Quantum (Ped)Agogy V:
Democritus's Schemata.
Information Quantization in Pedagogy.

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Abstract:

Thus far, the Quantum Pedagogy framework has introduced a series of conceptual tools aimed at describing learning, behavior, and cognition within a probabilistic and field-based model. However, the internal structure of knowledge and information has not yet been explicitly addressed. This article proposes that knowledge should be understood as quantized information: structured informational packages that emerge through the interaction between a subject's Accumulated Agoge and the Field of Agoge.

The notion of quantization is introduced as a conceptual necessity rather than a metaphorical embellishment. Without some form of informational discretization, cognition faces an informational catastrophe analogous to that encountered in classical physics prior to Planck's solution to black-body radiation. If information were processed as a continuous and unconstrained spectrum, all cognitive constructs would be equally possible yet indistinguishable in relevance, stability, or persistence. Quantization functions as a limiting principle that renders knowledge formation possible by allowing only specific and well-defined informational packages to emerge, stabilize, or dissolve through interaction.

This framework draws inspiration from quantum mechanics, but does not imply, nor deny, a physical quantization in the human brain. Instead, quantization is treated as an epistemological and cognitive constraint that explains the emergence of structure, meaning, and probability in learning processes. Through this lens, constructivism, relativism, and probabilistic behavior are not rejected but reinterpreted as consequences of quantized cognition. The distinction between relative and absolute knowledge is revisited and grounded in the differential interaction of cognitive packages with the Agoge Field.

By framing knowledge as quantized information, Quantum Pedagogy offers a coherent account of why certain cognitive constructs persist across individuals and contexts while others rapidly collapse, providing a unifying bridge between constructivist theory, cognitive schemata, memory formation, and behavioral reinforcement.

This paper is part of the Quantum Pedagogy framework (see Positioning Note).

Keywords: Quantum Pedagogy, Schemata, Quantization, Constructivism, Cognitive Development, Knowledge Formation, Gestalt Psychology, Learning Theories, Educational Epistemology, Accumulated Agoge.

Introduction.

Depicted on the 10 drachmae coin, we encountered him early in our lives. “By convention sweet and by convention bitter, by convention hot, by convention cold, by convention color; but in reality, atoms and void”. Democritus addressed us through that small coin, teaching us about the atomic theory – the idea that eventually you cannot divide matter further, that there are fundamental and indivisible particles, the universe consists of. And by combinations of them, and interactions with the void, greater structures are made, the structures we know and understand as reality.

His ideas and his work with his master Leucippus, were lost in fires of history, only reaching us through quotations from other philosophers – however their theory, the atomic theory, would return two thousand years later, in the Enlightenment. The main concept of the atomic theory, the greater structures made from smaller indivisible building blocks still applies today.

In pedagogy, Constructivism is analogically corresponding, the theory closer to his ideas. The excellence and wisdom of Constructivism is paramount, yet, its truth is incomplete. Though truth and knowledge are subjective, just as Protagoras would argue, and though they are formed by each, constructed with unique information every time, questions remain. Why some constructs persist through time and thought while others do not? What constrains the space of possible constructions so that knowledge can persist?

It is an Informational Catastrophe.

Quantum Pedagogy has yet to explain the use of “quantum” in its title. In this article we will explore the role of “quantization” in this framework, and utilize it as a bridge concept with Constructivism. This article is not an amendment to prior concepts, but rather aims to specify quantization as an ontological requirement.

This paper constitutes the fifth contribution to the Quantum Pedagogy series, following Bovolis

(2026a, 2026b, 2026c, 2026d, 2026e). Building upon the concepts of Accumulated Agoge, Relative Uniqueness, and Agoge as a field-like structure, it introduces quantization as a necessary condition for the emergence of stable knowledge and identity.

The Legos of Constructivism.

In Constructivism, knowledge is constructed by each student through the admission of information from teaching and its interaction with the existing sum (Elliott et al. 2008, Phillips 1995, Olusegun 2015). It is the only theory of learning that links itself with corresponding theories of cognitive development, and it can also be argued that it arises from them. Behaviorism is indifferent to cognitive development, Bandura's SCT is developmentally neutral and Information Processing Theory is more so complementary to them.

Thus, knowledge is fully relative, inasmuch as each student has constructed his idea with his own information. This is because, while students have common characteristics with each other due to age, the "materials" that each has from their daily life are different. Hence the final result of building will be different even if the students find themselves in the same teaching – therefore there is no absolute knowledge, because knowledge is subjective (Arends,1998; Von Glasersfeld, 1998). In past articles we already explored Vygotskian thinking and its Zone of Proximal Development. Constructivism has another great approach, the one from Jean Piaget.

Piaget's Schemata.

Schemata are a critical concept in Paget's theories of cognitive development – and, coincidentally, schema is also a Greek word (it means shape and form). Schemata are the basic building blocks of intelligent behavior, specific behavioral patterns, neural connections and memory indexes that are used to organize and interpret information. Schemata are dynamic structures, increasing in complexity and usage as the person gains more experience and information. Thus, the Piagetian child is an active scientist that continuously explores the word creating better schemata by its interaction with it. Yet, since experiences are unique, the schemata that are being constructed and updated are unique as well.

According to Piaget, in order to learn, and in terms of our cognitive development, there are two psychological mechanisms, the mechanism of assimilation, and the mechanism of accommodation, which Piaget defined as functional constants. Assimilation is about connections between cognitive

structures, while accommodation is about creating harmonious relationships with and adapting to the human environment, which lead to cognitive equilibrium (Eliot et al. 2008, Piaget 1952,1958). Piaget's schemata have a clear structure and discrete identity, existing as wholes inside human cognition (Piaget, 1971).

Quantus, Quanta, Quantum.

Meaning "how much" in Latin, the notion of quantization revolutionized physics. Up until its introduction there was no solution to the Ultraviolet catastrophe – according to classical physics a black body would emit infinite energy as we approached smaller wavelengths. In order to solve this impossibility, Max Planck proposed the idea that energy is being emitted in specific and discrete packets, the quanta. The smaller the wavelength the more energy was required in order to emit a packet, therefore eliminating the infinity.

The notion of quantization is the cornerstone of quantum mechanics. Properties do not exist in a continuous spectrum of values but rather in specific multiples of a fundamental quantity. We perceive that even time and space might be quantized – it has been hypothesized that there are elementary and indivisible units of spacetime (the Plank time and Plank length) from which the universe is later constructed.

Why Pedagogy must be Quantum?

Thus far we addressed the realm of this new model by using analogies to enlarge already existing pedagogical concepts into a broader theoretical framework. This process of enlargement, either by adopting probabilistic approaches or redefinitions of established ideas, has broaden the framework enough – thus the introduction of a concept that acts as a constrain is a necessity. Quantization serves exactly this purpose – it is a concept that weeds out the infinite probabilities to select the finite probable scenarios.

In the "*Brief History of Time*", the masterpiece of S. Hawking, there is a page where the author makes an amazing point. If we had a typing machine and an ape, by pure stroke of luck and after inconceivable time, by sheer probability that ape would type a coherent sentence, just by luck. Given enough time, it could even type a page from a Shakespearean work.

While this example is used to describe probabilities and entropy, it can also be utilized differently. In a simple sheet of paper, there is space for a finite number of letters. While both the letters and the space that they can exist in is finite, their possible combinations are inconceivable. With 24 letters, plus ten more for spaces and punctuation marks, multiplied by let's say 100 possible positions on the paper and we immediately have an astronomical number:

$$34^{100}$$

Out of these possible combinations, all are equally possible mathematically, and our ape could easily type one as much as the next one. However, although all are equally possible, only a finite subset can make sense and contain information. There must be structure and limitations, otherwise information cannot exist. Just like the Ultraviolet catastrophe, without some sort of limiting factor, we are faced with the infinite – the infinite our theory deems possible but our experience finds unacceptable.

Language is of paramount importance in Pedagogy, since it serves as a primary source of external stimuli and information and as an internal tool for organization. In our example every single position out of those one hundred can take 34 possible variations. Every position is fundamental – if we were to further dissect a letter (or a punctuation mark) we would lose all structure and meaning and would delve into geometry and not language. Thus, the single letter, is the least indivisible packet of language – the letter is a quantum. Without discrete units with clear identity, language cannot exist – quantization is a necessary process. Within the scope of this analogy, the letter is treated as the minimal indivisible unit of written language, not as a linguistic universal (Deacon, 1997).

A single letter (or punctuation mark) can used for information communication, however that is highly inefficient, generic and inaccurate. Therefore, we offer a greater degree of precision and structure with those packets- larger combinations of the same integers, where many can exist yet only some have use. These are larger structures than the letter, two letter words, three letter words… sentences… paragraphs and even whole texts. The structure of language hints of quantization – there are indivisible units that constitute larger constructs not in continua but only in specific and well determined combinations.

Quantum Pedagogy solves the critical impasse of the Informational Catastrophe by accepting that *Cognition quantizes raw information into specific packets. Knowledge and memory are quantized information, hereafter referred as a "packet", that has occurred after interaction with the Field of*

Agoge and one's Accumulated Agoge. Only specific and well determined combinations can exist – and every cognitive process serves as a quantizing factor.

Whenever Cognitive Dissonance occurs and the "packet" is faulty, further interaction forces readjustment. From the inglorious but necessary process of dictation, where students are being continuously worked on their quanta for letters and words, to interactions with the field of Agoge of higher importance and difficulty, continuous interaction either maintains the existing packets or forces the person to readapt them. Thus, are some constructs able to survive constant exposure to the field of Agoge and others are not. This process is closely linked with the processes of Positive and Negative Reinforcement form Behaviorism.

By accepting that information must be quantized, Quantum Pedagogy offers answers as to why some behaviors have nearly zero probability of occurrence and others have higher. By accepting probabilistic thinking as we did in the first article, we are forced to answer questions that can be technically postulated but are impossible in reality. Quantization works as a limiting factor for improbable scenarios as it narrows them severely by allowing only specific outcomes and not an infinite spectrum.

The packets however are themselves under constant pressure and adaptation – since language is a human construct and not a physical one, its packets are not permanent, but rather fluid, under the terms we set forth – language belongs to Diagoge; therefore, its packets can change over time since they are mere conventions (remember Prodicus!). We must also note however, that certain quantization cannot change as easily – the descriptions and interactions with Hyperagoge are not subject to change, no matter whether our "packets" for them change. Thus, there must be a critical differentiation, and knowledge separated in absolute and relative packets.

Quanta, not Continua.

It is already known that according to the Theory of Information Processing, memory, although it can exist in a continuum, is used in discrete packets. The same discrete packets already exist in Piagetian thinking, the schemata. Gestalt Psychology also has a corresponding requirement, unified wholes, not just assembled elements (Wertheimer, 1912, Koffka, 1935). There are no 1 and ½ schemas, no 1 and ½ memories, 1 and ½ wholes.

In Gestalt Psychology, quantization is an arising realization. If no discrete packets were to exist and the world functioned as an unending gradient of change, then perception could not form wholes, shapes, structures and schemas. Knowledge must be quantized, formed into discrete packets, so that wholes can exist.

Pre-epistemic information and memory can exist in a continuum before interacting with Cognition. If we are to utilize them, whether for interaction with the field of Agoge (communication) or for ourselves (adaptation) we are forced to quantize them into discrete packets. Knowledge must have a defined form and shape, otherwise it cannot exist in the Field of Agoge. Communication necessitates well defined packets of information, otherwise it serves no purpose, and ceases to exist in the Field of Agoge. Memory requires quantization otherwise the continuum becomes impractical and negative factor for adaptation and survival – precisely why we possess the processes of oblivion and retention. Memory processes function as limiting factors that enforce quantization.

Information and memory can exist in a continuum, much alike energy can and does in quantum mechanics. But just as the energy fields can exist in continuum, yet interaction with the universe requires quantization, the same is proposed for knowledge, memory and information – interaction with the field of Agoge necessitates their quantization, or perhaps, interaction with the Field of Agoge forces quantization.

Thus, although quantization is introduced as an analogy to physics, its existence is already implicit into our established psychology and cognitive models. What Quantum Pedagogy proposes is merely a new "quantum" for a notion that already exists, with the realization that the process is required for cognition.

Knowledge as Identity: Why Quantization Is Necessary

Knowledge cannot be defined solely as information in use, but as information endowed with identity. For knowledge to exist as an epistemic entity, it must be recognizable as the same across time, context and interaction. This requirement of identity cannot be satisfied within a continuous cognitive state. In a continuum, every infinitesimal modification produces a distinct state, rendering recognition, recall and differentiation impossible. Without discrete boundaries, without defined *schemata*, there is no criterion by which a cognitive structure can be identified as "this" rather than "that", nor as the same

structure reappearing under different conditions. Without a clear schema, there can be no clear identity, no clear whole, no well-defined object – knowledge requires a discrete boundary.

Quantization is therefore not introduced as a functional convenience for memory or communication, but as an ontological necessity for the existence of knowledge itself. Only by being packets into discrete, identifiable units can information acquire stability, persistence and epistemic status. In this sense, quantization is a prerequisite not merely for the use of knowledge, but for its very individuation. Quantization transmutes the flow of information into discrete packets, shaped quanta. Quantization creates Identity.

If we tried to treat Knowledge as a continuum, we would run into a dead end. It would be impossible for perception to recognize whole shapes, differentiate and produce categories – Gestalt Psychology, and Cognition would not work. The constant flux of change would never solidify into a clear shape – learning could not occur as we know it, and the adaptation that would be based on it would collapse. If knowledge was a flow and not a discrete packet, errors would only be temporal and of no meaning, and no reexamination, revision could exist – Piaget's equilibrium would be unattainable and we would exist in a permanent state of never-ending gnostic dissonance.

For Constructivism to exist, quantization is a requirement – if knowledge is constructed, building blocks are needed, the quanta. And while quantization is a universal requirement for knowledge to exist, the specific form and content of the resulting packets are contingent upon each subject's Accumulated Agoge. Quantization therefore does not eliminate subjectivity of Constructivism, but enables it and emerges from it. While no point in the Field of Agoge can ever be the same, the requirement for quantization is universal in it (we note the complementarity between the Principles of Uniqueness and Relative Uniqueness as we have examined in earlier articles). The need for a discrete boundary is ecumenical, but the content of each quantum is contingent to the node in the Field of Agoge – and thus constructivism arises.

Conclusion

Democritus's building blocks, the "Schemata" are crucial for our understanding of the universe and our continual survival in it. And more so, without their existence, there can be no identity or meaning – their importance is undeniable.

Quantum Pedagogy, is named Quantum because one of its core concepts is quantization. This article argues that quantization may be understood as a necessary condition for stable knowledge, not merely a metaphor. Through quantization, cognition sifts the finite probable from the infinite possible. Knowledge and memory are quantized information. Knowledge and memory must form discrete packets and their larger structures are formed by them. Continuous interaction with the Field of Agoge and our Accumulated Agoge create those quanta – it is those quanta that give us meaning and identity, and allows us to adapt and survive.

Without quantization, information flows; with quantization, meaning exists.

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