STRATEGIES FOR IMPROVING HIGHER ORDER THINKING SKILLS IN TEACHING AND LEARNING OF DESIGN AND TECHNOLOGY EDUCATION

[1]Chinedu, C.C. & [2]Kamin, Y.
Faculty of Education
Universiti Teknologi Malaysia, Malaysia
caleb4life56@gmail.com [1] , p-yursi@utm.y [2]

Olabiyi O. S.
Faculty of Education
University of Lagos, Nigeria
solabiyi@unilag.edu.ng

ABSTRACT

Higher order thinking skills (HOTS) should be an integral part of teaching and learning especially at the higher education level. Thinking skills lessons should be part of the curriculum if students are to solve problems individually, cooperatively and creatively. Teachers on the other hand must be conversant with relevant techniques needed for teaching higher order thinking. An in-depth review of literature reveals that teachers are faced with the problem of how to prepare and teach higher order thinking skills in design and technology education. This paper is a library based work; and data were collected from textbooks, journal articles and internet search. The paper critically examined existing practices in the teaching of higher order thinking skills in design and technology education. Some of the key features mentioned were the use of concept, inferences, visualization, and schemas, among others. Recommendations for practice change were made regarding the development of HOTS.

Keywords: *Higher Order thinking, Design & technology education, Teaching - learning*

1. INTRODUCTION

Technical and Vocational Education (TVE) is majorly concerned with the development of employability skills. These employability skills form the base upon which individuals within the sphere of Technical and Vocational Education and Training (TVET) are trained. In order for graduates within the TVE community to remain relevant, they need to be able to develop capacities to learn continuously through thinking and reasoning, problem solving, decision making and interpersonal competence (King, Goodson, & Rohani, 2011)

Developing these skills are not only critical for work, but are inevitably necessary to deal with the complexities of the family, community and society (Kerka, 1992; Lopez & Whittington, 2001). Research literature has led to the exposure of the level and state of thinking skills in Malaysia as well as other developing nations of the world. Literature emanating from recent studies has also revealed that students in both higher education and secondary education in Malaysia lag sufficient utilization of higher order thinking skills (HOTS). However, the questions posed are; is the concept of higher order thinking (HOT) still strange to these teachers? Or do students not grasp the meaning and understanding of the concept (Yee, Jailani, Razali, Widad, & Tee, 2010; Yee et al., 2011)?

According to Rajendran and Idris (2008), students who were taught how to develop creative insights to solving problems were better suited for more complex problem solving than those who were not. Therefore, the need for HOTS in the teaching and learning of TVET cannot be over emphasized. Rajendran and Idris (2008), also suggests that thinking skills enhance academic achievement. HOTS is a major component of creative and critical thinking and creative thinking pedagogy can help students develop more innovative ideas, ideal perspectives and imaginative insights. Again, it can also be noted that HOTS focuses on developing students' abilities to be able to analyze effectively, evaluate by drawing inference from existing information and creating (synthesizing) something new. When students are able to create and fuse these skills in their learning activities, then such student has been able to demonstrate HOT. Furthermore, (Yee et al., 2011) suggest that HOTS are teachable and learnable, and all students have the right to learn and apply this thinking to solving problems. Hence, the development of this skill is not just expedient for developing high cognitive capacities, but also responsible for the development of an all-round individual. By this, we mean that the individual develops an all-round capacity, thus enabling a competitive student's thought system, development in their intellect and a means to helping students avoid errors in thinking (Yee et al., 2010).

2. CONCEPTUAL DEFINITION AND IMPORTANCE OF HOTS IN TECHNICAL AND VOCATIONAL EDUCATION

According to Rajendran and Idris (2008), HOTS is the expanded use of the mind to meet new challenges. He viewed HOTS as a thinking function of the mind's ability to solving challenging situations, but the question is, is HOTS just about the extended use of the mind? Research findings have revealed more about the underlying importance of HOTS in the teaching and learning process. HOTS involve analyzing information to determine the problem, evaluating the problem and creating new workable solutions. The continuous development of HOTS is a direct determinant of continuous practice, and involving in tasks that stimulates the thinking faculties.

It is worthy of note that, problems which are very critical cannot be merely solved by direct application of previous knowledge. Rather such problems can be solved when the individual engage in critical and creative thinking, inferring from prior knowledge (R. Thomas, 1992). This is because HOTS is characterized by complex, self-regulative, meaningful, nuanced judgments, uncertainty, multiple criteria as well as multiple providing solutions (Yee et al., 2010; Yee et al., 2011). HOTS should be an important aspect of the teaching and learning process, because one of the major goals of teaching is to ensure that students can think and solve problems critically especially with regards to TVET. This feat can be achieved when students are not just taught a series of routine activities, but are taught how to think and create for themselves. This corroborates with the views of (Kerka, 1992) and (Chinedu, Libunao, Kamen, & Saud, 2014) that the best way to prepare future employees and problem solvers, is to teach students how to think instead of what to think. Yee et al. (2011) also opined that thinking skills is fundamental to the educational process. A person's thought can affect his/her ability to learn, speed and effectiveness of learning. Therefore HOTS cannot be separated from the learning process.

Research literature has also shown that students who are trained to think critically demonstrate a positive impact in the advancement of their educational pursuit. For instance, the world became a global village as a result of the invention of the World Wide Web. This is no doubt the consequence of HOTS. Similarly, in the automotive industry, there has been rapid developmental changes and evolution. In the manufacture of automotive vehicles, there has been a shift from the use of analogue systems to digital systems, from carburetors to injection fuel systems, as well as hybrid system. This clearly indicates that if the world is to continue to enjoy fruition from continual technological advances and innovative practices, we must no doubt engage in teaching students how to think creatively and become critical problem solvers. Since the need for HOTS in the teaching and learning process has been established, it then follows the question of how best can lessons be designed to reflect these high thinking behaviours in students.

3. HIGHER ORDER THINKING SKILLS FOR DESIGN AND TECHNOLOGY EDUCATION

The premise that research literature supports the teaching and learning of HOTS is no longer an issue for contention (Yee et al., 2011). Hence the issue lies with how best to teach this highly needed skill (HOTS). In a study conducted by Anderson et al. (2001), former students and colleagues of Bloom, after reviewing Bloom's taxonomy of HOT, came up with a six step taxonomy which includes; remembering, understanding, applying, analyzing, evaluating and creating process. These six steps they proposed promote the development of HOTS but emphasis much emphasis was placed on analyzing, evaluating and creating. They suggested that educators and teachers should teach analysis by using approaches that integrates– differentiating, organizing, attributing (to break into constituent parts) and determine how these parts relate to one another and also to an overall structure and purpose (Yunos et al., 2010; Zohar & Dori, 2003).

Furthermore, Anderson et al. (2001), also stated that teaching students to learn to develop evaluation techniques should comprise of activities that includes: coordinating, detecting, monitoring, testing, critiquing and judging. They further explained that exposing students to these kinds of activities would provoke their minds into recognizing patterns, distinguishing patterns and exposing the ideal problem. This would enable students to

critically weigh information and thus create workable solutions (Anderson et al., 2001; Krathwohl, 2002)

The problem or draw back with this approach would be that it only linearly enumerates the components needed for the development of HOTS without necessarily relating the strategies needed to fuse and integrate these components for developing lessons that would foster or develop higher order thinking skills in students. According to Thomas and Thorne. (2009), HOTS may seem easy for some students, but prove difficult for others. But the fact that it can be learned and developed by a person's practice is justifiable. They further stated that HOTS involves thinking on a level that is higher than memorizing facts or telling something back to someone exactly the way it was said. It involves doing something new with the facts, understanding them, infer from them, connect them to other facts and concepts, categorize them, manipulate them and put them together in a new or novel way.

Design and technology education according to the Ministry of Education (2006), is that aspect of technical and vocational education that is project based and anchors on design actions and the application of knowledge and process skills. Process in the context of the above description means that students should be able to produce creatively, technology based products. This therefore implies that design and technology education requires a higher level of thinking skills. David (2008) and Robinson et al. (1999) agrees that a national consensus for creative and cultural education is needed in order to unlock the potential of every student, thus they proposed that HOTS should be viewed as having the following features and in doing so, teach students to understand and integrate these features in design and technology education;

i) Using imagination
ii) Pursuing purposes
iii) Being original
iv) Being of value

According to Robinson et al. (1999), HOT is a function of one's imagination- the ability to creatively design what has not yet become fact or knowledge. This he opined is a fundamental tool in developing HOTS. His views may hold a stronger meaning than it appears to have, in the sense that every technological input or discovery in the world today was first created from imagination which later became insightful facts and knowledge.

Furthermore, Yee et al. (2010) reveals that there is research evidence supporting the teaching and learning of HOTS, owing to the low level of thinking skills among TVE students. This they ascertained, when they assessed students on the rubric standards of Marzano thinking skills. Thus they suggested that models, strategies, techniques and activities, model lesson plans, use of integrated approach as well as the use of a self-instructional approach be used in the teaching and learning of HOTS. They further opined that the self-instructional approach should be used on the ground that it caters for individual differences of learners and support students to study at their own pace. However, the problem with this approach according to King et al. (2011) is that it does not offer support (scaffolding) to students engaged in HOT activities. Instead King et al. (2011) suggested that lessons involving HOTS require particular clarity of communication to reduce ambiguities and confusion, and improve student's attitudes about thinking tasks.

When students engage in self-instructional study they may select only task that are aligned with their abilities, thus not provoking the domains of the thinking faculties. Without the teacher's role of clarifying communication and reducing ambiguities of the learning task,

students may engage in an array of misguided learning activities. King et al. (2011) opines that students should be given support at the beginning of the lessons and gradually allowed to operate independently. However, it should be noted that too much or too little support (scaffolding) can disrupt the development process of students. Therefore teachers should take caution in balancing the support they offer to students; as no support may lead to misguided learning and too much support would not aid students in the developing of their thinking skills.

Hence, (Thomas & Thorne., 2009) suggests that lessons that are designed to teach HOTS should reflect the following;

i) Concepts: a concept is an idea around which a group of ideas revolve- a mental representation of a group of facts or ideas that are formally and informally related. Students should be taught to build concepts, as concepts helps in organizing thinking.
ii) Schemas: According to McCarty as cited in (Thomas & Thorne., 2009) learning is the making of meaning, meaning is making connections, and connections are the concepts. In order words, to learn something, students must first understand its meaning and we make meaning by connecting new ideas to ones we already have. The term schema is simply a pattern or arrangement of knowledge that an individual has already stored in the brain that helps them understand new information. Integrating this into higher order thinking lessons would help students to infer about a particular thing based on the information they have gathered previously.
iii) Metaphors, Similes and Analogies: Metaphors, Similes and Analogies are ways to explain the abstract or unfamiliar by showing how the abstract or unfamiliar shares characteristics with a particular object, idea or concept.
iv) Visualization: not all thinking is done or carried out with words or writing, sometimes a person may form visual images as pictures in the mind that are equally as meaningful as or more meaningful than words. Visualization is a very useful instrument for developing HOTS; hence students should be taught to visualize in order to develop the desired thinking skills that teachers long for.
v) Inference: to infer simply means to draw conclusion, to conclude from presenting evidence.it implies reaching conclusion from a set of facts.

The above features when properly integrated into lessons helps teachers to structure the teaching and learning process to one that supports the development of HOTS.

4. STRATEGIES FOR TEACHING HIGHER ORDER THINKING IN DESIGN AND TECHNOLOGY EDUCATION

Research literature has revealed distinctive developments about the development of HOTS since discussions began about this particular discourse. Findings from previous research has highlighted various important features of what HOTS should constitute and how teachers can effectively develop these skills (King et al., 2011; Krathwohl, 2002; Lopez & Whittington, 2001; Lucas, Spencer, & Claxton, 2012; Miri, David, & Uri, 2007; Pickard, 2007; Yee et al., 2010; Yee et al., 2011; Yunos et al., 2010). To further reinforce these perspectives, the following strategies would are discussed.

The following are some of the strategies that could be used in enhancing HOT in the classroom. These should be seen as some of the ways in which HOTS can be effectively taught, as there are many ways to reach a particular goal, these are thus, some of the

highlighted strategies needed to reach the goal of integrating and developing HOTS in classroom lessons, the list should not be seen as being too exhaustive, but rather as a place to begin with:

4.1 Take the mystery away and teach the concept of concepts

Teachers should teach student about HOT, what it entails, its benefits as well as strategies. This enables learners to be aware of and understand their own strengths and challenges with regards to HOT and be better prepared to tackling these challenges.

4.2 Teach concept of concepts

In teaching a particular lesson, teachers should identify the main concepts and teach them critically. Teachers should also make sure that students understand the critical features that define a particular concept and how they differ from other concepts. In doing so, students are developing their analytical ability which is a major component of HOT.

4.3 Name and categorize concepts

Students should be alerted when new and key concepts are being introduced into the lesson. Also teachers should guide students in categorizing these concepts to determine which each one is – concrete, abstract, verbal, nonverbal or process. Doing this enables students to develop the skill of aligning their thinking in such a way that goes beyond mere understanding or memorizing of the concept.

4.4 Move from concrete to abstract and back

Teaching from concrete to abstract and back to concrete can be very helpful for students. When teaching abstract concepts, the use of concrete materials can be used to reinforce learning for both young and old alike. If a student is able to state an abstract concept in terms of everyday practical applications, then that student has understood the concept and can always make useful inferences and applications from what has been learnt to solving new problems.

4.5 Teach inference and connect concepts

Inferring is making useful conclusion by presenting evidence or facts. This is important as it helps students develop the ability to make logical conclusions upon examining the presented information, evidence or fact. Also teachers should lead students through the process of connecting concepts to other concepts. For example, if the concept being taught is "Tools," a larger concept to which Tools belongs may be "Construction," and an even larger (more inclusive) concept could be "Manufacturing.". This sort of thinking and connecting activity enables students to learn how to connect concepts to what they already know, and with that create a web of knowledge that aids them deeper understanding and clarity.

4.6 Teach question-answer relationships

Question-answer relationships teach students how to label the type of question being asked and this knowledge helps them in formulating answers. Thomas and Thorne. (2009) identified two major categories of question-answer relationship (1) questions where answers can be gotten from documented facts in text (book question) and (2) questions that require one's own experience (head question). This enables students to be aware of the relationship between textual information and prior knowledge aiding them in determining what strategy to utilize when seeking answers to questions.

4.7 Include brainstorming activities in the lessons

Brainstorming is a medium for creating original and useful ideas. When students are divided into groups and are allowed to brainstorm and reflect on solutions to a particular problem, they are open to a deeper level of thinking, as one student generates an idea, the other students are also challenged to think and develop better ideas similarly engaging in higher thinking. The goal here is to generate a pool of ideas that could be tentative solutions to a problem, and with this students can then scrutinize these ideas until a consensus is reached, in doing this students have been exposed to three levels of higher level thinking-analysis, evaluation and creating (Anderson et al., 2001).

4.8 Use teaching techniques that provokes higher thinking levels

Teachers have at their disposal a pool of teaching techniques and methods to choose from that provoke higher levels of thinking. Some of these techniques could be problem solving methods, cooperative learning, case method and so on.

4.9 Emphasize feedback generation for students

Evaluate student's comprehension level and creativity by assessing how well they respond to complex and seemingly abstract problems. This helps students to identify their areas of strengths and weakness in thinking activities. Teach them how to think about their thinking and learning (metacognition). This enables them to capitalize on their strengths and further develop them as well as look for a way around their weaknesses.

Thomas and Thorne. (2009) approach to teaching HOT could be argued to be somewhat general and not specific to TVET context. However, some deductions could be drawn as their approach centers around concept formation and development and could also be applied to TVET, because according to David (2008) conceptualizing is of paramount importance in developing HOTS, as it helps students to determine the overall purpose of the design. David (2008), also proposed a model for developing HOT in design and technology education. The model is composed of five key areas which are interdependent; Conceptual, Technical, Aesthetical, Constructional and Marketing areas. The model is shown below in Fig 1

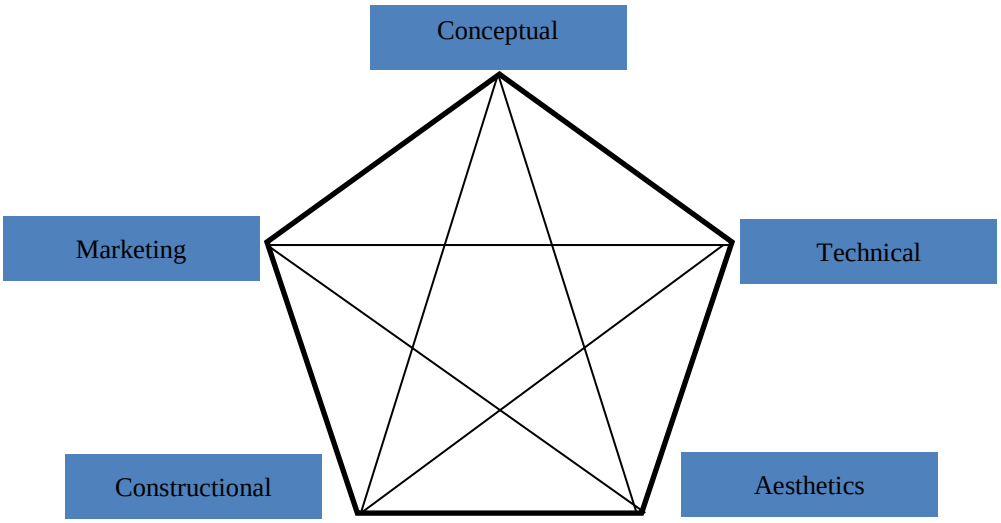

Figure 1 : Model for integrating HOTS in design and technology education; Source: David (2008)

According to David (2008), these five key areas are important in creative design decisions, conceptualizing as earlier stated helps students in determining the purpose of the design, which is determining the sort of product that it will be. Technical in the model describes the functionality of the product or how the product will work. Aesthetics deals with what the product will look like, constructional deals with how the design would be put together and finally marketing, (who the design is for, where it will be used and how it will be sold). These he opines forms the framework for HOT development in design and technology education.

5. CONCLUSION

The paper reviewed some of the existing practices, thoughts and concepts about HOT. For a long time, a lot exposition has been on the importance of HOTS in teaching and learning process, as well as what it constitutes. But scarcely in the literature are the strategies or ways in which teachers can actually utilize to teach HOT in the Technical and Vocational Education classrooms. This exposition paper therefore adds to the literature, relating several strategies that teachers can adopt in teaching their students for the development of HOTS. HOTS lessons in design and technology education should focus on activities that covers the key areas as suggested by (David, 2008) and should be systematically planned for, and taught to students, by integrating brainstorming activities, using co-operative learning as well as other suggested strategies for teaching as stated and explored in this paper. Then the desired results educators and teachers seek with regards the development of HOTS, would be gradually achieved, and students who can creatively develop new insights and workable solutions in design in technology education would begin to emerge increasingly and steadily.

6. RECOMMENDATIONS

The following recommendations are made to give teachers invaluable resource in designing and teaching for the development of higher order thinking skills;

i) Design lessons should be taught building on the five basic foundations (conceptual, technical, aesthetics, constructional and marketing areas) of creative design decisions as students insights are broadened and opened when they are taught to think in relation to these five areas.
ii) Teach students to keep track of their thinking, engaging in a purposive and conscious evaluation of thinking is in itself a higher level of thinking. As students will be able to critically engage in analysis, evaluating and creating something new and insightful when they do so.
iii) Use instructional teaching methods such as problem based learning to engage students in higher order thinking,
iv) Engage students in brainstorming activities to teach them idea and solution generation

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