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The Cognitive Neuroscience of Problem – Solving and Creativity: Implications for the Nigerian Secondary School Teacher

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A B S T R A C T

Cognitive neuroscience is a subfield of neuroscience that studies the physiological basis of cognition. Cognition is the process of knowing, that involves the reception of raw sensory information and the transformation, elaboration, storage, recovery and use of the information. Cognition depends on the workings of the nervous system and is directly concerned about intellectual function. Problem–solving and creativity are two cognitive processes that help the individual harmonize information for solving problems and generate novel ideas and innovative solutions to problems. Problem–solving is thinking that is directed towards the solving of a specific problem which may involve both the formation of responses and the relation among positive responses. Creativity is the ability to produce novel ideas and innovative solutions to problems. The cerebral cortex and the prefrontal cortex of the human brain are mainly involved in the cognitive processes of problem–solving and creativity. The cognitive theory of problem–solving are creativity and the four–model of creativity form the theoretical thrust of this study.

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Introduction

Secondary education according to Federal Republic of Nigeria (FRN, 2004) is the education received after successful completion of nine years basic education and passing of the Basic Education Certificate Examination (BECE). Nigeria presently operates a 9-3-6 educational system, where nine years are spent in basic education (which is free, universal are compulsory for all children). Federal Republic of Nigeria (FRN, 2004). The successful completion of basic education, will translate the children to secondary education for another 3 years. Secondary education is the link to tertiary education. It is the peruse upon which a student chooses certain subjects as approved by the National Policy on Education. It is upon the completion in passing of relevant examinations, such as West African Examination Council (WAEC), National Examination Council (NECO), National Business and Technical Examination Board (NABTEB), which will qualify students to write Unified Tertiary Matriculation Examination (UTME) for tertiary education. A sound secondary education makes a sound tertiary education. As such, the secondary school teacher should develop problem – solving skills and creativity in students of the secondary school level.

Teachers must learn not to provide answers rapidly to students but to create opportunities for them to find out answers for themselves (Denga, 2002). That is to say, students who ask questions, criticize, judge, evaluate and investigate develop creativity than those who receive answers without efforts. Learning must therefore, involve situations as well as problems that suit the age and maturational levels of students. Every teaching subject led itself easily to the creation of problem–oriented situations for the students to resolve. Abstract problems challenge the intellectual and stimulate learning.

Conformity to the status and does not encourage creativity. Students need to be encouraged to think divergently and to introduce novel ideas into learning (Denga, 2002). Uzoeshi and Iwundu (2014) opined that the teacher should create a classroom environment that acknowledges creativity; by accommodating learners contributions with open mind and by equally challenging learners to ask questions that will help to facilitate learning.

Problem–solving and creativity are cognitive processes that play an important role in human cognitive behavior. Humans are the most cognitive organisms in the universe. They receive information outside and within their bodies, interpret the information through the activities of their brains, give meanings to a variety of information their brains come into content with (Nnachi, 2010) problem solving requires thinking and prelease information from the memory and harmonize the information for problem solving. According to Solso (1988) as cited by Nnachi (2010), problem solving is thinking that is directed towards the occurring of specific problem which may involve both the formation of responses and the selection among possible responses. Creativity is a cognitive activity that results in a new or novel way of viewing a problem or situation. Searching for new meaning, solving new problems and trying to invent in a resourceful manner summarized the concept of creativity.

On defining problem solving learning is better transferred and facilitated through problem resolution. In a simple term, a problem is a difficult situation that creates some worries in the individual. In actual sense, a problem is an unsettling intellectual challenge (Ogbonnaya & Onwuegbuche, 2001). A problem has an initial state (the current situation) a goal (the desired outcome), and a path for reaching the goal (including operations or activities that move the individual toward the goal). A problem occurs when there is an obstacle between a present state and a goal and it is not immediately obvious how to get around the obstacle (Lovett, 2002). This, a problem, as defined by psychologists, is difficult, and the solution is not immediately obvious. Problems can range from

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well-structured to ill–structured, depending on how clear–cut the goals are and how such structure is provided for solving them. Most arithmetic problems are well structured, but finding the right college career is ill–structured.

Problem solving is usually defined as formulating new answers, going beyond the simple application to previously learned rules to achieve a goal (Wootfolk, 2017). Nnachi (2007) maintains that problem solving refers to the elimination of the obstacles to the attainment of a goal. To solve a problem, there is the need to resolve the available obstacle constituting a hindrance to the attainment of a goal. A problem is an obstruction to reach a goal. Problem solving would require the thought processes to remove the obstruction in order to achieve the goal. This is achieved by thinking to release some information in relation to the problem and organizing the information in a meaningful pattern for the goal attainment. Agulanna and Nwachukwu (2001) observed that problem – solving is taught to students so as to prepare them to solve problems if they are encountered fresh.

Some psychologists suggest that most human learning involves problem solving and that helping student become better problem solvers is one of education's greatest challenges (Anderson, 2010) solving complex, ill – structured, problems is one key ability measured by the Programme for International Student Assessment (PISA), a comprehensive worldwide assessment of reading, mathematics and science for 15 – year – olds.

A focus on problem – solving techniques. It is not enough to definite a problem – solving process and to describe how individuals differ in their approach to or use of it. It is also pertinent to identify specific techniques of problems – solving. The following problem solving techniques focus more on creative, lateral, or divergent thinking;

i. Brainstorming: According to Wonder and Donovan (1984), brainstorming is the attempt to spontaneously generate as many ideas on a subject as possible; ideas are not criticized during the brainstorming process. Students are encouraged to form new ideas from ideas already stated.

ii. Visualization: This is producing mental pictures of the total problem or specific parts of the problem (Wonder & Donovan, 1984).

iii. Incubation: Putting aside the problem and doing something else to allow the mind to unconsciously consider the problem

iv. Overload: Considering a large number of facts and details until the logic part of the brain becomes overwhelmed and begins looking for patterns.

v. Relaxation: This is systematically relaxing all muscles while repeating a personally meaningful word or phrase (Bastion, 1987).

vi. Synthesizing: Combing parts or elements into a new and original pattern (Sternberg, 1988).

On defining creativity, in actual sense, creativity is a cognitive phenomenon. It is a means of doing or producing things in novel ways. Creativity is a cognitive activity that results in a new or novel way of viewing a problem or situation (Solso, 1988). Heehenbury and Hockenbury (2000) consider creativity from the cognitive point of view. According to them creativity refers to a group of cognitive processes used to generate useful, original and novel ideas or solutions to problems. In their consideration, Plucker, Beghetto and Dow (2004) see creativity as the ability to produce work that is original but still appropriate and useful. Having a rich store of knowledge in an area is the basis of creativity but something more is needed. For many problems, that something more is the ability to see things in a new way–restructuring the problems, which leads to a sudden insight. Often this happens when a person has struggled with a problem or project and then sets it aside for a while at technique known as incubation. Creativity requires extensive knowledge, flexibility, and the continual recognizing of ideas.

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Thinking comes into creative acts, but it is divergent (Nnachi, 2010). Divergent thinking is the ability to propose creative acts, people want to do things in a novel manner and in a way different from the way others have been doing their own. A few possible indicators of creativity in students are curiosity, concentration, adaptability, high energy, independence, playfulness, non conformity, risk taking, attraction to the complex and mysterious, willingness to fantasize and day dream, intolerance for boredom, and inventiveness (Sattler & Hoge, 2006).

The Creative Process

The creative process is the step by step act of solving a problem in a novel manner. The steps influence the cognitive sector of the individual. As the individual physically takes the steps, the cognitive sector is influenced. It was Wallas that first identified the creative process as having form sequential stages (Solso, 1988). The sequential stages included preparation, incubation, illumination, and verification. However, the empirical evidence for the validity of Wallas' four stages is almost non existence (Solso, 1988). There are however, six steps in creative process. These steps according to Nnachi (2010) are as follows:

1. Reflection: As the problem is observed, the first step taken by the brain is reflection. The brain goes into reflection, trying to compare the situation with the already experienced situations.

ii. Preparation: The problem creates some excitement to the individual and keeps the person restless, sleepless, unsettled and greatly disturbed. It is at this time the brain goes into preparation on how to tackle the problem.

iii. Incubation: The individual relaxes the mind, pretends to forget about the problem. The ideas gathered and taken into the subconscious where they modern some incubation. The problem is left for a while and the individual to attend to some other matters.

iv. Inspiration: The ideas being informed inspire the individual. Inspiration occurs after some relaxation, sleep or rest.

v. Trial Act: The individual moves into action due to inspiration and the person is guided by the informed ideas in the brain.

vi. Verification: The individual starts to carry out the problem solving. The individual starts to verify his efforts.

Theoretical Perspective

The cognitive theory of problem–solving and creativity

According to Cognitive Theory of Problem–Solving and Creativity, creative problem solving can be explained as producing a novel method or procedure of solving a new problem. This theoretical thrust emphasized that individuals solve their problems through the establishment of perceptual reorganizations of the whole situation in the attempt to achieve insight into the solution. The cognitivists or the Gestalts believe those problems are solved by means of responding to a system of relationships (Nnachi, 2010).

Guilford discussed the concept of creativity as a cognitive ability, multivariate in nature. He equates creative thinking with divergent thinking (Pal, 2011). Thinking, thus, becomes a process by which a new mental representation is formed through the transformation of information by complex interaction of the mental attributes of judging, abstracting, reasoning, imagining and problem – solving (Solso, 1988).

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The Four–C Model of Creativity

James Kaufman and Ronald Beghetto developed the four–c model of creativity. They identified four developmental levels of creativity. The mini–c level of creativity, the little–c level of creativity, the pro–c level of creativity, and the big–c level of creativity (Kaufman & Beghetto, 2009).

Creativity is inherent in the mini–c level of creativity. Anytime one attempt a new task, there is a level of creativity involved. At the mini–c level of creativity, what one creates might not be revolutionary but it is new and meaningful to them. The little – c level of creativity reflects an aspect of growth from the mini–c level. With appropriate feedback, documents are made and what was created might be of value to others.

At the pro–c level of creativity, one has the ability to be creative at a professional level and in a professional situation. It is the characteristic of this level of creativity to make a living through creative pursuit. It is generally the objective of individuals at this level to support themselves and do what they love doing.

At the Big–C level of creativity people will be remembered in the history books. At the Big–C level, the twin components of novel and useful are automatically assumed to be present.

The cognitive Neuroscience of Problem Solving and Creativity

The nervous systems are the principal agents for information reception; storage and release. Human beings begin cognitive operations through the mental exploration of their immediate and extended environments. Their brains continue to collect information through their sensory systems. Through the sensory impressions, the cognitive network is enriched. By means of that, knowledge is built (Nnachi, 2010).

The brain is often divided into the brainstem and the forebrain (Telencephalon) because of their unique factious. The brainstem, located at the base of the brain, handles most of the autonomic factious necessary to stay alive. The lowest part of the brainstem, called the hindbrain, contains the medulla, the pons, and the cerebellum. The hindbrain provides essential regulation of autonomic activities such as breathing, heartbeat, and digestion, and the cerebellum contains motor coordination. The midbrain, which coordinates movement with sensory input (Mash & Wolfe, 2005).

At the very top of the brainstem is the diencephalon, located just below the forebrain. The diencephalon contains the thalamus and hypothalamus, which are both essential to the regulation of behavior and emotion. The diencephalon factious primarily as a relay between the forebrain and the remaining lower areas of the brainstem.

Next is the forebrain, which has evolved in humans into highly specialized functions. At the base of the forebrain is an area known as the limbic, or border system. It contains a number of structures that are suspected causes of psychopathology, such as the hippocampus, cingulated gyrus and amygdala. These important structures replicate emotional experiences and expressions and play a significant role in learning and impulse control. The limbic system also regulates the basic drives of sex, aggression, hunger, and thirst (Mash & Worfe, 2005).

The cerebral cortex, the largest part of the forebrain, gives us our distinctly human qualities and allows us to look to the future and plan, to reason, and to create. The cerebral cortex is divided into two hemispheres that look very much alike, but have unique specialties, or functions. The left hemisphere plays a chief role in verbal and other cognitive processes. The right hemisphere is better at social perception and creativity. Nevertheless, no evidence from cognitive neuroscience has been found that a particular brain area for creativity exits (Sawyer, 2012). Creativity involves the whole brain. The right and the left hemispheres play a critical but disparate, role at different stages of the

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creative process, and collaborate in different creative tasks, the same s they do for other cognitive function (Sawyer, 2012). When a person engages in creative thinking, the left hemisphere of the brain, which is dominant for analytic and verbal processes, works together with the right hemisphere, which is associated with natural perceptual, while–pattern, spatial processes (Kaufman, Kornilov, Bristol, Tan & Grigorenko, 2010).

The prefrontal cortex which is known for its "executive" functions in integrating complex information has been shown to be the central structure to enable higher – order processing, including but not limited to innovative thinking (Dietrich, 2004). The prefrontal cortex navigates attention, stores working memory and supports temporal integration (Funahshi & Andreau, 2013).

The frontal lobes constitute two thirds of the human brain, yet the functions performed by them remained mysterious for a long time. The frontal lobes contain the functions underlying most of our thinking and reasoning abilities, including memory, problem solving, thinking, planning and organizing.

The prefrontal cortex is the front portion of the frontal lobes and manages complex. Cognitive process such as memory, planning, reasoning and problem – solving.

Implications for the Nigerian Secondary School Teachers

The following are the implications of the cognitive neuroscience of problem – solving and creativity for the Nigerian Secondary School Teachers.

1. The teacher should create a classroom environment to recognize problem – solving skills and creativity. He or she should make problem – solving and creativity as parts of the learning process by encouraging student's participation and accepting good ideas from them.
2. Teachers should encourage curiosity in the classroom. Teachers should consider students interests, things that they value and cherish. Working towards student's interests and things that they value helps in promoting creativity and problem – solving skills.
3. Teachers should encourage team work approach. They should give assignments in groups and give freedom to each group to explore solutions to the problems. This will give each member of the group the opportunity to explore and contribute on how to solve the problem.
4. Teachers should encourage students to participate actively in classroom learning. The teacher should mostly adopt discussion method so as to ginger up creativity and problem – solving skills.
5. Teachers should give classroom assignments that involve divergent and convergent thinking. The teacher shoult use standardized tests in order to measure convergent thinking that incorporates analytical thinking or logical answers with the correct option. Divergent thinking relates to how a learner can employ different methods to approach a problem. The teacher should construct assignments that include both types of thinking models.
6. The teacher should perceive creativity and problem – solving skills positively. The teacher should reward students for thinking of divergent ways to solve a problem and should recognize their efforts for good attempts at solving problems.
7. The teacher should engage his / her students in brainstorming and creating new ways at solving problems.

Conclusion

Problem solving and creativity are both needed to make the world a pleasant place for habitation. These attributes are not visible to the naked eyes but their effects are easily noticeable constructs. The nation needs to advocate the problem – solving skills and creative capabilities of its

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citizens especially those in school and those engages in various creative occupations. Our learning environments both in and out of school, including the mass media, should be enriched and stimulating enough to foster problem – solving skills and creative abilities. The school remains the centre for nurturing high intellectual and creative abilities.

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