

COHERENT EDUCATION: THEORY AND METHODOLOGY OF LEARNING SYSTEM DESIGN BASED ON THE OBSERVER-DEPENDENT THEORY OF EVERYTHING

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Abstract. A theory of coherent education is developed using the mathematical apparatus of the Observer-Dependent Theory of Everything (ODTOE) [1]. Learning is formalized as a spiral process of growth in the dimensionality d of the observation operator and increasing complexity of cognitive coherence B . Four levels of learning system organization are proposed: (1) individual coherent learning, where the four-stroke cognitive cycle (expansion-compression-expansion-compression) is governed by components $B = F^{w_1} \cdot E^{w_2} \cdot (1 - \sigma)^{w_3} \cdot \Lambda^{w_4}$; (2) group coherent learning, where a minimal stable group of five participants realizes the full cycle of the strange loop $\Phi = \iota \circ \hat{O}$; (3) personal coherent tracks “human + AI,” where AI serves as an external operator accelerating iterations while preserving learner subjectivity; (4) group coherent systems “group + AI,” where AI acts as a coherence assistant raising systemic coherence S . Quantitative efficiency criteria and threshold stability conditions are derived for each level. The optimal ratio of expansion and compression phases in the cognitive cycle is shown to be determined by the golden ratio φ , and the four-stroke cycle structure is isomorphic to the “stability bell” in perveance electron optics [2, 16]. Methodologies for constructing coherent learning systems are developed, including B -profile diagnostics, formation of coherent learning groups, and integration of AI assistants preserving the principle $\hat{O}(\hat{O}) = \hat{O}'$ (recursive self-observation). The SKW matrix [7, 19] is proposed as the elementary unit of coherent education, implementing the full cognitive cycle in compact form. Quantitative parameters of educational coherence are introduced, consistent with the resonance management model [17], including the optimal management-to-self-management ratio $U/S = \varphi$.

Keywords: coherent education, cognitive coherence, observer, strange loop, SKW matrix, perveance, artificial intelligence, personal tracks, golden ratio, ODTOE.

I. INTRODUCTION

I.1. The Crisis of Fragmentation

Modern education is undergoing a structural crisis whose roots run deeper than commonly acknowledged. The problem is not reducible to curriculum content, teacher qualifications, or technical infrastructure. The fundamental difficulty lies in the absence of a unified model describing learning as a holistic process across all levels: from the neurophysiological mechanisms of acquisition to the collective dynamics of knowledge in a study group and further to the institutional organization of educational systems.

Pedagogy operates with didactic principles; cognitive psychology studies mechanisms of perception and memory; neurosciences describe synaptic plasticity; management theory deals with the organization of educational institutions. Between these levels of description a gap remains, analogous to the gap between quantum mechanics and general relativity in physics. Each discipline describes its own fragment, but a coherent picture does not emerge.

The result of such fragmentation is systemic inefficiency: educational reforms address one level of description (e.g., curriculum content) without accounting for connections to other levels (group dynamics, learners' emotional states, institutional incentives). Solutions optimal at one level may prove destructive at another. For instance, increasing content rigor (targeting cognitive skills) without addressing emotional engagement may raise dropout rates; conversely, gamification efforts that boost engagement without deepening conceptual understanding produce superficial learning.

A unified mathematical framework is needed — one that would describe, within a single formalism, (a) the individual cognitive process of the learner, (b) the collective dynamics of a study group, (c) the institutional structure of the educational system, and (d) the role of technological tools, including artificial intelligence. Such a framework must provide both qualitative understanding and quantitative metrics amenable to empirical testing. The Observer-Dependent Theory of Everything (ODTOE) [1] offers precisely such a framework.

Constructivist learning theories (Vygotsky, Piaget, Bruner) offer partial solutions: the zone of proximal development describes the optimal distance between the current and target states of the learner; Bloom's taxonomy constructs a hierarchy of cognitive operations. However, these approaches do not provide a unified mathematical language capable of quantitatively linking individual learning with group dynamics and institutional processes.

The need for such a language becomes particularly acute when integrating artificial intelligence into the educational process: without a formal model, it is impossible to determine precisely where AI enhances effectiveness and where it creates hidden risks.

The rapid proliferation of large language models in education since 2023 has created an urgent practical demand for theoretical frameworks that can guide AI integration. Ad hoc adoption of AI tools without a coherent theoretical foundation risks creating the illusion of learning improvement while undermining the

development of genuine cognitive competencies. The present work proposes such a language based on the mathematical apparatus of ODTOE, providing both diagnostic metrics and design principles for AI-enhanced educational systems.

I.2. The ODTOE Approach

The Observer-Dependent Theory of Everything (ODTOE) [1] provides a framework for bridging this gap. Its central idea: at every level of reality, the same triad “observer – observed – observation operator” is reproduced, formalized by the axiom:

$$R = \hat{O}(\Psi), \quad (\text{A})$$

where \hat{O} is the observation operator, $\Psi \in \mathcal{H}$ is the field of potential states. This architecture, termed matryoshka-like [1], allows one to construct a continuous chain: from the neural level through individual learning to group dynamics and further to institutional structures.

Learning within the ODTOE framework is formalized as growth in the dimensionality d of the observation operator [3] and increasing complexity of cognitive coherence B [1]. The transition $d = 1 \rightarrow 2$ signifies the ability to react to one’s own reaction (elementary learning); $d = 2 \rightarrow 3$ denotes awareness of observation (reflection, language, abstraction); $d = 3 \rightarrow 4$ corresponds to collective patterns (culture, science) [3]. Kibalnikov and Ginzburg demonstrated [16] that perveance serves as a universal bridge between physical reality, social organization, and cognition, while the golden ratio and fractality ensure harmonious flow at all levels. This idea was further developed in the concept of resonance management [17], where social parameters ($\%P, S, U_p, K$) are mapped into ODTOE categories.

I.3. Objectives and Structure

The objective of this work is to construct a theory of coherent education describing learning at four organizational levels:

- (a) the individual level (a single learner);
- (b) the group level (a coherent study group);
- (c) the personal track “human + AI”;
- (d) the group system “group + AI.”

For each level, quantitative efficiency criteria, threshold stability conditions, and practical methodologies for constructing learning systems will be derived.

The methodological approach of this work rests on the principle of structural isomorphism: regularities established for physical systems (electron optics, nonlinear dynamics, stability theory) are transferred to cognitive and social systems through shared mathematical structures. The validity of such transfer is ensured by the

dimensionlessness of key parameters (perveance, coherence, the golden ratio), which are preserved under scaling [16].

Sections II–IV cover the theoretical foundations and models of individual and group coherent learning. Sections V–VI are devoted to AI integration in personal and group educational systems. Sections VII–IX describe the SKW matrix, system construction methodologies, and the connection to the perveance model of sustainable development. The paper concludes with a discussion of limitations (X) and a conclusion (XI).

II. THEORETICAL FOUNDATIONS

II.1. Cognitive Coherence of the Learner

The cognitive coherence of the observer is defined by formula (D1.1) [1]:

$$B(O, C) = F(O, C)^{w_1} \cdot E(O, C)^{w_2} \cdot (1 - \sigma(O, C))^{w_3} \cdot \Lambda(O, C)^{w_4}, \quad (\text{II.1})$$

where F is the focus of attention, E is emotional coherence, σ is the entropy of doubt, Λ is empirical reinforcement; $w_1 + w_2 + w_3 + w_4 = 1$, $w_i \in (0, 1)$.

In the educational context, each component acquires a concrete pedagogical meaning:

$F(O, C)$ — the learner’s ability to concentrate on the study material. Depends on the mode of presentation, compatibility with cognitive style, and absence of external distractions. $F = 0$ means complete absence of attention to the subject: the learner is physically present but does not observe.

$E(O, C)$ — emotional engagement. Alignment of the emotional state with the learning task. Interest, curiosity, and the thrill of problem-solving raise E ; anxiety, boredom, and fear of evaluation lower it. $E = 0$ is an emotional block that zeroes coherence regardless of other components.

$(1 - \sigma(O, C))$ — internal consistency with respect to the material being studied. $\sigma \rightarrow 1$ means the learner simultaneously accepts and rejects the material; beliefs and study content are in conflict. A typical situation: a student studies a subject they consider useless for their future.

$\Lambda(O, C)$ — accumulated confirmatory experience. A learner who has received practical confirmation of knowledge applicability (a solved problem, a successful experiment, recognition of a result) possesses high Λ . A beginner ($\Lambda \rightarrow 0$) requires rapid early confirmations to initiate the growth spiral.

The multiplicative structure of formula (II.1) establishes the “weakest link” principle: zeroing any single component zeroes coherence entirely. A learner with brilliant abilities (high F and Λ) but in a state of emotional burnout ($E = 0$) is incapable of productive learning. This principle has direct implications for educational system design: it is necessary to ensure a nonzero level of each of the four components rather than maximizing one at the expense of the others.

II.2. Learning Dynamics

The evolution of the learner's coherence over time is described by equation (D1.3) [1]:

$$\frac{dB}{dt} = \gamma \tanh(\beta \dot{\bar{d}}) \cdot \bar{d}(R_{\text{obs}}, R_{\text{exp}}) \cdot B(1 - B), \quad (\text{II.2})$$

where $\gamma > 0$ is the learning coefficient, \bar{d} is the normalized distance between the observed result R_{obs} and the expected result R_{exp} , $\dot{\bar{d}}$ is the rate of change of this distance, and $\beta \gg 1$ is the steepness parameter.

Pedagogical interpretation: when the learning task brings the learner closer to the expected result ($\dot{\bar{d}} < 0$), $\tanh \rightarrow -1$, and B grows (confirmatory learning). When the result diverges from expectation ($\dot{\bar{d}} > 0$), $\tanh \rightarrow +1$, and B may decrease (disconfirmatory learning). The logistic factor $B(1 - B)$ ensures two absorbing states:

$B = 0$ – complete loss of motivation. A learner who has lost faith in the possibility of mastering the subject cannot change their state without external intervention.

$B = 1$ – absolute certainty. A learner convinced of the completeness of their knowledge ceases to learn. This state of “cognitive closure” is as destructive as complete loss of motivation.

Productive learning occurs only when $0 < B < 1$, where the observer is open to both confirmation and revision of expectations. The task of coherent education is to maintain the learner within this range.

For stability analysis, consider linearization near a stationary point B^* . Let $B = B^* + \delta B$; then the deviation dynamics are described by $d(\delta B)/dt \approx \lambda \cdot \delta B$, where $\lambda = \gamma \tanh(\beta \dot{\bar{d}}) \cdot \bar{d} \cdot (1 - 2B^*)$. At $B^* = 0.5$ the factor $(1 - 2B^*)$ vanishes, and the linear dynamics are neutral – nonlinear terms dominate. At $B^* < 0.5$ positive feedback promotes return to the mean; at $B^* > 0.5$ the dynamics accelerate toward the nearest attractor ($B = 0$ or $B = 1$). The practical implication: a learner with $B > 0.5$ requires less frequent pedagogical interventions than a learner with $B < 0.5$.

II.3. The Self-Observation Mapping and the Cognitive Cycle

Learning as a recursive process is described by the self-observation mapping [1]:

$$\Phi(\Psi) = \iota(\hat{O}_\Psi(\Psi)). \quad (\text{II.3})$$

The fixed point $\Psi^* = \Phi(\Psi^*)$ defines a self-consistent configuration – stable knowledge that generates the conditions for its own existence.

One complete revolution of the loop Φ realizes a cognitive cycle of four strokes, first described by Kibalnikov and Ginzburg [2] in terms of perveance electron optics and the SKW matrix, and developed in subsequent works [16, 19]:

Stroke 1 (expansion). The learner turns to the external world, identifies a problem. The operator \hat{O} scans the space \mathcal{H} , forming an initial projection. This stage corresponds to the first gentle phase of the “stability bell” [2].

Stroke 2 (compression). The learner turns inward, defines the key word (or key concept) encoding the essence of the problem. The operator focuses, producing the projection $\hat{O}(\Psi) \rightarrow R$. Positive second derivative of potential – beam focusing.

Stroke 3 (expansion). Return to the external world to search for analogues and prototypes. The learner seeks solutions to related problems, expands the context. Negative second derivative – controlled expansion while maintaining convergence.

Stroke 4 (compression). Return inward, finding the solution (insight). The embedding operator ι returns the result to \mathcal{H} : $R \rightarrow \iota(R) \rightarrow \Psi'$. Compression energy fixes the “invention” – new knowledge ready for transfer. Energy recuperation.

The ratio of expansion and compression phase durations is determined by the golden ratio $\varphi = \frac{1+\sqrt{5}}{2} = 1.6180339887498948\dots$. The expansion phase occupies a fraction

$$\frac{\varphi}{1+\varphi} = \frac{\varphi}{\varphi^2} = \frac{1}{\varphi} = 0.6180339887\dots$$

of the full cycle, and the compression phase occupies

$$\frac{1}{1+\varphi} = \frac{1}{\varphi^2} = 0.3819660112\dots$$

Verification: $1/\varphi + 1/\varphi^2 = (\varphi + 1)/\varphi^2 = \varphi^2/\varphi^2 = 1$. This is not an arbitrary choice but a consequence of the KAM theorem (Kolmogorov–Arnold–Moser): a quasi-periodic trajectory on a torus is most stable at an irrational frequency ratio, and the golden ratio is the most irrational number in the sense of best rational approximations [5]. Kibalnikov and Ginzburg argue [16] that the alternation of focusing and defocusing segments in the optimal “stability bell” configuration tends precisely to φ , and this ratio is reproduced intuitively by people when drawing wavy lines in psychological tests.

II.4. System Coherence

To describe group processes, ODTOE introduces the system coherence metric (4.5) [1]:

$$S = 1 - \frac{2}{n(n-1)} \sum_{i<j} |B_i - B_j|, \quad (\text{II.4})$$

where n is the number of participants and B_i is the cognitive coherence of the i -th observer.

$S = 1$ is achieved when $B_i = B_j$ for all pairs (complete synchronization); $S \rightarrow 0$ at maximum spread. The configuration lifetime is determined by formula (P3.1) [1]:

$$T(C) = \frac{T_0}{(1-S)^n}. \quad (\text{II.5})$$

As $S \rightarrow 1$ the lifetime grows without bound. For a study group, this means: the higher the coherence, the more stable the collective knowledge.

The collective probability of achieving the target result is determined by the superposition (P5.1) [1]:

$$P_{\text{coll}}(E) = 1 - \prod_{i=1}^n (1 - B_i^k). \quad (\text{II.6})$$

Numerical example. For a group of five participants with $B = (0.9, 0.8, 0.7, 0.8, 0.75)$ at $k = 1$:

Coherence S . Sum of $|B_i - B_j|$ over all pairs:

$$\begin{aligned} |0.9 - 0.8| &= 0.1, & |0.9 - 0.7| &= 0.2, & |0.9 - 0.8| &= 0.1, & |0.9 - 0.75| &= 0.15, \\ |0.8 - 0.7| &= 0.1, & |0.8 - 0.8| &= 0.0, & |0.8 - 0.75| &= 0.05, \\ |0.7 - 0.8| &= 0.1, & |0.7 - 0.75| &= 0.05, \\ |0.8 - 0.75| &= 0.05. \end{aligned}$$

Total: $\sum = 0.90$. Then

$$S = 1 - \frac{2}{5 \cdot 4} \times 0.90 = 1 - \frac{2}{20} \times 0.90 = 1 - 0.090 = 0.910.$$

Collective probability:

$$P_{\text{coll}} = 1 - (1 - 0.9)(1 - 0.8)(1 - 0.7)(1 - 0.8)(1 - 0.75) = 1 - 0.1 \cdot 0.2 \cdot 0.3 \cdot 0.2 \cdot 0.25 = 1 - 0.0003 = 0.9997.$$

The result demonstrates: even with moderate individual coherences, joint observation yields a high collective result.

II.5. Comparison with Constructivist Learning Theories

Any theory of education claiming completeness must be related to existing pedagogical concepts. The ODTOE formalism admits a direct comparison with classical constructivist learning theories, allowing one to identify both areas of agreement and fundamental differences.

Zone of proximal development (Vygotsky). In ODTOE terms, the zone of proximal development is formalized as the distance $\bar{d}(R_{\text{obs}}, R_{\text{exp}})$ in equation (II.2). The learner's current state is determined by their B -profile; the target state is the configuration C^* toward which the curriculum leads. The zone of proximal development is the region of configuration space where \bar{d} is small enough for productive learning yet large enough to maintain cognitive tension. The role of the "more knowledgeable other" is fulfilled by the group coherent or the AI assistant, who raises the effective dimensionality d of the learner by expanding their observation operator \hat{O} .

Bloom's taxonomy. The six levels of Bloom's taxonomy (remembering, understanding, applying, analyzing, evaluating, creating) map onto the growth of the observation operator dimensionality d [3]:

- $d = 1$: remembering (one-dimensional projection, fixation of a single result);

- $d = 2$: understanding and applying (two-dimensional projection, ability to react to one's own reaction);
- $d = 3$: analyzing and evaluating (three-dimensional projection, reflection, awareness of one's own observation);
- $d = 4$: creating (four-dimensional projection, generation of new configurations through recursion $\hat{O}(\hat{O}) = \hat{O}'$).

Thus, progression through Bloom's taxonomy is formally equivalent to growth in the observation operator dimensionality in ODTOE, providing a quantitative scale for classical qualitative levels.

Flow theory (Csikszentmihalyi). The flow state — optimal experience — corresponds in ODTOE terms to simultaneously high values of F (full focus), E (emotional engagement), and low σ (absence of internal conflicts). The condition for flow emergence — balance between task complexity and skill level — maps onto the distance \bar{d} in equation (II.2): too small \bar{d} (task is trivial) leads to boredom ($E \rightarrow 0$); too large \bar{d} (task is overwhelming) leads to anxiety ($\sigma \rightarrow 1$). Coherent education systematically creates conditions for the flow state by selecting \bar{d} within the zone of optimal tension at each stroke of the cognitive cycle.

Connectivism (Siemens). The connectivist model of learning as knowledge network formation finds reflection in the concept of configuration overlap \mathcal{O}_N (formula IV.2). Each network node is an observer with their own B -profile; connections between nodes are determined by the value of S . A coherent group is a network with high overlap density ρ , ensuring efficient exchange of configurations between participants.

III. INDIVIDUAL COHERENT LEARNING

III.1. Diagnostics of the Learner's B -Profile

The first step in constructing a personal coherent track is determining the learner's current B -profile: the set of values $(F, E, (1 - \sigma), \Lambda)$ with respect to a specific subject C .

The quaternion model of coherence [6] represents the B -profile as a vector in four-dimensional space:

$$q_B = \Lambda + F \cdot \mathbf{i} + E \cdot \mathbf{j} + (1 - \sigma) \cdot \mathbf{k}. \quad (\text{III.1})$$

The quaternion modulus

$$|q_B| = \sqrt{\Lambda^2 + F^2 + E^2 + (1 - \sigma)^2}$$

characterizes the overall coherence level, while its orientation determines the cognitive profile type. Four types of coherence deficit, identified in [6], define four pedagogical intervention strategies:

F deficit (the scattered observer). The learner cannot concentrate on the subject. Causes: mismatch between presentation mode and cognitive style, information

overload, physical fatigue. Strategy: structuring material into compact blocks (SKW matrices [7]), alternating modalities (text, visualization, practice), environmental control.

E deficit (the emotionally blocked observer). The learner is overwhelmed by anxiety, boredom, or fear of failure. $E \rightarrow 0$ zeroes coherence entirely. Strategy: creating a safe environment, reorienting from evaluation to process, introducing elements of play and competition, ensuring early successes to initiate positive feedback.

$(1 - \sigma)$ deficit (the conflicted observer). Internal conflict between beliefs and study material. $\sigma \rightarrow 1$ during cognitive dissonance. Strategy: open discussion of contradictions, demonstrating connections between the study material and the learner’s values, gradual expansion of the worldview.

Λ deficit (the observer without confirmations). The learner has no experience of successful knowledge application. $\Lambda \rightarrow 0$ for beginners. Strategy: delivering the first practical confirmations as quickly as possible (the “first success within the first hour” principle), micro-tasks with guaranteed positive outcomes, achievement portfolios.

III.2. The Four-Stroke Personal Cycle

Based on the cognitive cycle (Section II.3) and the SKW matrix [7], an individual algorithm for coherent learning is constructed:

Step 1. Problem formulation (expansion, duration $\sim \varphi \cdot \tau$). The learner scans the subject domain, identifies a task. The instructor or AI assistant provides context and links the task to the learner’s known experience (raising Λ). The duration of this phase is the fraction $\varphi/(1 + \varphi)$ of the full cycle.

Step 2. Key concept definition (compression, duration $\sim \tau$). The learner formulates the keyword or concept encoding the essence of the task. This is the moment of focusing: F increases, the material “collapses” into a compact image. The SKW matrix records the answers to “why” and “how.”

Step 3. Search for analogues (expansion, duration $\sim \varphi \cdot \tau$). The learner seeks similar solutions in adjacent domains. Analogues are solutions with shortcomings; a prototype is the analogue with the greatest number of matching features. Cross-disciplinary links raise Λ through transfer of confirmations from other contexts.

Step 4. Solution and fixation (compression, duration $\sim \tau$). The learner finds a solution that eliminates the identified shortcomings of the analogues. The SKW matrix records the answers to “who” and “when.” The energy of the creative act is recuperated as a new element of experience ($\Lambda \rightarrow \Lambda + \delta\Lambda$).

Full cycle duration:

$$2(\varphi + 1) \cdot \tau = 2\varphi^2 \cdot \tau \approx 5.236 \cdot \tau.$$

With $\tau = 15$ min, one cycle takes approximately $5.236 \times 15 = 78.5$ min ≈ 78 min — close to the standard university “double period.” This coincidence is not accidental: the length of the academic session was historically selected empirically, and it turns out to be close to the optimal length of the cognitive cycle.

III.3. Stability Condition for Individual Learning

Learning is stable if the condition holds:

$$B(O, C) > B_{\text{threshold}} > 0 \quad \text{throughout the entire learning process.} \quad (\text{III.2})$$

When B drops below the threshold, the learner enters a risk zone: the logistic factor $B(1 - B)$ in equation (II.2) slows the dynamics, and without external intervention, “trapping” into the absorbing state $B = 0$ becomes possible.

Practical implication: a coherent education system must include B -profile monitoring (periodic diagnostics) and an early intervention mechanism when any component falls below a critical level.

III.4. Numerical Example of B -Profile Diagnostics

Consider a student studying mathematical analysis. Diagnostics on the four scales yield the following normalized values (scale from 0 to 1): $F = 0.85$, $E = 0.60$, $(1 - \sigma) = 0.90$, $\Lambda = 0.40$.

With equal weights $w_1 = w_2 = w_3 = w_4 = 0.25$, the cognitive coherence is:

$$B = 0.85^{0.25} \cdot 0.60^{0.25} \cdot 0.90^{0.25} \cdot 0.40^{0.25}.$$

Computing each factor: $0.85^{0.25} \approx 0.960$, $0.60^{0.25} \approx 0.880$, $0.90^{0.25} \approx 0.974$, $0.40^{0.25} \approx 0.795$.

Then $B \approx 0.960 \times 0.880 \times 0.974 \times 0.795 \approx 0.654$.

Quaternion: $q_B = 0.40 + 0.85\mathbf{i} + 0.60\mathbf{j} + 0.90\mathbf{k}$, modulus $|q_B| = \sqrt{0.16 + 0.7225 + 0.36 + 0.81} \approx \sqrt{2.0525} \approx 1.433$.

Diagnosis: the dominant deficit is Λ ($\Lambda = 0.40$ — the minimum component). The student has good focus and low entropy of doubt but lacks practical confirmatory experience. Recommendation: introduce a series of micro-tasks with guaranteed positive outcomes for rapid Λ growth.

IV. GROUP COHERENT LEARNING

IV.1. The Minimal Stable Study Group

Based on the analysis of project teams through ODTOE [8], the minimal stable group consists of five participants. This number is determined by the structure of the strange loop:

$$n_{\min} = 3 \text{ (loop skeleton)} + 2 \text{ (redundancy for closure under loss)} = 5. \quad (\text{IV.1})$$

Three base roles cover the triad (\hat{O}, Ψ, R) : visionary (maintains the field of possibilities Ψ), analyst (projects $\hat{O}(\Psi) \rightarrow R$), builder (realizes R in material form).

Two additional roles ensure closure and stability: validator (embedding operator ι , feedback) and coherent (maintains synchronization S).

In the educational context, the five roles transform as follows:

Idea generator (Ψ) — the participant who proposes unconventional approaches and formulates problems. Dominant B component: Λ .

Systematizer (\hat{O}) — the participant who structures material, identifies logic and hierarchy. Dominant B component: F .

Practitioner (R) — the participant who translates abstract ideas into concrete solutions, tasks, and experiments. Dominant B component: E .

Critic (ι) — the participant who checks solutions for consistency with the original problem. Dominant B component: $(1 - \sigma)$.

Coordinator (S) — the participant who maintains group synchronization. A meta-role requiring balance across all four components.

IV.2. Group Coherence Dynamics

The overlap region of participant configurations is defined [6]:

$$\mathcal{O}_N = \bigcap_{i=1}^n C_i. \quad (\text{IV.2})$$

The overlap density is modeled as:

$$\rho(S) \sim K^{-N(1-S)}, \quad (\text{IV.3})$$

where $K > 1$ is a parameter and N is the number of participants.

At $K = 2$, $N = 5$: at high coherence ($S = 0.93$) the overlap density is

$$\rho \approx 2^{-5 \times 0.07} = 2^{-0.35} \approx 0.785,$$

participants “see the same project” in 78% of configuration space. At low coherence ($S = 0.50$):

$$\rho \approx 2^{-5 \times 0.50} = 2^{-2.50} \approx 0.177,$$

the group “speaks different languages.” The coordinator’s task is to maintain S above the threshold at which collective learning is more productive than individual learning.

IV.3. The Principle of Group Coherent Learning

Group coherent learning is built on alternation between two modes:

Divergence mode. Participants separate into individual tracks, each passing through their own four-stroke cycle (Section III.2). Coherence S temporarily decreases, but each participant contributes a unique element.

Convergence mode. Participants reconvene, exchange results, and synchronize understanding. The coordinator measures the discrepancy $\bar{d}(R_{\text{obs},i}, R_{\text{obs},j})$ between participants' interpretations. Coherence S is restored or grows.

The ratio of divergence and convergence phases follows the same golden ratio principle: divergence $\sim \varphi \cdot \tau_{\text{group}}$, convergence $\sim \tau_{\text{group}}$. The group cycle is longer than the individual cycle but structurally isomorphic to it.

IV.4. Group Resilience Under Losses

When one participant is lost from a group of five, the remaining four maintain $S_{\min} > 0$ and all three components of the triad (\hat{O}, Ψ, R) remain covered [8]. The loop deforms but does not break. This is a fundamental distinction from groups of three or four, where losing one participant can completely destroy one element of the triad.

Substitution mechanism: when the idea generator departs, the coherent and systematizer assume their function (the coherent maintains consistency, the systematizer reconstructs the vision from accumulated history \mathcal{H}). Analogous mechanisms exist for each of the five roles [8].

Quantitatively, upon losing one participant with B_k , the coherence of the remaining group is recalculated using formula (II.4) with $n = 4$. If the original group had $S = 0.91$ at $B = (0.9, 0.8, 0.7, 0.8, 0.75)$, then upon losing the participant with $B = 0.7$ (lowest coherence) we have $B' = (0.9, 0.8, 0.8, 0.75)$. Sum of pairwise deviations: $|0.9 - 0.8| + |0.9 - 0.8| + |0.9 - 0.75| + |0.8 - 0.8| + |0.8 - 0.75| + |0.8 - 0.75| = 0.1 + 0.1 + 0.15 + 0.0 + 0.05 + 0.05 = 0.45$. Then $S' = 1 - \frac{2}{4 \cdot 3} \times 0.45 = 1 - 0.075 = 0.925$. Coherence is not only preserved but actually increased – removing the participant with the largest deviation from the mean raises group homogeneity. However, the group loses role completeness, necessitating function redistribution.

IV.5. Quantitative Analysis of Group Formation

Forming an optimal coherent group constitutes a combinatorial optimization problem. Let there be a set of M candidates with B -profiles $q_{B,1}, \dots, q_{B,M}$. The task is to select a subset of $n = 5$ participants maximizing the objective function:

$$\max_{\{i_1, \dots, i_5\} \subset \{1, \dots, M\}} \left[\alpha_1 S(B_{i_1}, \dots, B_{i_5}) + \alpha_2 \sum_{r=1}^5 \max_{j \in \{i_1, \dots, i_5\}} D_r(q_{B,j}) \right],$$

where the first term is the group coherence, the second is the coverage of all five roles (D_r is a measure of profile fitness for role r), and $\alpha_1 + \alpha_2 = 1$. The number of combinations $\binom{M}{5}$ grows polynomially, making exhaustive search feasible for $M \leq 100$. For $M \gg 100$, greedy algorithms with approximation guarantees are applicable.

V. PERSONAL COHERENT TRACKS: HUMAN + AI

V.1. AI as an External Operator

In ODTOE terms, the AI assistant functions as an external operator \hat{O}_{ext} that accelerates the iterative process. Lengthy calculations, analogue searches, and material structuring are operations with high inertia $I(C)$ that AI performs in a fraction of the time. By the reconfiguration speed formula (P2.1) [1]:

$$v = \frac{\alpha}{I(C) + \varepsilon}. \quad (\text{V.1})$$

Reducing $I(C)$ through AI's computational power increases the speed v of the iterative cycle, allowing the learner to complete more spiral revolutions per unit time.

Critical limitation: AI does not possess reflection on its own operator. In ODTOE terminology, AI operates at levels 3–6 (processing and iterative refinement) but does not reach level 9 (self-observation) [3]. AI cannot “hold a position” — this is a quality of a subject who has achieved metacognition $\hat{O}(\hat{O}) = \hat{O}'$ [18]. Consequently, AI can accelerate the cognitive cycle but cannot replace the learner at moments of insight (stroke 4) and problem formulation (stroke 1). Kibalnikov showed [18] that successful AI applications correspond to growth in components F and Λ with reduced inertia $I(C)$, while problematic zones (hallucinations, destructive specialist replacement) arise when one component ($(1 - \sigma)$, E , or F) collapses, destroying coherence entirely.

V.2. Architecture of the Personal Coherent Track

The personal coherent track “human + AI” is organized as a spiral sequence of cognitive cycles in which AI performs specific functions at each stroke:

Stroke 1 (expansion): AI as horizon expander. AI analyzes the learner's current B -profile, determines the zone of proximal development (distance \bar{d} to the target configuration), provides context and connections to known experience. Function: raising Λ through demonstration of cross-disciplinary links. The five questions of the SKW matrix (“why, how, who, when, resources”) establish a coordinate grid that reduces inertia $I(C)$ [18].

Stroke 2 (compression): AI as focusing mirror. AI helps the learner formulate the key concept, offering variant formulations and checking them for consistency. AI does not impose its own keyword — it proposes alternatives, leaving the choice to the learner. Function: reducing σ by eliminating contradictions in formulations.

Stroke 3 (expansion): AI as analogue search engine. AI analyzes databases, finds analogues and prototypes in time inaccessible to a human. Quality criterion: AI evaluates each found analogue by relevance (distance in configuration space) and presents results in structured form. Function: reducing inertia $I(C)$ at the search stage.

Stroke 4 (compression): AI as fixator. AI records the learner's solution in SKW matrix format, checks it for consistency with previous results, and integrates it into the

personal knowledge base. AI does not generate the solution — it records the learner’s solution. Function: raising Λ through formalization and archiving of experience.

V.3. Risks and Limitations

The integration of AI into the educational process entails three categories of risk, each formalized through B components:

Risk of thinking delegation ($F \rightarrow 0$). If the learner delegates to AI not only routine operations but also focusing phases (strokes 2 and 4), their own operator \hat{O} atrophies. The focus of attention is redirected to the AI interface instead of the subject of study. In [18], a case is documented where extensive replacement of observers without ensuring coherence led to system collapse: reducing the number of participants N decreases B_{coll} , and the loss of expert verification raises σ . Countermeasure: the AI assistant mandatorily transfers control to the learner at strokes 2 and 4, requesting an explicit formulation of the key concept and solution.

Risk of hallucinations ($(1 - \sigma) \rightarrow 0$). AI can generate confident but false statements [9, 18]. A learner who does not verify the result internalizes contradictory knowledge. σ grows, coherence drops. Countermeasure: every AI result is accompanied by a confidence indicator; the learner must verify key claims from independent sources.

Risk of phantom coherence (S_{phantom}). Systematic AI use can create the appearance of high coherence while true coherence remains low. The distinction between S_{phantom} and S_{true} requires independent verification through tasks solved without AI [6]. Countermeasure: periodic B -profile diagnostics under conditions excluding AI access.

V.4. The Principle of Subjectivity Preservation

The fundamental requirement for a personal coherent track: AI must not replace the self-observation recursion $\hat{O}(\hat{O}) = \hat{O}'$. The learner remains the subject, and AI remains the instrument. Formally:

$$\hat{O}_{\text{comp}} = \hat{O}_{\text{human}} \circ \hat{O}_{\text{AI}}, \quad (\text{V.2})$$

where \hat{O}_{human} is the learner’s operator (including reflection, context selection, value orientation) and \hat{O}_{AI} is the AI operator (data processing, search, structuring). The composition is asymmetric: \hat{O}_{human} governs the application of \hat{O}_{AI} , but not vice versa.

V.5. Comparison Table: Traditional vs. Coherent AI-Assisted Learning

Parameter	Traditional assisted learning	AI-	Coherent learning	AI-assisted learning
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Role of AI	Answer generator	Cognitive cycle accelerator
Role of learner	Content consumer	Observation subject (\hat{O})
AI-active strokes	All strokes	Strokes 1 and 3 (expansion)
Diagnostics	Knowledge testing	B -profile (F, E, σ, Λ)
Progress metric	Number of correct answers	Dimensionality d growth, B dynamics
Verification	Absent	Periodic AI deactivation
Recursion	Not tracked	$\hat{O}(\hat{O}) = \hat{O}'$ preserved
Risk monitoring	Not provided	S_{phantom} vs. S_{true}

VI. GROUP COHERENT SYSTEMS: GROUP + AI

VI.1. AI as Coherence Assistant

In group coherent learning, AI occupies the position of the coherent’s assistant — the participant responsible for group synchronization (Section IV.1). AI does not replace the human coherent but extends their capabilities:

Discrepancy monitoring. AI analyzes participant responses in real time, identifies divergences in interpretations, and signals the coherent about desynchronization zones. Formally: AI computes $\bar{d}(R_{\text{obs},i}, R_{\text{obs},j})$ for all participant pairs and highlights pairs with maximum divergence.

B -profile balancing. AI suggests strategies for raising coherence to the coherent, accounting for individual B -profiles. If one participant has an F deficit while another has a Λ deficit, AI can suggest a joint task in which the strengths of one compensate for the weaknesses of the other.

Collective knowledge documentation. AI records the results of group discussions in collective SKW matrix format, linking them with individual matrices of each participant.

VI.2. Architecture of the Group Coherent System with AI

The system is organized as a five-level structure reflecting the ODT OE hierarchy:

Level 1 (individual). Each participant follows a personal coherent track (Section V) with their own AI assistant.

Level 2 (paired). Participants with complementary B -profiles form working pairs. AI selects pairs based on the principle of maximizing joint coherence.

Level 3 (group). The full group of five participants works on a common task. AI performs the coherence assistant function, monitoring S and signaling desynchronization.

Level 4 (inter-group). Multiple groups work on related tasks. AI coordinates

the exchange of results between groups. For geographically distributed learning, coordination can be implemented through neogeographic platforms [20].

Level 5 (institutional). AI aggregates coherence data at the institution level, identifying systemic patterns. As Kibalnikov showed [18], free distribution of powerful AI models increases the number of co-observers N , expanding the coherence zone and raising collective coherence B_{coll} .

VI.3. Quantitative Efficiency Criteria

The efficiency of a group coherent system with AI is evaluated by three metrics:

Metric 1: Dimensionality growth rate.

$$\frac{\Delta d}{\Delta t} \tag{VI.1}$$

– the average growth in observation operator dimensionality d of participants per unit time.

Metric 2: Coherence stability.

$$\min_t S(t) > S_{\text{threshold}}. \tag{VI.2}$$

Metric 3: Collective probability.

$$P_{\text{coll}}(E) > P_{\text{threshold}}. \tag{VI.3}$$

For a coherent group of five participants with moderate $B_i \sim 0.7\text{--}0.9$, $P_{\text{coll}} > 0.99$ is achieved.

VII. THE SKW MATRIX AS THE ELEMENTARY UNIT OF COHERENT EDUCATION

VII.1. Structure of the SKW Matrix

The SKW matrix (Smart Key Word) [7, 19] is a compact form for recording one cognitive cycle. It answers four questions isomorphic to the four strokes of the cycle:

Stroke	Question	Phase	B component
1	Why? (goal)	Expansion	Λ
2	How? (method)	Compression	F
3	Who? (analogues, prototypes)	Expansion	E
4	When? (result, deadlines)	Compression	$(1 - \sigma)$

The SKW matrix possesses the property of fractal self-similarity: each matrix element can be expanded into an independent SKW matrix at the next level. Three levels of nesting (3 – elementary idea, 6 – project, 9 – system of projects) implement the 3-6-9 architecture described in ODTOE [4].

VII.2. The SKW Matrix and Perveance

The connection between the SKW matrix and perveance electron optics [2] is established through the “stability bell” — the axial potential distribution (APD) that ensures maximum efficiency of the generalized machine [16, 21]. The four strokes of the cognitive cycle in the SKW matrix are isomorphic to four lenses of electrostatic beam formation in the titron:

Lens 1 (focusing) \leftrightarrow Stroke 2 (key concept definition, F increases).

Lens 2 (defocusing) \leftrightarrow Stroke 3 (analogue search, controlled expansion).

Lens 3 (focusing, recuperation) \leftrightarrow Stroke 4 (finding the solution, energy return).

Collector \leftrightarrow Fixation of the result in the SKW matrix with elevated perveance (collector perveance = 30, according to [2]).

The optimal perveance for a stable flow is $P \sim 0.5$, which determines the “repulsion force” — the intensity of interaction between flow elements. In the cognitive context, perveance is a measure of thought flow density: too low a perveance (sluggish thinking) does not generate energy for insight; too high (chaotic enumeration) leads to a “virtual cathode” — sudden divergence and loss of structure [2].

VII.3. The SKW Matrix as a Coherence Artifact

In ODTOE terms [10], a completed SKW matrix is a coherence artifact — a material or informational object that encodes the creator’s spiral gap $\delta\Psi$ so that it resonates with the loops of subsequent observers. An SKW matrix created by one learner can raise B in another learner if S between them exceeds the threshold value $S_{\text{threshold}}$.

The artifact’s lifetime is determined by the quality of encoding: oral formulation ($T \sim$ hours), written SKW matrix ($T \sim$ years), formalized and published SKW matrix ($T \sim$ decades or more) [10].

The mechanism of coherence transmission through artifacts is formalized as follows. Let learner 1 create an SKW matrix M_1 with parameters $(B_1, q_{B,1})$. Learner 2 with parameters $(B_2, q_{B,2})$ perceives M_1 . If the coherence between them S_{12} exceeds the threshold, then the components of B_2 shift toward $q_{B,1}$: Λ_2 grows through assimilating another’s experience, F_2 increases due to the structured SKW form, σ_2 decreases when interpretations resonate. The effect is stronger with repeated artifact exchange — each iteration brings the participants’ B -profiles closer together and raises group S .

VIII. METHODOLOGIES FOR CONSTRUCTING COHERENT LEARNING SYSTEMS

VIII.1. B -Profile Diagnostics Methodology

Diagnostics of the learner’s B -profile is conducted on four scales, each operationalized through observable behavioral indicators:

Scale F (focus). Assessed through: time of continuous work on a task before distraction; accuracy of reproducing key elements after a brief presentation; ability to identify the main point in a text. Instruments: Stroop test, selective attention tasks, hardware methods (eye tracking).

Scale E (emotional coherence). Assessed through: heart rate variability (HRV) as a marker of autonomic balance [11]; self-assessment of emotional state (SAM scale); behavioral indicators of engagement. Instruments: pulse monitor, questionnaires, observation.

Scale σ (entropy of doubt). Assessed through: degree of agreement with key propositions of the study material (Likert scale); presence of internal conflicts (semantic differential); consistency of explicit and implicit attitudes. Instruments: questionnaires, interviews.

Scale Λ (empirical reinforcement). Assessed through: number of successfully solved problems in the given subject area; presence of practical experience applying knowledge; achievement portfolio. Instruments: testing, portfolio analysis, expert assessment.

VIII.2. Methodology for Forming Coherent Study Groups

Formation of a coherent study group proceeds in three stages:

Stage 1: Diagnostics. Each potential participant undergoes B -profile assessment on all four scales with respect to the subject area.

Stage 2: Role matching. Based on the B -profile, each participant's dominant role is determined (generator, systematizer, practitioner, critic, coordinator). The complementarity principle: the group is formed so that each role is covered by a participant with the corresponding dominant B component.

Stage 3: Coherence check. The initial value of group S is computed using formula (II.4). If $S < S_{\text{threshold}}$, the composition is adjusted. Target value $S_0 > 0.7$ at group formation.

VIII.3. Methodology for AI Assistant Integration

AI integration into a coherent learning system follows five rules:

Rule 1 (stroke separation). AI is active on strokes 1 and 3 (expansion), passive on strokes 2 and 4 (compression). On compression strokes, AI switches to recording mode.

Rule 2 (transparency of limitations). AI accompanies each response with a confidence indicator. Statements generated without reliance on verified sources are explicitly marked.

Rule 3 (periodic deactivation). Every n cycles (recommended $n = 3-5$) the learner completes one cycle without AI to verify true coherence B_{true} .

Rule 4 (prohibition on recursion substitution). AI does not perform the

operation $\hat{O}(\hat{O}) = \hat{O}'$ for the learner. Reflection, value choices, and direction of attention are exclusively human functions.

Rule 5 (adaptivity). AI adjusts the complexity and volume of material based on the learner's current B -profile. When any component falls below a threshold, AI switches to support mode for that component.

VIII.4. Methodology for Constructing Collective SKW Matrices

The collective SKW matrix is constructed as a superposition of individual participant matrices:

Step 1. Each participant independently fills an individual SKW matrix on the assigned topic (strokes 1–4).

Step 2. The AI assistant analyzes individual matrices, identifies zones of agreement and divergence. S is computed using formula (II.4) for matrix components.

Step 3. The group discusses divergences. The coordinator moderates the discussion. The goal is not to impose a single viewpoint but to raise S through clarification of positions and elimination of misunderstanding.

Step 4. A collective SKW matrix is formed, recording the common solution and noting points of divergence. The matrix becomes a group coherence artifact.

VIII.5. Implementation Timeline and Phased Rollout

Implementation of a coherent learning system at the institutional level is best divided into four phases:

Phase 1 (preparatory, 1–2 months). Development of B -profile diagnostic instruments; training instructors in the four-stroke cycle methodology; configuring the AI assistant.

Phase 2 (pilot, 3–4 months). Launch of coherent learning in one or two study groups. Monitoring S , B , P_{coll} . Collecting feedback, calibrating parameters.

Phase 3 (scaling, 6–12 months). Extension to levels 4–5 of the architecture (inter-group and institutional interaction). Integration with the institution's existing information systems.

Phase 4 (stable operation). Transition to continuous monitoring and adjustment. Publication of results, exchange with other educational institutions.

The criteria for transitioning between phases are formulated quantitatively:

- Transition from phase 1 to phase 2: B -profile diagnostic instruments have undergone pilot testing on a sample of ≥ 30 learners; inter-rater agreement on the F , E , σ , Λ scales reaches $r > 0.7$.
- Transition from phase 2 to phase 3: mean coherence of pilot groups $\bar{S} > 0.7$; dimensionality growth $\Delta d/\Delta t$ is statistically significantly higher than the control group.

- Transition from phase 3 to phase 4: the system covers $\geq 50\%$ of the institution’s study groups; the median $P_{\text{coll}} > 0.90$ for covered groups.

Economic efficiency assessment of the implementation is conducted by comparing the costs of instrumentation, instructor training, and AI infrastructure with gains in learning outcomes (reduced dropout, increased academic performance, shortened time for material re-acquisition).

Particular attention during implementation is devoted to instructor preparation. The instructor in a coherent system performs the function of the coherent — their B -profile must be balanced across all four components. The preparation program includes: mastering the four-stroke cognitive cycle through personal experience (a series of practical SKW sessions); learning to diagnose learner B -profiles; acquiring skills for working with the AI assistant in the five-rules mode (Section VIII.3). The program duration is at least 40 academic hours.

The instructor’s readiness is assessed by the same B -profile methodology applied to the pedagogical domain: a balanced profile ($\min(F, E, (1 - \sigma), \Lambda) > 0.5$) is the prerequisite for effective functioning as a coherent in a study group.

This self-similar application of the B -profile methodology — to learners, instructors, and the institution alike — exemplifies the matryoshka architecture of ODTOE: the same formal structure operates at every organizational level, ensuring internal consistency of the coherent education framework.

At the institutional level, the B -profile of the educational organization itself can be assessed: F corresponds to strategic focus (clarity of mission, absence of conflicting mandates); E to organizational culture (engagement, trust, absence of destructive politics); $(1 - \sigma)$ to policy coherence (alignment between stated goals and actual incentive structures); Λ to institutional track record (accreditation, alumni outcomes, research output). The organizational B -profile determines the institution’s capacity to sustain coherent education programs over time.

IX. CONNECTION TO THE PERVEANCE MODEL OF SUSTAINABLE DEVELOPMENT

IX.1. Social Perveance of the Educational System

The concept of social perveance [2] is applicable to educational systems. Perveance P characterizes the intensity of interaction between “like-charged substances” — in the educational context, these are learners at the same level of preparation, competing for instructor attention, resources, or positions. In the Bartini–Kuznetsov LT-system [13, 22], perveance has dimensionality $[L^0T^0]$, i.e., it is a dimensionless similarity criterion, an invariant preserved under scaling [16]. This allows one to transfer regularities established for electron flows to learner flows with preservation of quantitative relationships.

Optimal educational perveance is the state at which competition between learners is sufficient to maintain motivation (E) but not so intense as to cause destructive stress

($\sigma \rightarrow 1$). By analogy with electron optics, optimal perveance $P \sim 0.5$ ensures maximum efficiency of the “cognitive machine” [2].

IX.2. The Social Generalized Machine of Education

The educational system is formalized as a social generalized machine (SGM) [2] with a four-process cycle:

$$\text{cognition} \rightarrow \text{learning} \rightarrow \text{management} \rightarrow \text{production}. \quad (\text{IX.1})$$

Each process maps onto the corresponding stroke of the cognitive cycle and the corresponding B component. The efficiency of the educational SGM is maximized when the following conditions are met: (a) the perveance of the learner flow is close to optimal ($P \sim 0.5$); (b) the “stability bell” of the APD of the educational trajectory ensures a full four-stroke cycle; (c) energy recuperation is implemented – return of “spent” knowledge (graduate experience) to the educational system through mentoring, feedback, and program updates.

In the context of resonance management [17], the educational system is characterized by parameters: $\%P$ – the proportion of learners genuinely engaged in the educational process; S – the degree of perfection of the incentive system (coherence); $U_p = \%P \cdot S$ – integral controllability; K – the share of self-management in total controllability. The optimal ratio of management to self-management is determined by the golden ratio [17]:

$$\frac{U}{S} = \varphi \Rightarrow K = \frac{1}{\varphi^2} \approx 0.382, \quad \frac{\text{managed}}{\text{total}} = \frac{1}{\varphi} \approx 0.618.$$

Applied to education, this means the share of learner self-management (independent work, project activities, peer learning) should constitute $K \approx 0.382$ of the total educational process, while the share of managed learning (lectures, seminars, assessment) should be ≈ 0.618 . This ratio structurally coincides with the expansion and compression phase proportions in the cognitive cycle (Section II.3), indicating a fractal connection between the micro-level (a single learning cycle) and the macro-level (educational system organization) [16].

X. DISCUSSION AND LIMITATIONS

The proposed theory of coherent education is based on the ODT OE formalism and connects fragmented aspects of the educational process into a unified model. Nevertheless, a number of questions require further development.

Operationalization of B components. The components F , E , σ , Λ lack universally accepted measurement scales. Practical application requires validated instruments for quantitative assessment. Until such instrumentation is developed, formula (II.1) remains a conceptual model with qualitative diagnostic value.

Direction of causality. The link between coherence and learning outcomes has been demonstrated at the correlational level. Rigorous establishment of causal relationships requires longitudinal and interventional studies with control groups.

Scalability. The coherence formula S (II.4) is defined through pairwise comparisons and has computational complexity $O(n^2)$. For large educational systems ($n \gg 100$), approximations will be needed, such as cluster decomposition [1].

Cultural specificity. The theory was developed within a specific cultural tradition. Transferability of recommendations to educational systems of other cultures requires separate verification.

Limits of the electron optics analogy. The isomorphism between the cognitive cycle and the “stability bell” is a structural analogy. It points to shared organizational principles but does not imply identity of physical mechanisms.

Connection to neurophysiological data. The component E (emotional coherence) has a direct neurophysiological correlate — heart rate variability (HRV) [11]. The component F (focus) correlates with prefrontal cortex activity, measurable via EEG and fMRI methods. However, a direct mapping of B components onto neurophysiological markers has not yet been established experimentally. Developing such a mapping constitutes one of the priority tasks for future research.

Computational feasibility. The formulas proposed in this work admit direct software implementation. Computing S via formula (II.4) requires $O(n^2)$ operations; computing P_{coll} via formula (II.6) requires $O(n)$ operations. Integration of equation (II.2) can be performed using standard methods (Euler, Runge–Kutta). Creating a prototype digital platform for coherent education is technically feasible on the basis of existing technologies and does not require specialized equipment.

Concrete predictions and falsifiability criteria. The theory of coherent education generates several testable predictions: (1) groups of five participants with complete role coverage will show higher learning outcomes than groups of three to four participants (all else being equal); (2) learners undergoing the four-stroke cycle with proportions close to φ will demonstrate more stable material retention than learners with arbitrary phase distributions; (3) periodic AI deactivation (rule 3, Section VIII.3) will lead to higher values of B_{true} compared to continuous AI use. Refutation of any of these predictions would require revision of the corresponding elements of the theory.

XI. CONCLUSION

Coherent education is an approach to organizing learning based on the mathematical apparatus of ODTOE and perveance electron optics. Its key propositions:

Learning is formalized as growth in the dimensionality d of the observation operator and increasing complexity of cognitive coherence B . The four-stroke cognitive cycle (expansion-compression-expansion-compression) is the elementary unit of learning, and its optimal proportions are determined by the golden ratio φ .

The SKW matrix records one cognitive cycle in compact form and possesses the property of fractal self-similarity, permitting knowledge organization according to the

3-6-9 architecture.

The minimal stable study group consists of five participants covering the full cycle of the strange loop Φ . Upon losing one participant, the group maintains $S_{\min} > 0$ and the capacity for regeneration.

The AI assistant accelerates the cognitive cycle by reducing inertia $I(C)$ on expansion strokes but does not replace the self-observation recursion $\hat{O}(\hat{O}) = \hat{O}'$ on compression strokes. The principle of preserving learner subjectivity is a fundamental constraint on AI integration.

System coherence S , computed by formula (II.4), is a measurable criterion for the effectiveness of group educational systems. Its monitoring and maintenance is the task of the coherent (or the AI-based coherence assistant).

The educational system as a whole is formalized as a social generalized machine with optimal perveance $P \sim 0.5$, a four-stroke “stability bell,” and a knowledge recuperation mechanism.

Future work involves experimental verification of the proposed metrics on learner samples, development of validated B -profile diagnostic instruments, and creation of a prototype digital platform for coherent education.

In summary, coherent education provides a unified mathematical language that bridges the gap between individual cognition and institutional organization, offering practitioners a toolkit of diagnostic metrics, design principles, and quantitative benchmarks. The theory is falsifiable, computationally tractable, and amenable to experimental verification — qualities that distinguish it from purely qualitative pedagogical frameworks.

The practical significance of this work is determined by the fact that the proposed formalism enables a transition from intuitive pedagogical decisions to quantitatively grounded ones: B -profile diagnostics identify the specific component requiring intervention; the metric S enables real-time assessment of group work quality; the formula P_{coll} provides a forecast of the collective result before the learning process is completed. AI integration within the five rules (Section VIII.3) ensures acceleration of the cognitive cycle while preserving learner subjectivity — the fundamental condition of genuine education.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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APPENDIX. SUMMARY TABLE OF FORMULAS

Number	Formula	Notation
	$B = F^{w_1} \cdot E^{w_2} \cdot (1 - \sigma)^{w_3} \cdot \Lambda^{w_4}$	F – focus, E – emot. coherence, σ – entropy of doubt, Λ – empirical reinforcement
	$\frac{dB}{dt} = \gamma \tanh(\beta \bar{d}) \cdot \bar{d} \cdot B(1 - B)$	γ – learning coeff., \bar{d} – distance, β – steepness
	$\Phi(\Psi) = \iota(\hat{O}_\Psi(\Psi))$	ι – embedding operator, \hat{O} – observation operator
	$S = 1 - \frac{2}{n(n-1)} \sum_{i < j} B_i - B_j $	n – number of participants
	$T(C) = \frac{T_0}{(1 - S)^n}$	T_0 – base lifetime
	$P_{\text{coll}} = 1 - \prod_{i=1}^n (1 - B_i^k)$	k – nonlinearity parameter
	$q_B = \Lambda + F \mathbf{i} + E \mathbf{j} + (1 - \sigma) \mathbf{k}$	B -profile quaternion
	$n_{\text{min}} = 3 + 2 = 5$	Min. group size
	$\rho(S) \sim K^{-N(1-S)}$	Overlap density
	$v = \frac{\alpha}{I(C) + \varepsilon}$	Reconfiguration speed
	$\hat{O}_{\text{comp}} = \hat{O}_{\text{human}} \circ \hat{O}_{\text{AI}}$	Composite operator
	$\Delta d / \Delta t$	Dimensionality growth rate
	$\min_t S(t) > S_{\text{threshold}}$	Coherence stability
	$P_{\text{coll}}(E) > P_{\text{threshold}}$	Collective probability
	cognition → learning management → production	→ Four-process SGM cycle
–	$U/S = \varphi, K = 1/\varphi^2 \approx 0.382$	Optimal management-to-self-management ratio
–	$2\varphi^2\tau \approx 5.236\tau$	Full cognitive cycle duration

Principal notation.

Symbol	Definition
$B(O, C)$	Cognitive coherence of observer O in configuration C
$F(O, C)$	Observer's focus of attention
$E(O, C)$	Emotional coherence

$\sigma(O, C)$	Entropy of doubt
$\Lambda(O, C)$	Empirical reinforcement
w_i	Weight coefficients of B components, $\sum w_i = 1$
d	Dimensionality of the observation operator
\hat{O}	Observation operator
Ψ	Field of potential states, $\Psi \in \mathcal{H}$
R	Observation result, $R = \hat{O}(\Psi)$
ι	Embedding operator, $\iota : \mathcal{C} \rightarrow \mathcal{H}$
Φ	Self-observation mapping, $\Phi = \iota \circ \hat{O}$
S	System (group) coherence
n	Number of group participants
$T(C)$	Configuration lifetime
P_{coll}	Collective probability of achieving the result
φ	Golden ratio, $\varphi = (1 + \sqrt{5})/2 \approx 1.618$
τ	Time unit of the cognitive cycle
γ	Learning coefficient
β	Steepness parameter
\bar{d}	Normalized distance between R_{obs} and R_{exp}
$I(C)$	Configuration inertia
v	Reconfiguration speed
q_B	B -profile quaternion
P	Perveance
K	Self-management share
$\rho(S)$	Configuration overlap density
