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Explaining The Thinking, Learning Styles, And Cognition Constructs

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Abstract

This article briefly identifies and explains the key features of the three constructs, namely thinking, learning styles, and cognition, to show the relationships among them. The constructs have been given different terms like cognitive, teaching, or leadership styles, learner analysis, and psychological types. No matter how they are labeled, these constructs involve mental processes that change insights and thought patterns. The strategies which individuals follow to perceive, think, and process information to achieve their learning goals are equally different. Keefe (1982) provided new insights into cognitive development and academic learning when he said,

> *Knowledge about learning styles and brain behavior is a fundamental new tool at the service of teachers and schools... it provides a deeper and more profound view of the learner than previously perceived and is part of a basic framework upon which a sounder theory and practice of learning and instruction may be built. (Guild and Garger, 1985, p.14)*

Learning Styles

One important aspect of individuality crucial in determining the selection of appropriate teaching strategies and learning resources is 'learning styles' which is defined as the conditions or stimuli under which an individual is most likely to learn, absorb, retain information, and achieve (Dunn, Dunn & Price, 1992). Through *The Learning Styles Inventory* (Dunn, Dunn, & Price, 1985) an individual's learning style profile can be diagnosed according to five basic stimuli with 22 elements. They are environmental (sound, light, temperature, design); emotional (motivation, persistence, responsibility, structure); physical (perceptual, intake, time, mobility); sociological (peers, self, pair, team, adult, varied);

psychological (analytic versus global, cerebral dominance, impulsive versus reflective). The National Association of Secondary School Principals (NASSP, 1986) similarly defined learning styles as cognitive, affective, and physiological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment. To diagnose the learning style profile of individuals, NASSP developed a diagnostic instrument, known as *The Learning Style Profile,* (NASSP, 1986).

Renzulli and Smith (1978) defined learning styles differently as instructional strategies that are most preferred by individuals as they interact with the curriculum. The instructional strategies identified are projects, drill and recitation, peer teaching, discussion, teaching games, independent study, programmed instruction, lecture, and simulation. The researchers removed 'the psychological middleman that characterizes measuring instruments of this type [but]... deals with instructional practices of this type,' (p. 2). They developed the instrument *Learning Styles Inventory* (Renzulli & Smith, 1978) to measure students' preference for instructional techniques.

Schmeck (1982) regarded learning style as a learning strategy that a person consistently showed across all types of learning situations... 'a pattern of information processing activities that a person engaged in when confronted by a learning task.' (p.27). His instrument, *Inventory of Learning Processes (*Schmeck, 1982*)* measured 'deep and elaborative processing' and 'fact retention and methodical study.' The former described individuals who can evaluate critically, organize conceptually, and translate new information. The latter described individuals who follow instruction closely.

Learning style is still used without a single entity or a definition to work on because of the repertoire of mind qualities. The diversity of definitions ranges from simple statements to elaborate categorizations of learning style elements. However different the definitions may be, they all point to the stable patterns on how individuals perceive, interact, absorb, retain, organize, and process information.

Cognitive Styles

Researchers have been examining the psychological and unobservable dimensions of learning styles, that of cognition/cognitive styles. It is a person's

typical ways of 'information processing habits representing the learner's typical mode of perceiving, thinking, problem solving, and remembering (Messick, 1976, p.188). Cognition represents processes or organizes information rather than content. It involves a host of mental processes like attention, memory, rehearsal, forgetting, and retrieval instead of a single integrated theory. It refers to the 'how' rather than the 'what' of behaviour.

Cognition should not be confused with 'Intelligence Quotient' (IQ) which marks a current stage of mental development in a few specified areas. IQ measures what a student should be capable of achieving. A child with a higher IQ score is more likely to succeed in school learning. Though intelligence is highly related to school achievement, 'psychologists have not yet determined which is cause and which is effect' (Peterson, 1985, p.844).

There are many interpretations to cognitive styles. Witkin (1969) assessed cognitive functioning as field-dependent and field independent which is a continuum of analytic to global ways of dealing with a variety of cognitive tasks. The dimensions are diagnosed through the instrument *Embedded Figures Test* (Witkin, 1969).

Kolb (1986) and Gregorc (1982) saw learning styles as distinctive behaviours in terms of two dimensions, namely perception (how do I know) and processing/ordering (how do I think). Perception is the initial stage of cognition where an individual grasps information to discern information, ideas, and concepts. Kolb presented 'perception' as a continuum ranging from concrete experience (feeling) to abstract conceptualization (thinking). Gregorc presented it as concrete sequential to abstract sequential. Processing/ordering represents what individuals do with the knowledge gained and how they arrange and formulate the information received. Gregorc described 'processing/ordering' as concrete random and abstract random. Kolb saw processing as reflective observation (watching) and active experimentation (doing). The perception and processing scores make up an individual's learning styles termed as assimilator, accommodator, diverger, and converger. The cognitive characteristics can be diagnosed through *The Learning Style Inventory* (Kolb, 1986), and *Gregorc Style Delineator* (Gregorc, 1982).

Hemisphericity / Cerebral Dominance

Educators are now drawing on psychology and neurobiology to expand their awareness of individual differences. Recent advances in neuroscience and cognitive psychology are providing a clearer understanding of the three pound human brain. The newest element in cognition is hemisphericity/cerebral dominance which is another dimension of individual differences. This refers to the tendency of a person to use one side of the brain to perceive and function more than the other. Ornstein (1972) summed up as follows:

> *We are biologically equipped to process information in two distinct and complementary modes that are developed in different manners and that these specializations are not absolute but are rather a matter of relative predominance of one of the hemispheres (p. 62).*

Brain research shows that the brain has two hemispheres which specialize in different functions or process information in different ways. The two hemispheres extract different aspects of meaning from the same experiences. The interconnecting fibre, the corpus callosum and other connections allow interhemispheric communication between the hemispheres for comparing and evaluating the knowledge. Individuals have the capacity to engage in both the left and right hemisphere processing modes, but which mode takes the lead may depend on the individuals' dominance. There is a need to cultivate both hemispheric modes so that an individual can develop the ability to use both hemispheres in a complementary fashion.

Research showed that verbal, logical, convergent, and analytic functions can be ascribed to the left hemisphere. Intuitive, divergent, visual, spatial, and gestalt functions can be ascribed to the right hemisphere of the brain. Psychologists began to redefine and reconceptualize the hemispheric differences in terms of the processing of information rather than in terms of the types of tasks. Levy (Springer & Deutsch, 1985) conceptualized hemisphericity in terms of processing information, namely, the analytic - holistic distinction which moves away from the original verbal-nonverbal dischotomy. However, Zenhausern (1982) conceptualized hemisphericity differently. To him, individuals with a right hemisphere cognitive style tend to express their thoughts in pictorial form, and prefer deductive reasoning. Those with a left hemisphere cognitive style tend to express thoughts more abstractly, and prefer inductive reasoning.

Hemisphericity is relative rather than absolute. It only emphasizes 'differences' in brain functioning and processing.

A few established names are associated with this dimension, namely, Harold Gordon, Betty McCarthy, E. Paul Torrance, and Ned Hermann. All of them interpret cognition in terms of hemisphericity from the brain theory : that the two hemispheres of the brain specialize in different functions or process information in different ways. Hemisphericity can be diagnosed through the following instruments: *The Cognitive Laterality Battery* (Gordon, 1986), *Your Style of Learning and Thinking* (Torrance et al., 1988), *4Mat* (McCarthy, 1993), *and the Herrmann Brain Dominant Instrument* (Herrmann, 1990). All are preference tests except for *The Cognitive Laterality Battery* which is a performance test.

Below is a summary listing some researchers, definitions/dimensions, and instruments of learning styles (figure 1).

Researchers	Definitions / Dimensions & description of learning & cognitive styles	Instruments
1. Rita Dunn, Kenneth Dunn, & Gary E. Price.	**Conditions / stimuli under which an individual is likely to learn, absorb, retain information & achieve:** environmental, emotional, sociological, physical, psychological.	Learning Style Inventory (1985)
2. Joseph Renzulli & Linda Smith	**Instructional Strategies :** recitation, peer teaching, discussion, teaching games, independent study, programmed instruction, lecture, & simulation.	Learning Styles Inventory (1978)
3. Ronald R. Schmeck	**Learning Strategies :** elaborative processing, deep processing, fact retention, methodical study.	Inventory of Learning Process (1982)

Fig. 1: Researchers, Definitions/Dimensions and Instruments of Learning Styles

Researchers	Definitions / Dimensions & description of learning & cognitive styles	Instruments
4. Herman A. Witkin	**Typical ways of processing information :** continuous dimensions of field dependence & field independence.	Embedded Figures Test (1969)
5. David Kolb	**Perception & processing :** concrete experience & abstract conceptualization (perception); reflective observation & active experimentation (processing) Learning styles : Diverger, converger, accommodator, assimilator.	Learning Styles Inventory (1986)
6. Anthony Gregorc	**Perception & ordering :** concrete sequential, abstract sequential (perception); conrete random, abstract random (ordering).	Gregorc Style Delineator (1982)
7. Bernice McCarthy	**Hemisphericity**	4MAT (1993)
8. Harold Gordon	**Hemisphericity**	Cognitive Laterality Battery (1986)
9. Ned Herrmann	**Hemisphericity**	Herrmann Brain Dominant Instrument (1990)
10. E. Paul Torrance	**Hemisphericity**	Your Style of Learning & Thinking (1988)

Fig. 1 (cont'd)

Thinking

Thinking has been a topic of considerable interest to educators and psychologists. Thinking is mental activities of examining to make sense out of experience regardless of specific content. It is 'to find meaning assumed to exist already or making meaning out of something that has no readily apparent

meaning....for the purpose of producing a solution to a problem, a new truth, a clearer understanding, a judgment...' (Beyer, 1987, p.16). Thinking consists of three key components, namely, knowledge (subject matter), dispositions (attitudes), and operations (activities which the mind performs).

The thinking component of 'operations' includes the 'metacognitive' and 'cognitive' aspects (figure 3). 'Cognitive' includes thinking strategies and thinking skills. Nisbet & Shucksmith (1986) defined strategy as 'a level above that of skills: strategies are the executive processes which choose, coordinate and apply skills.' Strategies are different from skills in that a strategy has a purpose It is a sequence of activities and it is more readily modified to suit the context, whereas a skill is more specific. Thinking strategies consist of complex operations like decision making, problem solving, or conceptualizing. They are major functions of thinking embodying precise, and sequential operations and skills to come out with something meaningful like a solution, a decision, or a concept. Thinking skills are straightforward, like recalling, analyzing, synthesizing, clarifying, reasoning, distinguishing, determining, and detecting biases.

Frequently associated with thinking are creative and critical thinking skills. Creative thinking is the ability to see things in a new way that can result in inventing new combinations. Critical thinking evaluates the new combinations, products, solutions, or decisions by judging the value of the ideas through a single mental operation or a collection of specific mental operations. Associated with critical thinking operations are '....distinguishing relevant from irrelevant information, claims or reasons; determining the factual accuracy of a statement; determining the credibility of a source; identifying ambiguous claims or arguments; detecting biases; recognizing logical inconsistencies in a line of reasoning; determining the strength of an argument or claim.....judging the authenticity , worth, or accuracy of something.....assertion or claim accompanied by evidence, a line of reasoning and general principles supporting the claim and denying any alternative claims' (Beyer, 1987, p. 27, 33, 34). These skills have analysis and evaluative elements.

Creativity is a state of the mind. It can be defined in many ways, ranging from : imagination, originality, intelligence, problem solving, inventiveness, putting things together in new and novel ways, having unusual and original ideas, a process or a mental functioning without an end product, convergent and divergent thinking. Divergent thinking strategy is usually central in the creative process as it involves the production of multiple solutions triggered

from one idea. Unlike the convergent thinking strategy, it is involved with the production of one correct solution.

Thinking strategies in problem solving, decision making, and conceptualizing are involved with analyzing a problem, putting separate evidences together through synthesis, assessing the value of the product, applying data and knowledge, understanding and recalling experiences. These levels of thinking overlap with the cognitive domain of the Bloom's Taxonomy (recall, comprehension, application, analysis, synthesis), and cognitive processes. Figure 2 shows the relationships among them.

Levels of Thinking	Bloom's Taxonomy	Cognitive processes
Level I: **The basics:** • gather knowledge • gain information	1. **Knowledge :** • remember • recall information the same form as is presented. 2. **Comprehension :** • ability to use some of information without necessarily understanding all its implications & relationships.	• acquire • store • recall
Level II: **Critical thinking:** • apply and analyze information • distinguish facts and flaims • determine accuracy of statement • determine credibility of source • detecting bias	1. **Application :** • ability to use learned material in different circumstances • correctly using information 2. **Analysis :** • ability to take material apart to understand its component • ability to subdivide information into components	• perceive • encode • draw inferences

Fig. 2 : Levels of Thinking, Bloom's Taxonomy, and Cognitive Processes
Adapted from "The Constitution in Style", (Cardamone & Butler, 1987)

Levels of Thinking	Bloom's Taxonomy	Cognitive processes
Level III: **Dynamic thinking :** • create • evaluate	1. **Synthesis :** • ability to re-create parts into a new whole • put separate evidences together • combine elements to form a structure 2. **Evaluation :** • make judgements about values, creations, methods, and materials for given purposes	• transform • organize • construct • new connections and interconnections • restructure relationships and inter-relationship • formulate new information • new applications unique methods of analysis & synthesis

Fig 2 (cont'd)

Thinking, Learning Styles, Cognitive Styles

Thinking and learning styles were developed and researched into independently during the developmental stages. As such the constructs may appear unrelated. Continuous research led to a better understanding about learners and the factors that affected their learning. This led to more definite interpretations of the constructs that subsequently brought the relationship among the constructs closer.

Thinking consists of three components, namely knowledge, disposition, and operatons. The commonality among the thinking, learning styles, and cognition constructs lie in the thinking component of 'operations' (figure 3). 'Cognitive' in the thinking component of 'operations' includes the thinking strategies, and the thinking skills. A cognitive style can be considered within 'cognitive' not as a direct line from the thinking component. Instead it is drawn in as a dimension of the psychological domain of learning styles. It is directly related to the thinking process in that cognitive styles shape and enhance the thinking strategies and skills and the metacognition operations.

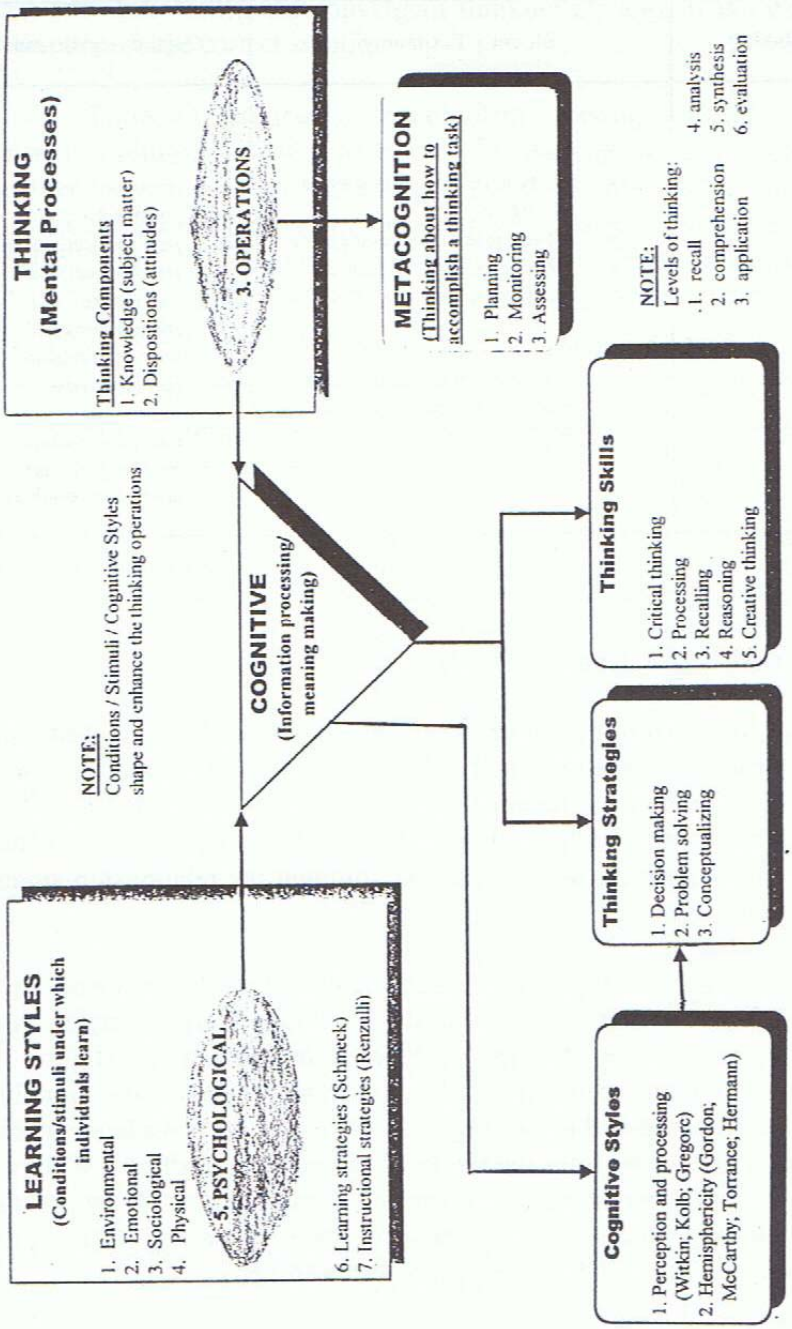

Fig. 3: Yeap's model linking thinking, learning and cognitive styles

The whole purpose of thinking is to find a new meaning, a product, a solution to a problem, or a decision. This can be achieved by interacting the input and experiences with the thinking strategies and skills of cognition. However the sequences of the thinking process need to be planned in advance, selected, redirected to overcome obstacles, probed into to ensure success, monitored periodically, and evaluated to assess the extent of the achievement. Thinking about how to accomplish a thinking task is metacognition which is described as the 'seventh sense.' (Nisbet & Shucksmith, 1986, p. viii).

The stimuli, namely, environmental, sociological, perceptual, and physical provide those conditions under which individuals could think, be able to absorb and retain information, and achieve. Cognitive styles including hemisphericity emphasize on individuals' typical manner of work in a given situation. There is an array of style constructs, namely, concrete versus analytic; reflective versus active; sequential versus random; field dependence verses independence; elaborative processing, deep processing versus fact retention and methodical study; analytical versus holistic; verbal versus visual; global versus analytical; cognitive complexity versus simplicity; reflectivity versus impulsivity; convergence versus divergence. These dimensions of cognitive styles influence individuals' approaches to thinking strategies in problem solving, decision making, and conceptualizing in different ways. Some may need step by step instructions, some are impulsive and make many mistakes, some work slowly and make fewer errors, some see patterns as a whole, some analyze patterns into different parts, some prefer to work in pairs, some grasp concepts through visuals, and some can do equally well through verbal means.

Individuals' cognitive styles can similarly determine the approaches of thinking strategies and skills of decision making in the following ways : how to define the goals, identify, analyze, rank, judge, and select the alternatives to the decisions, and how to plan, monitor, and assess the thinking tasks. Similarly, cognitive styles will shape and enhance thinking strategies and of conceptualizing in the following ways : how to identify the common and critical attributes, illustrate the examples and non examples, examine choices, classify the attributes, relate the categories of attributes, and modify concept attributes. Each dimension of cognitive styles represents how individuals recognize and represent problems, devise, generate, and execute plans, determine and evaluate the solutions when they think about how to accomplish a problem solving task.

The preferred conditions under which individuals think best, their typical information processing habits, and their hemispheric dominance will enable them to develop their own range of thinking strategies to best solve problems, make decisions, and conceptualize. This will bring out the best in them when individuals think about their thinking operations. Mastery of both operations, namely cognitive and metacognitive, will distinguish the effective and efficient thinkers from the others.

Implications for Mathematics Teaching

Understanding the various theories related to how a person learns, processes and organises information, thinks, solves problems and applies heuristics is an important prerequisite for effective mathematics teaching. As mathematics teachers, we need to select teaching strategies that are most effective for individuals or groups of individuals using a framework which will maximise learning effects based on differences in learning styles, cognitive styles, and thinking skills.

One of the objectives of Singapore education is to enable pupils attain problem solving abilities through a number of inter-related components in the mathematics curriculum framework. One of the components is ' processes.' This refers to the thinking and heuristics involved in mathematical problem solving, namely, deductive reasoning (logical thinking and drawing inferences), inductive reasoning (recognizing patterns and structures, forming generalizations) and heuristics for problem solving (using diagrams, making suppositions, looking for patterns, restating the problem).

Knowledge of one's own learning style profile enables one to select more appropriately the learning strategies and use them to solve problems in the most efficient manner. For example, in high order mathematical problem solving, a person is able to tackle the problem encountered under conditions which best enable him to perceive, interact with and respond to the learning task.

For more complicated problems, especially real-world problems, a person's cognitive styles in perceiving information, formulating hypotheses, determining procedures, and selecting the most appropriate strategies to arrive at the solution.

In mathematics in most cases, there can be many alternative ways of solving a problem. In mathematical problem solving, one has to think divergently exploring many plausible alternatives. One is able to perceive information in new ways. Creative thinking not only makes a person into a better problem solver in mathematics but also in many other real-life situations.

Teachers are often more occupied with the teaching strategies of good lessons, paying attention to many requirements in class, such as explanation, pupil participation, classroom management, homework, class exercises, and use of instructional materials. To them, the concepts of learning styles, cognitive styles, hemisphericity, and thinking are rather theoretical. But, if they have some knowledge of them and are able to apply them together with other effective teaching strategies, their own teaching and their pupils' learning will be much more successful.

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