This orientation does not define the destination of learning.

It seeks to preserve the conditions under which further learning can continue.

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