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The Effectiveness of Using The Discrete Mental Skills in Teaching According to Costa's Model on Brain Information Processing, Thinking, and Feelings Strategies Development

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Abstract:

This research was designed to study the effectiveness of using the discrete mental skills in teaching according to Costa's model on brain information processing as well as developing and promoting thinking, creative thinking, and feelings strategies.

Two teaching units (energy and chemical reactions) were chosen from the curriculum of first preparatory level. Their contents were analyzed and the concepts were restated per lesson and were taught during the first (energy) and second (chemical reactions) semesters (2013) for two classes (experimental, N= 38 and control, N = 36) of a randomly chosen girls' school, in Benha, Qualubia Governorate. A teacher guide and tests were prepared for logic, decision-making, problem – solving, and critical thinking strategies. Frank Williams' translated test was used for creative thinking and feelings strategies.

After completing teaching the contents of the two units, the results indicated relative to the control that there were: 1- Significant increases in the discrete mental skills means and total scores of each strategy, 2- Significant increases in the mean total scores of each strategy, 3- The magnitude of increases in the mean scores of discrete mental skills for each strategy were higher for the chemical reactions unit than their counterparts of the energy unit, 4- The frequency distribution of the student scores according to research variables showed that scores of the chemical reaction unit were mostly grouped at the interval (>70), while those of the energy unit were scattered among the preceded intervals

The research recommended the extension of implementing Costa's model in the curricula of all educational levels, and ended with three interrogative suggestions.

Keywords:

Costa's Model of hierarchical thinking skills; Information Processing; Critical Thinking; Problem Solving; Creative Thinking and Feeling Strategies

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فعالية التدريس باستخدام المهارات العقلية بنموذج كوستا في معالجة المعلومات ونمو استراتيجيات التفكير والمشاعر الابتكارية

الملخص :

يهدف البحث إلى دراسة فاعلية استخدام المهارات العقلية المنفصلة وفقاً لنموذج كوستا في التدريس على معالجة المعلومات في المخ وتنمية وتعزيز استراتيجيات التفكير الناقد وحل المشكلات واتخاذ القرار والتفكير الابتكاري والمشاعر الابتكارية ، وقد تم انتقاء وحدتين من وحدات العلوم بالصف الأول بالمرحلة الإعدادية (وحدة الطاقة ووحدة التفاعلات الكيميائية) حيث تم غرس مهارات التفكير المنفصلة بداخلهما ، تكونت عينة الدراسة من مجموعتين من الطالبات بالصف الأول الإعدادي- تجريبية (38 طالبة) وضابطة (36 طالبة) – تم اختيارهما عشوائياً من إحدى المدارس بمدينة بنها بمحافظة القليوبية . وتم إعداد دليل للمعلم ومجموعة من الاختبارات تتناول التفكير المنطقي واتخاذ القرار، وحل المشكلات ، والتفكير الناقد والتفكير الابتكاري والمشاعر الابتكارية ، ولقد توصل البحث إلى مجموعة من النتائج التي أشارت إلى فعالية استخدام مهارات التفكير المنفصلة بنموذج كوستا في تدريس المفاهيم العلمية وتنمية استراتيجيات التفكير المختلفة ، ولقد قدم البحث مجموعة من التوصيات المتعلقة بتنفيذ نموذج كوستا في المناهج الدراسية.

الكلمات المفتاحية :

نموذج مهارات التفكير الهرمى لكوستا – معالجة المعلومات – التفكير الناقد – حل المشكلات –اتخاذ القرار – التفكير الابتكاري- المشاعر الابتكارية.

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Introduction:

There has been great interest in education due to its crucial role in shaping the mind and thought of the future generations. So, educationalists have developed several teaching methods based on different theories aiming to improve the thinking capabilities of learners to be good thinkers.

After intensive researches, Costa (1988) was able to synthesize a list of pervasive behaviors and characteristics of mental action. He reported that the basis of all learners' thinking involves taking information through the senses and driving some meaning which will enable the learner to think and develop a plan or strategy leading to the achievement of the goal.

As a cognitive scientist Costa (1988) proposed a hierarchical model of cumulated thinking skills, according to complexity, into four levels.

Level I : Discrete Mental Skills:

This level includes individual discrete skills which are prerequisite to move complex through on the basis that information processing includes input, processing, and output.

- Gathering of data through senses for data input;
- Comparing, inducing, deducting for data processing; and
- Concluding, evaluating for data output.

Level II : Strategies of Thinking:

This refers to the linkage of the discrete mental skills to form strategies such as:

- Problem solving
- Critical thinking
- Decision making
- Strategic reasoning
- Logic

Level III : Creative Thinking:

They are the behaviors of novelty and insight to create new thoughts of behavior, innovative solutions, e.g. creativity, fluency, insight, imagery, etc.

Level IV : Creative Thinking:

The thinking person must have some properties to think, like willingness

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and commitment, Some attitudes and tendencies that demonstrate this internalization of the thinking spirit include several points, e.g.,

- Being open – minded
- Being honest
- Searching for alternatives
- Being sensitive to the feelings, level of knowledge, and concern of others.

Kelada (2015) was able to visualize this hierarchical organization in a form of a pyramid. (Figure 1).

The student cannot process without adequate input, and cannot produce an outcome without experience in processing (Costa, 1992).

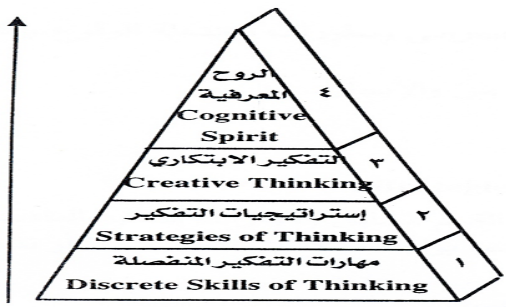

Figure (1): Costa's Model of hierarchical thinking skills as designed by Kelada (2015)

Accordingly and due to scarcity of work in this area, this research was designed to study in an extended manner the effectiveness of using the discrete mental skills in teaching according to Costa's model on brain information processing, and developing as well as promoting strategies of thinking, creative thinking, and feelings of female students at the preparatory stage. This research is significant for it claims to achieve the following:

1. Raising the achievement of student's knowledge on the basis of improving the comprehension abilities beyond the memory level.
2. Arranging the contents of the teaching units as a medium to promote the discrete mental skills and processes.
3. Improving the program of teachers' academic training to enable them to promote the students' discrete mental skills and thinking strategies beyond memorizing and retrieval.
4. Helping the teacher to create a rich educational environment with various experiences and flexibility.

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Methodology:

Two first grade classes for experimental (N: 38) and control (N= 36) samples were randomly chosen in the year 2013 from "January Twenty Fifth Preparatory Female School" at Benha, Qualubia Governorate, Egypt. For teaching, two units of energy (physics) and chemical reactions (chemistry) were chosen from the school curriculum. According to the schedule, energy unit was taught during the first semester and chemical reactions unit in the second. The content of each unit was analyzed and the concepts were re-stated into learning experiences using the discrete mental skills in each lesson. A teacher guide and tests of strategies skills were prepared specially for logic thinking, problem solving, decision-making, and critical thinking, adapted from Wastson and Glasser tests (2008, 2009 and 2010) to suit the objectives of the study. Williams' test, translated by Kandil (1992), was used for creative thinking and creative feelings skills.

Differences between means were tested by "t" test at 0.05 levels. The stability coefficient (70%) and content validity were determined by specialized professors.

Research Variables:

The manuals of the teaching guides and the development of the discrete mental skills for thinking strategies were considered the independent and dependent variables, respectively.

Null hypotheses were stated as follows:

1-There were no significant differences between the research variables mean scores of the strategies discrete mental skills as follows:

- pre and post- mean scores for each of the control and experimental samples.
- pre-total scores of both the energy and chemical reaction units.

2-There were no differences between the energy and chemical reactions units in frequencies distributions of students according to the mean scores of the strategies discrete mental skills.

Results

1- The results in Tables (1 and 2) show that there were no significant differences between the mean scores of the discrete mental skills in each thinking strategy, creative strategy, and creative feelings before teaching the lessons of both the energy and chemical reactions units. This indicates that the research samples were homogeneous.

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Table (1): The mean, SD, and "t" test of discrete mental skills scores of each thinking and feeling strategy before and after implementing the teaching program tests for the control and experimental samples of "energy" unit

The discrete Mental Skills	*Pre test*			*Post test*		
	"t" test	*Expt.*	*Control*	*"t" test*	*Expt.*	*Control*
			Critical Thinking			
Reasoning	2.17±0.39	3.17±0.39	1.06	5.42±0.54	6.3±0.39	6.67*
Perception Relationship	1.18±0.53	1.04±0.47	1.29	3.53±0.83	4.13±0.60	3.52*
Deduction	2.08±0.94	2.42±0.87	0.91	4.72±0.89	6.61±0.72	4.20*
Interpretation	1.7±0.42	1.34±0.39	1.56	3.58±0.50	4.21±0.34	5.72*
Evaluation	1.21±0.20	1.22±0.44	0.1	3.00±0.40	4.08±0.51	9.82*
			Problem Solving			
Identifying Problem	0.61±0.48	0.71±0.46	0.49	1.58±0.50	2.90±0.38	2.93*
Problem Determination	0.33±0.38	0.24±0.43	0.91	0.81±0.81	1.20±0.0	2.79*
Problem Presentation	0.06±0.23	0.26±0.61	0.61	1.28±0.51	1.84±0.33	2.80*
Formulating Alternatives solutions	0	0	--	1.11±0.40	1.58±0.57	3.92*
Planning and Implementing best solutions	0	0	--	14.44±3.57	19.0±3.46	5.57*
Drawing & Evaluating best solution	0	0	--	0.94±0.47	1.47±0.51	3.69*
			Decision Making			
Stating Desire goal	0.75±0.44	0.61±0.41	1.13	1.28±0.51	2.50±0.46	5.50*
Identifying Alternative	0.39±0.49	0.39±0.49	0.05	1.06±0.41	1.66±0.48	4.28*
Evaluating Activities	0.08±0.28	0.13±0.34	0.66	0.67±0.53	1.13±0.41	3.83*
			Logical Thinking			
Induction	0.76±7.1	1.00±0.42	1.41	2.13±0.81	3.16±0.41	6.64*
Deduction	1.03±0.43	1.08±0.51	0.29	3.67±1.14	5.66±0.61	9.05*
			Creative Thinking			
Fluency	1.58±0.81	1.37±0.75	1.19	5.25±1.03	7.32±0.90	9.41*
Flexibility	1.17±0.61	1.11±0.65	0.42	4.81±0.95	5.32±1.02	10.20*

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Novelty	3.39±0.46	3.29±1.47	0.29	12.81±1.49	15.26±1.84	6.28*
Improvement	4.03±1.16	4.95±1.21	0.09	13.36±1.38	16.16±1.78	7.57*
Creative Feelings						
Taking Responsible risk	9.64±1.27	9.6±1.48	0.27	14.44±1.36	16.76±1.48	7.03*
Curiosity (Habit of curiosity)	9.31±1.14	9.3±1.38	0.14	14.50±1.40	16.26±1.43	6.77*
Challenging Difficulties	9.17±0.88	9.3±1.14	0.57	14.93±1.59	17.32±1.36	6.83*
Habit of Imagination	9.11±0.75	9.2±0.87	0.52	14.56±1.46	16.58±1.46	9.49*

Table (2): The mean, SD, and "t" test of the discrete mental skills scores of each thinking and feeling strategy before and after implementing the teaching program tests for the control and experimental samples of "chemical reactions" unit

The discrete Mental Skills	*Pre test*			*Post test*		
	Control	*Expt.*	*"t" test*	*Control*	*Expt.*	*Control*
Critical Thinking						
Reasoning	2.19±0.89	2.47±0.69	1.64	5.33±0.86	7.26±0.69	11.35*
Perception Relationship	1.17±0.56	1.23±0.62	0.42	3.33±0.61	5.03±1.00	12.5*
Deduction	1.83±0.81	1.97±0.85	0.82	4.56±0.97	8.21±1.2	21.47*
Interpretation	1.31±0.67	1.39±0.59	0.47	3.31±0.67	5.66±0.53	13.88*
Evaluation	1.19±0.62	1.24±0.59	0.29	3.03±0.81	5.34±0.71	13.59*
Problem Solving						
Identifying Problem	0.50±0.51	0.63±0.49	0.76	0.95±0.50	1.89±0.31	8.55*
Problem Determination	0.42±0.50	0.43±0.49	0.91	1.53±0.51	2.55±0.0	10.00*
Problem Presentation	0.06±0.23	0.13±0.16	0.70	1.39±0.49	1.79±0.41	2.86*
Formulating Alternatives solutions	0.0	0.0	0.0	1.42±0.50	1.79±0.52	2.64*
Planning and Implementing best solution	0.0	0.0	0.0	12.67±3.19	17.20±0.30	8.54*
Drawing & Evaluating best solution	0.0	0.0	0.0	1.14±0.59	2.31±0.81	8.36*
Decision Making						

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Stating Desire goal	0.50±0.51	0.61±0.50	0.80	19.72±5.0	27.82±3.16	8.2*
Identifying Alternative	0.53±0.51	0.53±0.51	0.00	1.08±0.44	2.11±0.45	7.37*
Evaluating Activities	0.25±0.44	0.25±0.43	0.00	0.78±0.50	1.82±0.49	7.43*
Logical Thinking						
Induction	0.81±0.40	0.82±0.51	0.07	2.71±0.81	3.37±0.59	8.57*
Deduction	0.97±0.51	1.00±0.46	0.21	3.72±0.97	5.47±0.51	8.75*
Creative Thinking						
Fluency	1.11±0.62	1.21±0.52	0.70	14.33±2.29	16.97±2.07	5.08*
Flexibility	1.41±0.64	1.21±0.51	0.50	13.53±1.99	15.87±2.18	5.48*
Novelty	0.87±0.38	0.97±0.53	0.80	11.64±1.57	15.58±2.31	8.56*
Improvement	1.00±0.51	1.20±0.60	1.43	8.50±2.0	14.10±1.9	12.17*
Creative Feelings						
Taking Responsible risk	2.10±2.00	2.2±3.00	0.17	3.0±2.0	5.5±1.09	17.86*
Curiosity (Habit of curiosity)	3.10±1.90	3.3±2.1	0.43	3.1±1.90	9.5±2.00	13.96*
Challenging Difficulties	2.9±1.8	3.5±3.0	1.50	5.30±2.0	11.9±2.3	16.84*
Habit of Imagination	2.0±2.0	2.5±2.00	0.43	3.50±1.8	12.50±1.9	18.89*

2- Teaching the lessons of both energy and chemical reaction units resulted in significant increases in the mean scores of the discrete mental skills in each thinking strategy, creative thinking, and creative feelings (Tables 1 and 2).

The results are comparable to those reported by Kelada and Alsaedan (2013). They found improvements in the discrete mental skills of strategies of thinking, creative thinking, and creative feelings after using the discrete mental skills according to Costa's model in teaching the cell biology unit lessons for preparatory school females in Kuwait.

3- The data in Table (3) show that there were significant differences in the mean total scores of the discrete mental skills of each strategy of thinking, creative thinking, and feelings after applying teaching the lessons of the energy and chemical reactions units.

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Table (3): The mean, SD, and "t" test of the thinking strategies total scores before and after implementing the teaching program tests for the control and experimental samples of "Energy and Chemical reactions" units

Thinking strategies			Critical thinking	Problem solving	Decision making	Logical thinking	Creative thinking	Creative feelings
"Energy" Unit	Pre	Control	8.34±2.01	1.0±0.63	1.22±0.72	1.79±0.51	10.17±2.99	37.23±2.64
		Expt	9.19±3.47	1.21±0.62	1.13±0.80	2.08±0.93	9.82±3.23	37.4±2.66
	"t" test		1.22	1.50	0.49	1.71	0.48	0.27
	Pre	Control	19.78±8.90	20.16±4.8	3.01±1.21	5.80±3.73	36.23±2.78	58.03±3.86
		Expt	31.37±8.98	27.79±3.46	4.84±0.97	8.82±1.20	58.06±3.06	66.92±2.77
	"t" test		7.73*	7.71*	7.04*	4.58*	31.63*	10.11*
"Chemical Reactions" Unit	Pre	Control	7.89±5.01	0.98±0.29	1.28±0.44	1.78±0.54	4.39±2.8	10.10±2.37
		Expt	8.30±3.47	1.19±0.68	1.39±0.49	1.82±0.61	4.59±2.73	11.50±3.21
	"t" test		0.59	1.91	1.29	0.23	0.31	1.9
	Pre	Control	16.56±2.43	29.10±5.0	21.58±2.0	6.43±1.35	48.0±3.53	15.30±2.93
		Expt	27.40±2.01	37.53±3.16	31.75±3.74	8.84±0.74	62.52±3.44	29.40±2.5
	"t" test		20.45*	8.52*	14.74*	10.04	17.71*	21.69*

4- When studying the data in Table (4), it can be seen, as a result of teaching the lessons, that the magnitude of improvement of scores in the discrete mental skills of thinking, creative thinking, and creative feelings in the chemical reactions unit was higher than that of their counterparts in the energy unit in most cases.

Table (4): The mean increase in scores of the discrete mental skills for each strategy after implementing the teaching program tests in energy and chemical reactions units

Chemical reaction unit	Energy unit	Strategies and thinking skills	Chemical reaction unit	Energy unit	Strategies and thinking skills
Critical thinking			Logical thinking		
Reasoning	0.92	1.97	Induction	1.03	0.66
Perception relationship	0.62	1.70	Deduction	1.99	1.75
Deduction	1.89	3.65	Creative thinking		
Interpretation	0.64	2.30	Fluency	2.07	2.64
Evaluation	1.08	2.31			
Problem solving			Flexibility	0.51	2.34
Identifying problem	1.32	0.94			
Problem determination	0.39	1.02	Novelty	2.45	3.94
Problem presentation	0.56	0.04			

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Formulating alternative solution	0.47	0.37	Improvement	2.80	5.60
Planning and Implementing best solution	4.56	4.53	Creative feelings		
Drawing & Evaluating best solution	0.53	1.17	Taking responsible risk	2.35	2.50
Decision Making			Curiosity		
Stating Desire Goal	0.77	0.81	Challenging difficulties	2.39	6.6
Identifying alternatives	0.60	1.03	Habit of imagination	2.39	6.6
Evaluating activities	0.46	1.04		2.02	8.6

Also, it can be noticed from Table (4) that the discrete mental skills clustered preferentially together to form the different thinking strategies. In addition, some discrete mental skills functioned in forming more than one thinking strategy, e.g.

- deduction skill is a component of critical and logical thinking strategies.
- reasoning skill is a component of critical and logical thinking strategies.
- interpretation skill is a component of critical thinking strategy, and it coincides with problem presentation skill in problem solving strategy.
- evaluation skill is a component of critical thinking, problem solving, and decision making thinking strategies. Also, evaluation skill coincides with improvement skill in creative thinking strategy.
- formulating alternative solution skill is a component of problem solving and decision making thinking strategies. Also, this skill coincides with novelty (generating alternatives) in creative thinking strategies.
- stating desire goal skill in decision making thinking strategy coincides with induction skill in logical thinking strategy, and fluency skill in creative thinking strategy.
- identifying problem skill is a component of problem solving thinking strategy and it coincides with induction skill in logical thinking strategy. This skill coincides also with curiosity skill in creative feeling strategies.

5- The data in Table (5) show the frequency distribution of the students according to their pre-scores intervals of the discrete mental skills for each strategy in energy and chemical reactions units. It was found that scores of the chemical reactions unit were mostly grouped at the highest interval (>70), while scores of the energy unit were scattered among the preceded intervals. This finding is in line with results of Table (4).

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Table (5): Frequency distribution of the samples according to their final tests scores interval of the discrete mental skills for each strategy in energy and chemical reactions units

Teaching units	*"Energy" Unit*				*Chemical Reaction" Unit*			
Score intervals Research data	50	>70	61-70	51-60	50	>70	61-70	51-60
Critical thinking (total)	--	38	--	--	--	33	5	--
Reasoning	--	35	3	--	--	32	6	--
Perception relationship	--	25	12	--	--	23	15	--
Deduction	--	38	--	--	--	29	9	--
Interpretation	--	37	1	--	--	23	15	--
Evaluation	--	23	5	--	--	27	11	--
Problem solving (total)	4	20	15	--	3	22	12	--
Identifying problem	4	34	--	--	4	--	34	--
Problem determination	38	--	--	--	38	--	--	--
Formulating alternative solution	6	28	2	--	8	--	32	--
Planning and Implementing best solution	16	2	26	--	10	--	22	--
Drawing & Evaluating best solution	2	30	4	2	2	30	1	5
Decision making (total)	12	15	18	3	2	--	10	16
Stating Desire goal	3	13	23	--	2	5	30	--
Identifying Alternative	13	33	3	--	2	--	25	--
Evaluating Activities	32	--	31	--	7	--	6	--
Logical thinking	6	38	--	--	--	31	--	1
Induction	7	38	--	--	--	31	--	--
Deduction	--	38	--	--	--	33	--	5
Creative thinking	--	30	8	--	--	--	21	17
Fluency	8	33	4	1	--	3	14	13
Flexibility	--	35	3	--	--	7	11	10
Novelty	4	20	8	8	--	--	20	14
Improvement	1	28	10	--	--	--	27	10
Creative feelings	--	38	--	--	--	4	34	--
Taking Responsible risk	--	35	3	--	--	4	27	5
Curiosity (Habit of curiosity)	--	36	2	--	--	13	24	1
Challenging Difficulties	--	34	4	--	--	7	29	2
Habit of Imagination	--	37	1	--	--	19	17	2

According to the results, all the null hypotheses were rejected.

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Discussion

The results of Tables (1) and (2) showed the significant superiority of the experimental sample over the control relative to the discrete mental skills mean scores of each thinking, creative thinking, and creative feelings strategy.

Such finding clarifies that using Costa's model had a role in organizing the lessons of the two units to suit the learning situations. This led to reinforcing the discrete mental skills and help them to immerge in a hierarchal order which facilitated using the skills properly.

So the brain of the learner was helped to process the information in an integral way. This goes in line with Clark (1988) and CERI (2007) who indicated that for complete learning, the brain processes the information fully in cognitive, emotional, physical sensing, and intuitive functions in an integral way. This may serve to increase the degree of intelligence which may be extended as in the gifted child.

The mean total scores of each discrete mental skill for each strategy of thinking, creative thinking, and creative feelings (Table 3) were significantly higher in the chemistry unit than their analogues in the physics unit in most cases. Also, the results of Tables (4) and (5) were in harmony with those in (Table 3) as better results were in favor of the chemistry unit.

As the chemistry lessons were taught after the physics lessons, this might give better chances in learning chemistry. During teaching chemistry lessons, each discrete mental skill of the strategy was given an opportunity to benefit from the improvement in learning capabilities caused by teaching the preceded energy unit.

This might explain the higher scores of chemistry lessons than in physics lessons. Such results are in agreement with what French and Rhoder (1992) who reported that the continuous use of the discrete mental skills might help to group such skills into clusters of thought which help to immerge the strategies of thinking.

Thinking strategies, which immerged as a result of teaching the lessons of this study, were:

a- Logic, decision-making, problem-solving, and critical thinking strategies which represent the second level of Costa's model (Figure1) are characterized with the left brain hemisphere convergent thinking including verbal, logical, sequential, symbolic, and abstract thinking (Mayer 1982, Clark 1988, and CERI 2007). They represent the second level of Costa's model as the discrete mental skills represent the first level.

b- Creative thinking strategy which represents the third level of Coast's model

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(Figure1) and is characterized with divergent thinking of the right hemisphere function (Clark, 1988 and CERI ,2007).

c- Creative feelings and emotion learning characterized with affection, represent the fourth level of Coast's model (Figure1), and are processed in the limbic system of the brain (Figure 2).

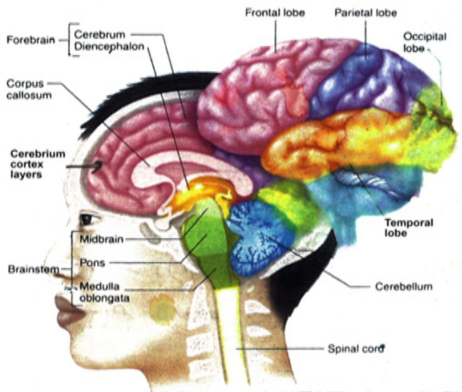

Figure (2): Cerebrum, cortex layers and the limbic system inside the brain

Source: Widmaier et al., (2006) Vander's Human Physiology

d- The problem-solving strategy, which is considered the impact of both the left and right hemispheres of brain information processing, and it forms both convergent and divergent thinking, respectively.

The problem solving strategy is accomplished through five steps of mental thinking as stated by John Dewey in 1910.The first and second steps which are defining and recognizing the problem, respectively are left brain hemisphere kind of thinking. But starting from the third step the problem solver might seek the best solution from his/her previous experience depending on his/her memory and his/her intended reconciliation. S/he starts to put alternative hypothesis reflecting that the right hemisphere is functioning (Mayers, 1982 and CERI, 2007). Reports of human brain studies (CERI, 2007) mention that the left hemisphere function is a prerequisite for the right hemisphere processing (Kelada, 2015).

Earlier in 1926, Wallas put a model classifying the brain function into four levels including preparation, incubation, illumination, and verification. According to this model, the creative thinking starts from the incubation level. This was supported by Gilford (1988) who reported that the emergency of creative abilities starts from the incubation level through seeking the up-to-date solution of the problem.

In this context, we suggest that starting from the third step and beyond

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the problem-solving strategy development, that the transfer of information processing from the left to the right hemisphere through the corpus-callosum (Figure 3), be considered as a stimulator to start processing the information.

This can be proved by the cerebrumcortex scanning using the E.E.G. The results generally show that there were significant improvements in all strategies of thinking and creative feelings. '

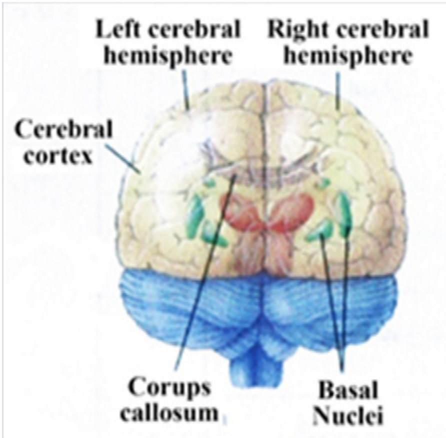

Figure (3): Corpus callosum Source: Campbell and Resse (1999), p. 983

This indicates that both the left and right hemispheres were functioning. According to Clark (1988), Aganti, et al. (1995), and CERI (2007), the continuous use of the brain in learning might help in immerging of new dendrites and forming new synapses, reflecting signs of new learning. This phenomenon accelerates the transmission of learning to many other neurons and synapses (Aganti et al., 1992) by wire or volume transmission (Sykova and Chatal, 2000 and Sykova, 2004) as in Figures (4 and 5) respectively. The mechanism of the two kinds of transmission will lead to achieving more learning and memory as was mentioned earlier by (Thompson, et al., 1980 and Fuxe et al ,2005).

Here it is relevant to mention that the complex human brain and the uniqueness of neuronal heterogeneity, variable interconnections, and network communication by neuronal circuits, produce different combinations of channels for ion transmission. This produces facilitated countless chances for new learning (Moutri and Gage, 2006).

Both learning and memory are processed in the cerebrum cortex (Figure2) which is covered by thick density of multi-six levels of neurons (Struss and Benson, 1984, Clark, 1988, and CERI, 2007).

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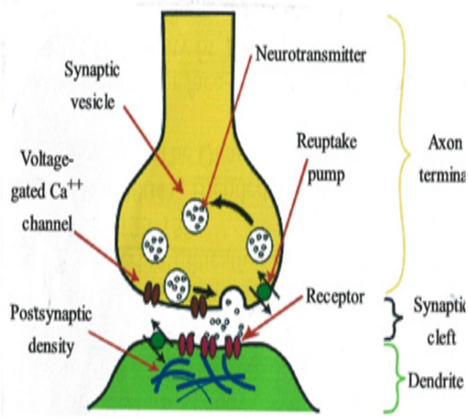

Figure (4): Wire transmission through chemical synapse Source: Wikipedia, the free (encyclopedia (http//en.wikipedia.org/wiki/neurotransmitter

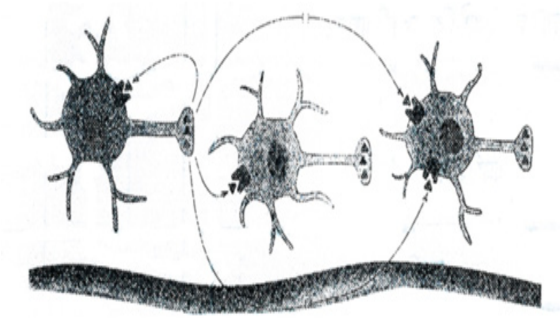

Figure (5): Volume transmission Source: Aganti et al. (1992)

The immerging thinking strategies of the left hemisphere, after continuous learning, are organized as we suggest hierarchically according to complexity on these levels of neurons as follows: The logic thinking strategy is at the bottom or the first level as it is the simplest and is required by other thinking strategies (Holyoak and Nisbett, 1988).

Then the decision-making and the problem solving strategies (first two steps only) are at the second and third levels respectively. The top or the fourth level is for the critical thinking strategy (Figure 6).

This can be proved by a neurologist by scanning the cerebrum cortex and its multi-6 levels of neurons cover using E.E.G., MEG, and F.M.R.I. We suggest that the experiment of Nichorlson and Rice (1991) be done on rabbits jointly by educationalist and neurobiology to detect the K and Ca ions movement through wire and volume transmission during learning and forming thinking strategies. Earlier Aganti et al. (1992, as well as Fuxe et al 2005, and Taber

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et al , 2014) referred to this experiment in the simplest conditions of learning.

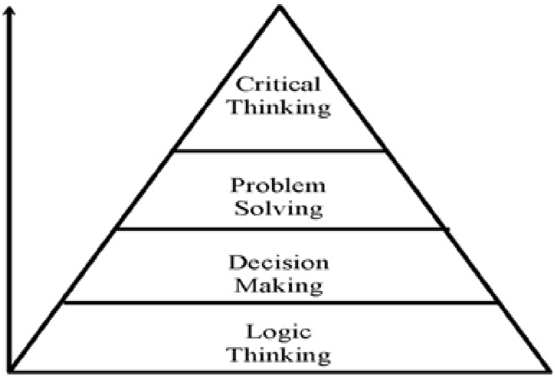

Figure (6): Logic hierarchical organization of the left hemisphere thinking strategies

This suggested hierarchical order that coincides with Costa's (1985 and 1992) arrangement of the discrete mental skills in clusters for forming strategies of thinking. He views that all the students during learning are engaged in all thoughts clusters to make adjustment in the level and complexity of the cognitive task to a level more appropriate to the student's current level of intellectual functioning. The student remains at that level until enough data are gathered or the data are processed sufficiently before moving to higher levels productively.

The above information shows that the roles of the discrete mental skills are astonishing as mentioned above .So it is worth to scrutinize the functions of the discrete mental skills in forming the strategies of thinking during learning, which starts with planning, organizing, and implementing the learning situation lessons as well as forming questioning. This stimulates the discrete mental skills to form thinking strategies.

The continuous use of the mental skills results in clustering the discrete mental skills together. This results in making groups containing different skills that form the required thinking strategies according to the learning situation. So any discrete mental skill can participate with others to form the needed thinking strategy. Also, the discrete mental skill may function, as mentioned earlier, in more than one thinking strategy (Table 4) as needed. There are other functions for the discrete mental skill in addition to the formation of skill clusters, e.g:

- Induction involves reasoning which provides an explanation for tentative inference (Holyoak and Nisbetl, 1988).
- Deduction is closely tied to problem solving as it is often used to solve a

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problem (Holyoak and Nisbett, 1988).

- Deduction is used to give validity to induction (Rips, 1988).
- Problem solving thinking strategy involves decision making thinking strategy and both are closely linked and each requires creative skill (*).
- Good decision making thinking strategy requires a mixture of skill, creative development and identification of options(**).

In addition, the functions of thinking strategies may be interrelated as reported by Mayers (1992) and Kelada (2015) because the logic thinking strategy is basic to other strategies.

In view of that, we suggest that the function of the discrete mental skill may resemble the function of the undifferentiated stem cell. These stem cells are able to differentiate into special cell type and can potentially be used to grow to a particular type of tissue or organ if directed in a certain way (MNT, 2003) and Srivastr and Invey, 2006). Accordingly, any mental discrete skill can be directed by continuous use to cluster with other specific discrete mental skills to form the required thinking strategy suitable for the learned lessons.

In light of the research results, we recommend that Costa's model be implemented in most, if not in every subject matter of the curriculum for all educational levels.

Finally we suggest three interrogative suggestions that need to be investigated in joint researches done by specialists in education and neurology to find out answers to these questions:

- Is the transfer of information processing from the left hemisphere to the right one, during the emerging of the problem solving strategy considered as a stimulator to the right hemisphere to start processing the information?
- Are the emerged thinking strategies during learning organized hierarchically according to complexity on the layers of the cerebrum cortex of the left hemisphere?
- Does the function of the discrete mental skills during learning simulate that of the stem cells?

*http : // www.eduscapes.com/topic 69.hfn,29/ 3/ 2016

** http://www.businessballs.com/problemsolving:htm,29 /3 /2016

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Appendix A. Gubbins Matrix of thinking skill's (Adapted from Sternberg).

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