

# ***COGNITIVE GROWTH IN DUAL CULTURE: IMPLICATION FOR THE DEVELOPMENT OF CRITICAL THINKING FOR PROBLEM SOLVING IN SCIENCE, TECHNOLOGY AND MATHEMATICS EDUCATION***

**Aminu Umar Yabo** (PhD)aminuabeyabo@gmail.com

Department of Basic Science Shehu Shagari University of education, Sokoto  
&

**Abdullahi Adamu** (PhD.)

Department of Quality Assurance Sokoto State Universal Basic Education Board

## **Abstract**

There is shift from what occurs in the mind alone to what occurs in the mind and its social environment. Piagetian and neo-Piagetian structural theory account for the former while Vygotsky functionalist theory account for the later. Thinking isolated from practice is a purely scholastic question. Practice provides the first step in human cognition, and that, too, must be its conclusion and orientation. Teaching and learning of science in non western country exposes the learners to (Dual) two different cognitively cultural schema. Science as social activity is culture laden, how science is done largely depends on the culture in which it is practice. Due to the recognition of the cultural background of learners there is need to change from traditional instruction in science education to enhance cognitive abilities in critical thinking for effective problem solving. Science Technology Engineering and Mathematics (STEM) is an interdisciplinary instructional approach aim to develop the cognitive abilities in problem solving and critical thinking for the survival of 21<sup>st</sup> century generation. This paper argued that without culturally relevant pedagogy and instructional congruency both problem based instruction and interdisciplinary approach, may not be sufficient to develop the critical thinking and analytic problem solving abilities of nonwestern students. Conversely, may even serve to challenge students cultural ways of knowing due to the differences in cultural schema of student and instructional representation of western science. This conceptual paper recommends that frame switching should be adopted for reform effort in science education to reach all learners in their cognitive niches.

**Key Words:** Cognitive Growth, Dual Culture, Critical Thinking, Problem Solving, and Interdisciplinary

## **Introduction**

For many decades' science educators, researchers and policy makers in Nigeria are making effort to ensure that learners acquire knowledge, values, skills, creativity and critical thinking required to build democracy, establish a system of lifelong learning, promote social development and growth in the 21<sup>st</sup> century (NPE, 2004). In recent years, one prominent element outlined from the critical outcomes is an emphasis on the development of critical thinking skills. The new curriculum stressed and call for the full implementation of learner centered curriculum down to primary schools in the country. Despite the policy which emanated from research evidences, development of critical thinking in science, students are facing a serious challenge in acquiring such skills. This implies that educators have to base their teaching on constructivist principles that will provide learners with the opportunity to develop as thinkers (Green,2006; Pienaar, 1999; van den Berg, 2000,). Similarly, in addition to the flaws in pedagogy, some scholars contend that the emphasis placed on the individualistic and universal nature

of cognitive development in some cognitive development models has resulted in the neglect of cultural context in the development of cognitive abilities (Hong, Morris, Chiu, & Martinez, 2000,).

Piagetian constructivist model of learning is deficient as basis of cognitive growth in critical thinking. However, with modification proposed by social constructivist model which added the cultural background of learners as crucial element in cognition. Failure of interdisciplinary approach in nonwestern culture to develop critical thinking in students cannot be unconnected to the neglect on occurrence of changes in the relationship between individuals and their surrounding environment which is crucial for the development of cognitive abilities,

### **STEM Interdisciplinary education and Critical thinking**

The ever changing world of interaction seeks out people who adapt to changing circumstance and environment, and embrace new ideas. In this century people will be selected by their ability to deal with change and uncertainty. The greatest responsibility of our educational system is to train the present and the next generation how to live successfully. One prominent skill substantiated is teaching children how to think critically and solve problems. It has been well acknowledged that educating students in STEM subject prepares students for life, regardless of the profession they choose to follow. Those subjects teach students how to think critically and how to develop problem-solving skills that can be used throughout life, to help them get through tough times and take advantage of opportunities whenever they appear. In 21<sup>st</sup> century, successful generations are those who learn to think critically and solve problems. Hence, the best way to achieve that is to provide them with good foundation in science technology, engineering, and mathematics (STEM). The traditional method of rote learning of scientific facts for passing test and school grading is not compatible with the need and aspiration of 21<sup>st</sup> century society. Teacher centered method is deficient in the preparation of independent thinkers and lifelong learning. The discipline that can do that best is STEM related. It has been observed that thinking critically is a defense against a world of too much information and too many people trying to convince us (Epstein, 2006). It is also widely accepted that the development of critical thinking skills is a top goal of higher education (Browne & Keeley Vasudeva, 1992).

In recent years, policy makers in Nigeria are making efforts to transform the education system into a dynamic instrument capable of promoting cognitive development, the current national education policies which call for the extension of critical thinking skills to primary school level has not been considered by classroom teachers, due to lack of enabling environment for its implementation. Scholastic world is replete with different notion of critical thinking. Dewey's (1933,) opined that "reflective thinking" is one of the forerunners of what has come to be known as critical thinking: "reflective thinking, a distinction from other operations to which we apply the name of thought, involves

- A state of doubt, hesitation, perplexity, mental difficulty, in which thinking originates.
- An act of searching, hunting, inquiring to find material that will resolve the doubt, settle and dispose of perplexity.

This paper concurs with the view that critical thinking involves a variety of cognitive activities which include solving problems and making informed decisions, developing evidence and arguments to support views, critically evaluating the logic and validity of information. Epstein (2006) substantiate the view by stating that critical thinking involves evaluation, namely to be convinced that some claim is true or some argument is good, as well as being able to formulate good arguments. It is against this background that this paper expects Nigerian science educators to prepare generation of learners that are capable of identifying arguments, draw conclusions within arguments, draw conclusions about arguments and construct their own arguments.

### **STEM Education and Problem Solving**

Problem solving is one of the prominent skills required by the 21<sup>st</sup> century generation. Interdisciplinary STEM education is frame to develop skills in critical, creative, analytical, and dialectical thinking to be able to survive in globalized, fast-pace and media saturated environment. It can be observed that individuals approach educational goals with a holistic perspective (Bybee, 2010; 2013). Twenty-first century demand brain resources capable of harnessing human and material resources for, social, political and economic development. It has been observed that scientific and technological innovations have gained great importance in order to catch up with the developments in the world and to use the world's resources more efficiently (Maryland, 2012). It has been acknowledged that scientific and technological innovations have become a necessity for development (White, 2014). Scholars have defined problem solving in different facet, this paper view it as an approach in tackling life challenges for meeting social, political and economic needs, or ability to navigate the world locally and internationally. In another view the concept of problem-solving includes processes such as defining the problem, revealing effective solutions, choosing the appropriate solution, and decision-making, as well as efforts to look at a situation from multiple points of view to close the gap, meet the need, overcome the difficulties, and remove the obstacles that include cognitive and behavioral processes (Philips & Soltis, 2005; Şahin, 2015).

It has been opined that Problem-solving is a skill that needs to be learned, acquired, and constantly improved, which requires time, effort, energy, and practice; in terms of its multiform, it combines creative thinking with intelligence, emotions, will, and action with the self at the same time. It is related to need, goal, value, belief, skill, habit, and attitude (Başaran, 1994; Bingham, 2004). Problem solving requires ability to think metacognitively, but this paper observed that cultural background affect the way people think, our thoughts and orientation are determined by our local practice. Science education in non-western country is a foreign concept because science education programme is mounted on culture deficit theory. This theory assumed that non-western culture as deficient to think analytically to solve problem particularly in science. By implication cognitive development in critical thinking in non-wester country would be a great challenge for educators.

### **Culture and Cognition**

Schemata influence attention and the absorption of new knowledge; people are more likely to notice things that fit into their schema while reinterpreting contradiction to the schema as exception or distorting them to fit schemata. Schemata have a tendency to remain unchanged even in the face of contradiction. The cultural setup of a society dictates the type of cognitive demand it required for

existence, in progressive movement into information age our generation need more skills for complex cognitive task to compete effectively in ill structured domain.

Culture according to Linton (1947) is the configuration of learned behavior and the results of behavior, whose components elements are shared and transmitted by the members of a particular society. The link between cognitive demand and culture accounts for the significant relationship between the two elements. To substantiate, researchers identified two prominent views with regard to the relationship between culture and cognition. Culture has been viewed as a latent variable and as toolkit of strategies. When members of a particular culture share a limited number of consistent elements such as beliefs, attitudes and strategies and exclude any inconsistent elements, the culture is latent variable (DiMaggio, 1997). But if there are weaker pressures for the exclusion of inconsistent elements the culture will be viewed as toolkit of strategies. (Swidler in DiMaggio, 1997).

In the first view the uncritical reliance upon culturally available schemata become a possible barrier to cognitive growth due to the dominance of automatic cognition in the individual members of the culture. Conversely, in the second view there is possibility of less clustering of cultural elements within social groups, less strong linkages among the elements, it has been opined that individual will, when sufficiently motivated, when dissatisfied with the status quo of an issue or when existing schemata fail to account adequately for new stimuli, over-ride programmed modes of thought to think critically and reflexively (DiMaggio, 1997). In this view, cognitive growth vis-à-vis critical thinking is significantly possible. The second view support the thesis that the cultural environment in which a learner grows up, is a major factor contributing to the development of critical thinking abilities. Therefore, the role of social experience in cognitive development and growth cannot be over emphasized. Hence, parents, teachers, other adults, siblings and peers influence children's cognitive development (Gauvain, 2001). It has been observed that in its indirect form the role of social experience considers the tools, symbols and values that influence human action (Gauvain, 2001). Cultures have developed many types of tools to support the daily activities of people—labour saving devices, sign and symbol systems, street signs, price tags, product labels, recipes, patterns for dress making etcetera. Gradually, these tools become part of children's own actions. These tools not only enhance human thinking but also transform it (Gauvain, 2001).

### **Cognitive Development Models**

Piaget stage theory has been criticized for its neglect of social and environmental factors while giving emphasis on biological maturational capabilities for cognitive growth. However, his schema theory according to Flavel, (1977), provides a valuable conception of how cognitive systems might interact with their external environment. The observed deficiency of assimilation and accommodation theory proposed by Piaget takes account of only internal process of cognitive development at the peril of external process of cognitive development. Hence it has been argued that the perspectives that only concentrate on internal processes of cognitive development, growth and age related factors and ignore external processes cultural environment and the interaction of the two, cannot give a complete account

of the emergence of human intellect (Gauvain, 2001). Therefore, consideration of social and cultural circumstances became necessary.

Social constructivist theory proposed by Vygotsky has provided a complimentary perspective towards understanding process of cognitive development. According to Vygotsky (1986) cultural development is the principal driving force of all development. He stressed that all things cultural are social, and all higher functions evolve socially (Vygotsky, 1986). Therefore, understanding the relationship between culture and cognition lies in the heart of Vygotsky theory. Having the longest period of physical dependence on matured members, humans have the highest tendency to come in contact with intellectual and emotional dispositions that prepares the child for mature participation in society.

According to Nisbett, Peng, Choi, and Norenzayan (2001) and Nisbett and Norenzayan (2002) the cultural differences that exist among different cultures affect not only their beliefs about specific aspects of the world but also impacts on the nature of their cognitive processes. History has taught us that the existing two models of cognitive development owed their differences to social and cultural background of the two authors. It was suggested that Vygotsky had strong cultural ties compared to Piaget having a lonely childhood. Vygotsky contend that children are born with basic biological constrain on their mind. Each culture, however, provides tools of intellectual adaptation.

These tools allow children to use their abilities in a way that is adaptive to the culture in which they live. For example, one culture may emphasize memory strategies such as note taking. Another may use tools like reminders or rote memorization. These nuances influence how a child learns, providing the tools that are appropriate to their culture (Cherry, 2022). The lesson learnt from the theory is that social factors influence cognitive development and which can differ between cultures. Contrary to Vygotsky, Piaget opined that childhood interaction and exploration influence development and development is largely universal.

Modern scholars are in perfect accord with Vygotsky, for example Nisbett and Norenzayan, (2002), substantiate the view that cognitive processes emerge from practical activity that is culturally constrained and historically developing. This suggest that critical thinking is a product of cultural leverages. On this note, Nisbett et al. (2001) are of the opinion that individuals raised in a society focusing on personal freedom, choice, criticism, debate, curiosity and diversity will be characterized by analytic thought (for example, the Western culture). Conversely, individuals constrained by their cultural norms, dogmas, and focus on shared responsibility will be characterized by dialectical or insightful thought; for example, Africans and East Asians.

Evidence afoot, had revealed that cultural variation in cognition emerges as a result of the different historical development of societies, leading to different social activities and tools, which lead to different thought processes that are congruent with the particular historical trajectories of societies (Nisbett & Norenzayan, 2002). This converse with the universal view of cognitive growth, because problem could be the same but strategies differ, similarly, different levels of knowledge about a domain may also lead to the use of different cognitive strategies to solve the same problem.

### **Culture and cognition: The Nigerian Situation**

Nigerian scenario is very complex due to multicultural nature of various cultural groups. However, like any other African nation, Nigeria share similar organizational pattern in its community structure. It is well acknowledged that a sense of collective agency governs the thinking of the African culture (Ayisi,

1992). Individuals are part of a closely knit collectivity in which prescriptive role relations in a hierarchical system is a guide to ethical conduct (Nisbett et al., 2001). It has been observed that:

Collectivism is contrary to western culture which is rooted on individualism. Western thought understands objects in detachment to from their context, they focus on the attributes of an object to assign it to categories, a preference for using rules about the categories to explain and predict the object's behaviour, making inferences that involve the de-contextualizing of structure from content and the use of formal logic and avoidance of contradiction. On the other hand, individuals raised in a society focusing on holistic, collective thought and social obligation, as in the African culture will focus on paying attention to relationships, and rely on experience based knowledge rather than abstract logic, reconciling, transcending or even accepting contradictions. ( Nisbett et al., 2001 & Lombard, 2008).

This paper opined that collectivist culture could not be able to produce critical thinkers, therefore, the great implication is that science educators, researchers and policy makers in Nigeria need to revisit and rethink how critical thinking abilities could be developed in STEM education in the midst of collectivist cultural constraints. There are different scholastic views on how educators could train learners in culturally varied environment. Concept such as psychological priming, conceptual change, possibility continuum and goal based scenario has been proposed as possible mechanism for cognitive growth in dual culture. However, educators still find it challenging to teach critical thinking in schools. Some scholars are of the view that critical thinking should be explicitly taught, but it is argued that teaching critical thinking out of content domain could not produce the desired result, because it is still de-contextualized learning. Contrary others argued that teaching critical thinking in isolation is cumbersome and a semi detach from practice, hence the procedural schema is missing. Nevertheless, since Nigeria is characterized with collectivist under the hegemony of western thought, the concept frame switching and dynamic cultural approach proposed by DiMaggio could be the possible route to cognitive growth in developing critical thinking in nonwestern countries like Nigeria.

According to Grosser and Lombard (2008) Frame switching refers to the internalization of two cultures. In the context of this paper this refers to how some of the student's internalized home culture (African culture) and the school culture (Western culture). In this context the western culture is not supplanting the local cultures. It has been argued that incongruent representation in science classroom demean interpretive abilities of learners. (Hong et al., 2000). This paper observed that scientific concepts presented out of context makes non-western learners to internalized scientific facts in form of a loose network of a domain-specific knowledge structures for memorization to pass exam. Frameswitching provide opportunity for learners to make their own interpretation in multicultural meaning system, even if these systems contain conflicting theories. This approach empowers students to ponder on conflicting or contradictory constructs simultaneously. Proponents of Frame- switching and cultural dynamics, opined that it is possible to equip students with critical thinking processes, even though these processes might not be operative in their home culture.

## Conclusion

It is now understood that dialectical/insightful thinking and critical thinking are produced by different cultural context, therefore, teaching critical thinking in dialectically engrossed society with the aim of cognitive growth is an exercise in futility. Cognitive growth in critical thinking could hold when it is intentionally mediated in some modeled efforts to direct and develop cognitive skills through parents and teachers. Analytic thought, is the foundation of critical thinking and critical thinker's cognition thrive most where making inferences, criticism, curiosity and freedom of choice are the focus of the local culture. The authors of this paper argued that the challenges of dual culture in the teaching of critical thinking skills in Nigeria could be attributed to a lack of intentional efforts to nurture these skills.

## Recommendations

Nigerian policy in STEM education call for the spread of critical thinking down to primary school. Hence this paper proffers the following suggestions:

1. Teachers at all levels should be professionally prepared to adopt teaching strategies that create a learning environment which encourages the development of thinking strategies, including critical thinking, analysis, reflection, evaluation, problem solving, judging, justifying and interpretation.
2. Training and retraining of STEM teachers in the skills of critical thinking by policy makers
3. Open mindedness/ growth mind set and willingness to face difficult situation should be inculcated in the students to reduce reliance heavily upon uncritically and culturally available schemata which possibly block the opportunities to equip students with critical thinking processes which might not be operative in their internalized cultures,
4. STEM education should be taught in native language or degree of English proficiency be improve at all levels of education.
5. Seminars and workshops on frame switching should be organized for teacher training institutions and professional bodies.

## References

- Ayisi, E. O. (1992). *An introduction to the study of African culture*. Nairobi: East African Educational Publishers.
- Başaran, İ. E., (1994). Eđitimpikolojisi, *Modern eđitimintemelleri, içinde s: 34-90, Gül*.
- Bingham, A. (2004). Çocuklarda problem çözmeyeteneklerinineliştirilmesi (Çev. A. Ferhan Oğuzkan). *MilliEđitim Basımevi, 2-51*
- Browne, M. N., & Keeley-Vasudeva, M. L. (1992). Classroom controversy as an antidote for the stage model of learning. *College Student Journal, 26, 368–373*
- Bybee, R. W. (2010). What is STEM education? *Science, 329(5995), 996*.
- Bybee, R. W. (2013). *The Case for STEM education: Challenges and opportunities*. NSTA Press

- Cherry, K. (2022). What is sociocultural theory. Retrieved on 18 April, 2022 from: <https://www.verywellmind.com/what-is-sociocultural-theory-2795088>
- Dewey, J. (1933). *How we think*. Boston: Heath
- DiMaggio, P. (1997). Culture and cognition. *Annual Review of Sociology*, 23,
- Epstein, R. L. (2006). *Critical thinking*. Belmont, CA: Wadsworth Thomas Learning
- Flavell, J. H. (1977). *Cognitive development* (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall
- Gauvain, M. (2001a). *The social context of cognitive development*. London: The Guilford Press.
- Gauvain, M. (2001b). Cultural tools, social interaction and the development of thinking. *Human Development*, 44, 126–143.
- Green, L. (2006). Becoming a thinking teacher. *Journal of Cognitive Education and Psychology*, 5(3), 310–327
- Grosser, M.M and Lombard, B.J.J.(2008). The relationship between culture and the development of critical thinking abilities of prospective teachers. *Teaching and Teacher Education* 24 (2008) 1364–1375 Elsevier Ltd. doi: 10.1016/j.tate.2007.10.001. [www.elsevier.com/locate/tate](http://www.elsevier.com/locate/tate)
- Hong, Y., Morris, M. W., Chiu, C., & Martinez, V. P. (2000). Multicultural minds. A dynamic constructivist approach to culture and cognition. *American Psychologist*, 55(7), 709–720 July.
- Linton, R. (1947). *The cultural background of personality*. Routledge & Kegan publishers
- Mazrui A. (1986) *Tool of Exploitation: A Television documentary* by Greater Washington educational telecommunication Association and British broadcasting corporation.
- Maryland State STEM Standards of Practice. (2012). Maryland STEM: Innovation today to meet tomorrow's global challenges. Retrieved from: [http://mdk12.msde.maryland.gov/instruction/academies/marylandstatestemstandardsofpractice\\_.pdf](http://mdk12.msde.maryland.gov/instruction/academies/marylandstatestemstandardsofpractice_.pdf)
- National Policy on Education, (2004).
- Nisbett, R. E., & Norenzayan, A. (2002). *Culture and cognition*. In D. L. M. edin (Ed.), *Stevens' handbook of experimental psychology* (3rd ed.). New York: Wiley
- Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of thought: Holistic versus analytic cognition. *Psychological Review*, 108(2), 291–310.
- Şahin, H. (2015). *Psikososyal gelişim temelli eğitim programının, anasınıfı na devame eden çocukların problem çözme becerilerine etkisi* [Doktoratez]. Gazi Üniversitesi. Ankara.
- Van den Berg, M. E. S. (2000). Is there a need for critical thinking skills modules at tertiary level? *South African Journal of Higher Education*, 14, 96–107.
- Vygotsky, L. (1986). Concrete human psychology. *Psikhologiya*, 14(1), 51–64