Creativity, problem solving, critical thinking: Are they all skills?

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Abstract

A mix-up prevails in the educational literature within and among unidimensional and multidimensional knowledge aspects. Precise knowledge taxonomy based on sound cognitive criteria and cutting across disciplines is necessary to adopt efficient pedagogy for learning and teaching all sorts of knowledge and to design and implement appropriate curricula.

Keywords

Competency, conception, disposition, habit, middle-out, profile, regulator, skill, taxonomy, trait.

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Distinct aspects of knowledge that impose different cognitive demands, and thus different teaching and learning approaches in any discipline, are often not clearly differentiated in the educational literature[1]. This is for example the case of creativity, problem solving, and critical thinking that are often commonly classified or referred to as "skills". The three terms refer to what belong to different knowledge types or categories under any sound taxonomy, and specifically to what we refer to as profile traits (i.e., sustained mind states that warrant, say, creativity and collaboration), competencies (e.g., communication and problem solving), and skills (e.g., expression and critical thinking). These three categories are outlined along with others in this paper, and some recommendations are offered in their respect.

Educationists, teachers and other educators, and educational organizations have long relied on one knowledge taxonomy[1] or another when designing and implementing various curricula and related educational materials, and when deciding, or calling to concentrate in practice, on select knowledge aspects that they deem critical for meaningful learning of course material and success in the workplace and elsewhere in daily life. Nevertheless, there has often been some mix-up, in literature and practice, between certain knowledge categories leading, despite all serious and worthy efforts, to significant pedagogical shortcomings.

For instance, a distinction has been commonly maintained in taxonomy between cognitive and behavioral knowledge, or between content and process knowledge (often referred to as declarative and procedural knowledge respectively), and different sub-categories have further been distinguished within each of these categories based on certain criteria, especially in relation to what it takes to develop any aspect of knowledge to a given level of satisfaction. However, for lack of consensus on criteria and what they mean and imply, different people continue to: (a) interpret differently a given knowledge category or subcategory they commonly recognize, (b) disagree on subcategories distinguished under one common category or another, and/or, (c) determine differently what it takes for students to develop in meaningful and productive ways a commonly recognized aspect of knowledge. As a consequence, educators who commonly adopt a given knowledge taxonomy diverge in class practice, even when belonging to the same pedagogical school, and fail to lead their students consistently to satisfactory results within and across different courses and schools.

Of course, knowledge taxonomy is not the only matter educators and educationists disagree about. Lack of consensus sweeps across various other matters, and so does lack of consistency in adopting and in handling any matter in various pedagogical respects. It is always hoped for diversity to be a source of enrichment. However, in this instance, this has far from being the case, and it will never be the case in education, at least as long as diversity is not substantiated and well-informed from all cognitive and other pedagogical perspectives.

This paper is meant to solicit discussion that may bring consensus on what type of knowledge some educational terms refer to, and what cognitive demands they subsequently impose, which may ultimately help stakeholders agree on sound taxonomy and figure out what pedagogical theory and practices are most suitable for teaching and learning knowledge of any type in any course. The paper comes in eight concise sections. The first section is about knowledge taxonomy. Four sections follow respectively on conceptions (content knowledge), skills (procedural knowledge), and the two axio-affective controls of dispositions and regulators. These four knowledge types are most important in the makeup of competencies discussed in the sixth section before we proceed to profile traits in the seventh section. The paper concludes with quick pedagogical recommendations implied by the cognitive demands and related epistemological foundations of discussed knowledge aspects.

[1] We refrain from citing any reference in this paper in order not to give the false impression that we are focusing on some works but not others, or favoring some over others.

1. Knowledge taxonomy

Knowledge about our own self and the world around us is classified in different ways and in accordance with different taxonomies in the literature. This includes, in education, the broad classification mentioned above into content and process knowledge, and into cognitive and behavioral knowledge, along with related hierarchical ramifications into lower level(s) clusters.

Content knowledge, often referred to in the literature as declarative knowledge, includes "facts" that we admit individually or collectively about the state of, and events in, the physical world around us and within us, e.g., the facts that you, the reader, exist and that you are currently reading this text. Interpreting facts and developing and exchanging personal or collective ideas about them require thought and communication vehicles that make up "conceptual" knowledge, a higher, abstract level of content knowledge. Conceptual knowledge consists of: (a) "concepts" that we, humans, invent to represent in our minds individual objects, or sets of objects that we deem to be similar in certain respects, or to represent individual properties of such objects, and (b) "connections" or relations among concepts that we typically formulate in the form of definitions, theorems, laws, axioms, or other conceptual statements. Concepts and relations among concepts are commonly referred to hereafter as "conceptions" (§ 2).

Process knowledge (or procedural knowledge) pertains to all mental and physical actions we undertake to complete any task, and includes particularly reasoning and sensorimotor skills that we deploy to such end (§ 3) following particular rules, and using particular physical and/or conceptual tools. Process knowledge is required to construct new content or process knowledge, and to deploy and regulate any existing knowledge in any mental or physical exercise.

Cognitive knowledge pertains to thought dynamics. It involves predominantly reasoning skills necessary to complete certain tasks, along with conceptual knowledge and axio-affective knowledge (values, ethics, emotions, sentiments, dispositions) that control and regulate our thoughts and actions. *Behavioral knowledge* pertains to physical action. It involves predominantly sensory and motor skills (or sensorimotor skills) along with necessary reasoning skills, content knowledge, and axio-affective knowledge. For example, reading this text requires sensorimotor skills (to fix your eyes and head and move them around, and to turn pages or scroll a screen); interpreting what you read requires cognitive knowledge. Picking up, say, a dictionary or a related reference book from a bookshelf requires behavioral knowledge.

We have developed our own taxonomy of unidimensional and multidimensional aspects of knowledge based on particular criteria including: (a) the epistemological intricacy of various knowledge aspects, inherently and in relation to each other, and (b) cognitive demands they impose for constructing them and deploying them in thought and action (Halloun, 2017/19). Unidimensional aspects include conceptions, reasoning skills, sensorimotor skills, and

Box 1. Taxonomy of learning outcomes.

A learning outcome (LO) is is a unique bit of content or process knowledge, or of any related state of mind, about a particular object of learning or set of objects. LOs are the simplest, unidimensional knowledge aspects that may be envisaged as quasi-elementary constituents of more complex, multidimensional aspects, particularly competencies. SCE taxonomy of LOs is a four-dimensional taxonomy, with five major facets distinguished within each dimension (Halloun, 2014/19, 2017/19):

The *epistemic* dimension pertains to conceptions, i.e., object and property concepts and connections among concepts.

The *rational* dimension pertains to reasoning skills.

The *sensorimotor* dimension pertains to dexterities or skills necessary for physical action.

The *axio-affective* dimension pertains to value-related and affective factors that control our thoughts and actions and determine their efficacity and efficiency.

fundamental axio-affective controls (Box 1). These aspects make up the object of the following four sections. Multidimensional knowledge aspects involve in constitution and/or in practice a mix of unidimensional aspects. This is the case of competencies and profile traits that make up the object of sections 6 and 7 in this paper.

2. Conceptions

Conceptions are the building blocks of the "episteme" or corpus of content or declarative knowledge (factual and conceptual) in a given field or discipline. The term "conception" is hereby used to denote the output, the conceptual product in human mind, not the process, of conceiving whatever fact, notion, or idea about a physical or abstract entity or set of entities and events. Conceptions include object and property *concepts* (e.g., flower and color respectively), as well as conceptual *connections* or relations among concepts. As noted above, connections may take the form of definitions (of one concept in terms of other concepts), laws, principles, theorems, or other premises (theoretical/foundational statements).

Appropriate semantics and syntax help making sense of a given conception, connect it with, or relate it to, other conceptions, and subsequently make proper use of that conception. *Semantics* set the meaning of the conception, how it can be interpreted by correspondence to what it refers to in the physical world and/or the abstract realm of a given episteme, and how it can be expressed and communicated in significant ways. *Syntax* sets how the given conception relates to other conceptions in meaningful ways, what means can depict such relationships or connections most explicitly, and what relationships and depictions entail in practical respects, especially in terms of choosing and using proper conceptual tools for various operations with that conception (e.g., narrative, topographic, or schematic tools).

3. Skills

Skills are sustained abilities for knowledge management (Box 2), particularly for constructing new knowledge, regulating it, and deploying it in order to successfully achieve cognitive or behavioral tasks and bring about meaningful ends. Any such task, like any knowledge management it entails, usually requires the coordination of many skills and conceptions. Skills are at a higher cognitive level than conceptions and conceptual or physical tools. They are

Box 2. Knowledge management glossary.

Acquire: To retain, mostly at face value, new knowledge (new conception, skill, disposition, competency, etc.) provided or displayed by another person or any other source of information.

Articulate: To regulate and/or reinforce some existing knowledge (already acquired or constructed) within its scope (domain and function), enrich and strengthen its connections with other knowledge, and elaborate it beyond its original scope.

Construct: To actively put together new knowledge using, and connecting with, existing knowledge.

Deploy: To use (apply, implement, utilize, put into action) existing knowledge in familiar and new contexts following specific rules, and articulate it as a consequence.

Develop: To construct and constantly articulate new knowledge.

Elaborate: To modify and ramify existing knowledge in order to expand its scope and adapt it to new circumstances or situations.

Regulate: To insightfully refine and enhance existing knowledge subsequent to its evaluation and the recognition of its shortcomings and potentials.

Reinforce: To further demonstrate the viability (validity, reliability, usefulness, affordability, etc.) of existing knowledge and sustain it in memory as it already exists with minor changes.

indispensable to construct or choose conceptions and tools and to make proper use of them in defining and undertaking any task.

Two broad categories of skills are usually distinguished in the literature: reasoning skills and sensorimotor skills *Reasoning skills* are required for inception of, and operation with, conceptions in working memory, meaningful understanding and sustainable integration in long-term memory (consolidation) of conceptions, and their efficient retrieval from memory and productive deployment in various situations. They are also required to decide upon and sustain sensorimotor skills. Analytical reasoning, criterial reasoning, relational reasoning, critical reasoning, and logical reasoning are major types of reasoning skills (Halloun, 2017/19).

Critical thinking involves, among others, identification of problematic issues in a given situation; generation of adequate questions or problem statements about that situation; insightful inquiry and proper conclusions about various elements that are determined through differential analysis (*analytical reasoning*) to be primary or pertinent to the stipulated question or problem; ascertaining underlying assumptions and hypotheses (formulated through *logical reasoning*); judicious choice of necessary conceptions, tools, and procedures; ascertaining and finalizing proper criteria and means (set through *criterial reasoning*) for evaluating everything needed to answer questions or solve problems and every step leading to a proper answer or solution; anticipation of possible risks and challenges that might arise in the process of dealing with the situation at hand, and setting plans to face such impediments (Halloun, 2014/19).

Sensorimotor skills (or *dexterities* in a broad sense) are required to achieve perceptual or physical operations involving, in addition to our brains (for reasoning and controlling our dexterities), our senses and other parts of our human body (e.g., looking and listening in perception, and manipulating a computer keyboard or writing on paper in physical operations). Major types of sensorimotor skills include expressive dexterities for oral, kinesthetic, written, and other forms of expression of ideas, digital dexterities for operating computers and other electronic devices, manipulative dexterities for handling all sorts of physical tools and hardware, artistic dexterities for producing and using all sorts of arts and related tools, and eco-engagement dexterities for conscientious interaction with others and the natural environment (Halloun, 2017/19).

4. Dispositions

A disposition is a sustained, preexisting tendency that determines in predictable ways the course and outcome of conceptual or physical activities a person undertakes, and particularly the efficacity and efficiency with which any conception or skill may be deployed. A disposition may be constructive or destructive. In contrast to destructive dispositions that take things in negative or unproductive directions, constructive dispositions sustain our resolve for successful and efficient completion of any activity. Perseverance, curiosity, risk-taking, empathy, open-mindedness are examples of constructive dispositions.

Fundamental axio-affective factors like attitudes, ethics, and values are necessary to elicit and sustain dispositions of one sort or another (Halloun, 2017/19). Our use of the term "disposition" hereby implicitly embeds such factors. Constructive dispositions always come along with positive attitudes and ethical conduct. Positive attitudes are about holding positive thoughts and stance toward what we're doing and, particularly, whom we're dealing with, and about commitment for constructive, synergetic, and respectful interaction with others. Ethical conduct takes place in conformity with globally valued morals and codes of conduct, especially those valued by professionals in a given community of practice.

5. Regulators

Regulators (or circumstantial or situational controls) are spontaneous, environment-driven and mind-controlled axio-affective factors that determine, along with dispositions, and sometimes more than dispositions, the course and outcome of any activity. Unlike dispositions that are already sustained in mind, regulators are determined, far more significantly than dispositions, by the nature and circumstances of the situation a person is involved in, including the overall mental and physical conditions of that person (dispositions included) at the time of engagement in that situation. Attention, motivation, volition, and emotions are major types of regulators.

Depending on prevailing circumstances, dispositions and regulators may either complement and reinforce each other, or one may subdue and supersede the other. The course taken by any given conceptual or physical activity may however affect regulators significantly more than dispositions. For example, the drive or sustained desire (disposition) to learn specific materials in specific ways is pre-established to a large extent in a person's mind before a learning experience about those materials kicks off. However, the way the experience is set and proceeds may change significantly, say, how much attention that person pays to various aspects of the experience, as well as the person's motivation and volition regarding that experience. The more novelty the experience holds that is of interest to the person, and the more successful the person is at given stages of the experience, the better the person's attention, and the more s/he would be motivated and determined to pursue that experience towards fruitful ends. In contrast, the experience would tumble altogether in the lack of novelty of interest and with the failure to make any progress at certain stages, no matter how well the person might have been originally pre-disposed or intentioned to get engaged in that experience.

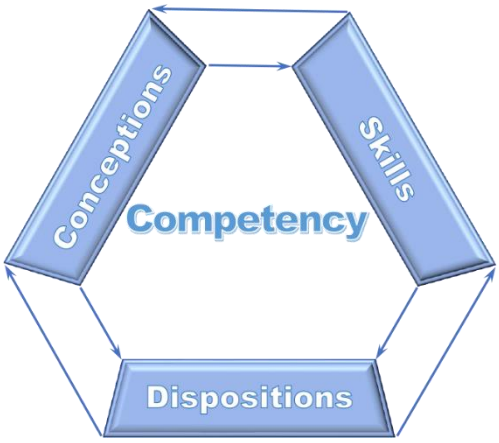
6. Competencies

A competency is what it takes – all that it takes – to successfully achieve certain tasks. It consists of a coherent, tridimensional network of conceptions, sensorimotor and/or reasoning skills, and dispositions that are sustained in long-term memory and that can be readily deployed together to achieve a given task or set of tasks (Fig. 1). The efficiency, and thus relative success, of a given competency depends, like its constituents, on the regulators governing the overall situation in which the competency is being deployed.

A competency may be specific or generic. A *specific competency* serves to accomplish a particular task or category of similar tasks, usually falling within the narrow scope of a particular branch of a given discipline in formal education. Examples include attending to the medical needs of patients with a given sickness or injury, writing a report about particular events or experiments, solving a particular type of problems, assembling a particular piece of furniture

Figure 1. Competency.

Pairs of arrows indicate that various constituents affect each other, and that any change in one constituent might induce changes in other constituents. The course and outcome of any change, like the creation of the competency in the first place, are governed, let alone determined, by regulators.



or a particular type of electric circuits. A *generic competency* is a cross-cutting competency that serves to accomplish a variety of tasks spreading across different disciplines or fields of knowledge. Examples include attending to the needs of people in emergency, mediating the resolution of different sorts of conflict, creative decision making and problem solving, designing and assembling a variety of equipment.

People who master a specific competency can successfully: (a) carry out specific tasks in familiar, real or conceptual contexts, and (b) transfer what they have learned in the process to new tasks involving similar objects and/or events in similar contexts. In contrast, people who master a generic competency can successfully: (a) carry out a variety of tasks, in familiar and novel, real or conceptual contexts, and (b) transfer what they have learned to new tasks involving similar and different objects and/or events, in a variety of familiar, similar, and novel contexts.

Some competencies, like communication and problem-solving competencies, are often referred to in the literature as skills. *Communication* involves conceptions, dispositions, and regulators, in addition to reasoning and sensorimotor skills. Reasoning skills include, among others, the *critical choice* of appropriate vocabulary (conceptions), and *relating* and *expressing* different ideas (conceptions) in accordance with appropriate syntax and semantics. Sensorimotor skills include, in addition to oral and written expression, putting together and displaying necessary kinesthetic, pictorial, and/or graphical representations. Communication also involves dispositions and regulators that ensure respectively, among others: (a) clarity, sensibility, empathy, open-mindedness, respect, and (b) emotional relaxation, language and anger control, attention to certain details for persuasion.

Problem solving competencies may be specific (scope-limited) or generic (cross-cutting), and involve a mix of conceptions, skills, and dispositions. Necessary reasoning skills extend from the *analysis* of a given task or situation to tease out primary from secondary details (i.e., pertinent from irrelevant information or elements) to the *critical* choice of appropriate conceptions and procedures and the *criterial* evaluation of the resulting solution and of every element and step involved in, and leading to, that solution. Dispositions (and regulators) include precision, attention to details, curiosity and volition to try out new tools and ways, and perseverance to pursue a fruitful solution to the end.

A given competency may evolve into, or contribute to the making of, more complex competencies. Such is the case of communication and problem solving with respect to, say, negotiation and conflict resolution. Negotiation involves communication with additional skills, like critical judgment and logical argumentation, and additional dispositions, like caring, fairness, and impartiality. Conflict resolution involves problem solving and negotiation, with all conceptions, skills, and dispositions the latter two competencies involve, in addition to particular knowledge about the nature of a given conflict and concerned parties.

7. Traits

When competencies are sufficiently reinforced, they turn into *habits* that are spontaneously triggered and deployed whenever necessary to realize our goals in the most efficacious and efficient ways possible. A person's cognition and behavior, but especially development and deployment of the person's habits, are governed by that person's profile traits. A *profile* consists, for us, of all knowledge sustained in long-term memory around a core set of specific and generic competencies and habits and governed by particular traits. *Profile traits*, or "traits" for short hereafter, are, for us, *not innate* psychological characteristics that define a person's character. They are, instead, sustained, *habitual* or nurtured mind states that characterize and

Box 3. 4P Profiles.

We call for formal education to form people with 4P-profiles at the core of which are systemic habits and competencies and characterized with the following four broad traits (Halloun, 2023):

Progressive mind with an overall dynamic mindset with clear vision and critical and insightful commitment to empower oneself and others for self-determination and continuous progress in various aspects of life.

Productive habits with efficient skills and dispositions for wise resourcing and systematic, orderly, and innovative engagement in any individual or collective endeavor and for overall sound conduct in everyday life.

Profound episteme with a rich cohesive corpus of content knowledge focused in any field on generic epistemic essentials that readily lend themselves to practical aspects in the field and to coherence and consistency within and among different fields.

Principled conduct with constant value-laden drive for beneficiary outcomes that come about in accordance with righteous and constructive individual and collective stance and aspirations and in aesthetic harmony with local and global natural and social orders.

reign over all other aspects of a person's profile. They are cognitively higher and more complex than the fundamental, unidimensional axio-affective factors of dispositions, regulators, and others (Box 3).

Traits are thus, for us, overarching or dominant mind states that each of us develops consciously and purposefully through experience and sustains in long-term memory, and that determine, among others, our drive to pursue any thought and action in particular directions and bring about specific outcomes, in accordance with specific norms and standards. As such, a trait is always coupled with cross-cutting habits and generic competencies, along with a value system that governs and helps us regulate every endeavor we undertake. A given trait, along with underlying norms and standards, and related competencies, habits, and values, constantly affect each other and evolve with each other.

A trait may be positive or negative. A person with *positive traits* is well and ambitiously intentioned, sets constructive goals, pursues them systematically, and brings them about to a high level of achievement. A person with *negative traits* is ill or weakly intentioned, sets often irrelevant or more destructive than constructive goals, and, when under-motivated, pursues any goal haphazardly and achieves it with poor quality. Traits are *dynamic*, not fixed or static. They continue to evolve through experience. With proper experience, negative traits may be transcended into positive traits, and positive traits may reach higher levels and take habits and competencies into unprecedented levels of achievement. The latter is the case of the broad positive traits of *progressiveness* and *productiveness* in Box 3 that may ultimately evolve to engender *innovativeness*.

Innovativeness is a trait coupled with generic competencies and habits that allow an *innovative* person to set unprecedented goals and pursue them boldly in ways that transcend common practices, and to bring about unprecedented, high-quality outcomes. The person brings already developed habits and competencies into coordinated action, and/or develops new competencies, in order to treat a given situation creatively and/or bring about conceptual and/or physical inventions.

Creativity and invention are the two sides of the innovation coin. A *creative person* takes already existing ideas, products, and practices into new dimensions, and deploy them in novel ways to come up with unprecedented answers and solutions to common questions and problems. An *inventive person* transcends existing ideas, products, and practices, and come up with novel

ones, in order to: (a) re-formulate common questions and problems and deal with them in unprecedented ways, and (b) formulate new questions, identify new problems, come up with proper answers and solutions, and subsequently advance human knowledge and welfare to unforeseen levels.

8. Pedagogical implications

Development and deployment of various unidimensional and multidimensional profile components discussed in part in the preceding six sections impose cognitive demands of different levels of complexity, and thus require different pedagogical means and methods for teaching and learning them. Unidimensional components of conceptions, skills, and dispositions, impose, in this order, increasing cognitive demands. They all impose less cognitive demands than competencies which in turn impose, individually, less cognitive demands than the coordination of various competencies and habits to result into a profile of particular traits. As indicated in Figure 2 and discussed elsewhere (Halloun, 2023), competencies stand in the middle of the cognitive hierarchy between their unidimensional constituents and the profile they are part of, and are critical to develop all knowledge below and above the center they occupy in the *middle-out* hierarchy.

To understand what Figure 2 is about, let us borrow a simple analogy from linguistics. Individual words in any language begin to gain their significance when related to other words in one sentence or more in a short paragraph. Putting many sentences together in a paragraph, and then many paragraphs together in a comprehensive text of particular function (or literary genre) allows us to gradually master a given language with its semantics and syntax. As such, sentences (or short paragraphs) occupy the center of the middle-out hierarchy between individual words and texts of different function and structure in a given language, and are most fundamental to make sense of individual words and to master various types of text in any language. Similarly, competencies, like sentences, give full significance to unidimensional knowledge components (conceptions, skills, dispositions), and allow us to take full advantage of these components in the formation of various profile aspects.

All in all, the following issues are worth mentioning at this point and wrapping up our discussion with:

1. Knowledge aspects like creativity and problem solving are *not skills* like critical thinking. Creativity is a dimension of the innovativeness *profile trait*, and problem solving is about a *competency* for dealing with real and abstract situations. Profile traits and competencies require skills for their formation and for coming into action.

Figure 2. Middle-out, competency-centered, development of a person's profile and unidimensional knowledge components.

The bottom arrow pointing upward to competency indicates that any competency consists of unidimensional knowledge components of conceptions, reasoning and sensorimotor skills, and dispositions. However, and as indicated by the adjacent downward arrow, it is the mastery of a competency that allows for meaningful understanding and sustainable consolidation in long-term memory of the individual components in question.

The top pair of upward and downward arrows similarly indicate, respectively, that a given competency contributes to the formation of a person's profile with particular traits, and that it gains its full significance – and so do any related trait and the overall profile – when related to other competencies and habits, and when sustaining, and sustained by, certain traits, all within the person's overall profile.

2. *Precise taxonomy* is necessary in education that cuts across all sorts of knowledge (and respective disciplines and fields) and that clearly distinguishes between different knowledge aspects that impose different *cognitive demands* and require different *pedagogical approaches* for learning and instruction.
3. *Clear relationships* need to be established among various knowledge aspects from a cognitive perspective that takes into account *epistemological foundations* of the discipline(s) which knowledge comes from, as well as *mind-and-brain* conditions and processes for developing and deploying each aspect in relation to other aspects.
4. *Middle-out* cognitive hierarchies are among the most meaningful – and perhaps the most meaningful – for knowledge organization and, thus, for designing and implementing various curricula and courses.
5. Elements at the *center* of middle-out hierarchies are *most crucial* for developing knowledge of any sort. Unidimensional knowledge components gain their full significance only when related coherently and systematically to each other to makeup multidimensional knowledge components like *competencies* needed to deal with real life situations and to develop powerful profiles like 4P-profiles.
6. Curricula at all educational levels need to be coherently designed, implemented, and constantly regulated under well-established *pedagogical frameworks* that are grounded in – and constantly regulated, based upon – latest developments in neuroscience and cognitive science, on top of reliable educational research.
7. *Systemic Cognition and Education* (Halloun, 2023) may be relied upon for all the above and more.

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