

Critical Thinking And Creativity In Science And Technology Education For Sustainable Development

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Abstract: Education is an essential tool for achieving sustainability. People around the world recognize that current economic development trends are not sustainable and that public awareness, education and training are keys to moving society towards sustainability. There is growing international recognition of education for sustainable development as an integral element of quality education and a key enabler for sustainable development. Critical thinking skills help people learn to examine economic, environmental, social and cultural structures in the context of sustainable development. Education is critical for promoting sustainable development and improving the capacity of the people to address scientific and technological development issues. Both formal and informal education is indispensable to changing people attitudes so that they have the capacity to assess and address their sustainable development concerns. It is also critical environmental and ethical awareness, values, attitudes, skills and behavior consistent with sustainable development and for effective public participation in decision making. We live in a world that is creative, we live in a time where innovation is the keyword, inventions by human has reached every sphere of life, we cannot deny the fact that that much of the education that has been imparted till now has been memory-based, proper learning should involve creativity that triggers the cultivation of the use of analytics and proper evaluation of skills. The creative process can help children of all ages build cognitive skills that include critical thinking and problem- solving. As educators it is our job to help students embrace creativity to build environments where students' imaginations are nourished. This article discusses the environment of the classroom and suggests that one which is creative and stimulating is of most benefit to both the teacher and the student. It highlights the importance of thinking skills and creativity and how to foster these skills in the classroom.

Keywords: Critical, thinking, creativity, science, technology, education, sustainability, development.

I. INTRODUCTION

Critical thinking is the ability to think rationally about what to do. It includes the ability to engage in reflective and independent thinking. A person with critical thinking skills is able to understand the logical connections between ideas, identify, construct and evaluate arguments, detect inconsistencies and common mistakes in reasoning, solve problems systematically, identify the relevance of ideas, and reflect on the justification of one's own belief and values. A

critical thinker is able to deduce consequences from what he knows, and know how to make use of information to inform himself. Critical thinking is the intellectually disciplined process of activity and skillfully conceptualizing, applying analyzing, synthesizing, and/or evaluating information gathered from, or generated by observing, experience, reflection, reasoning, or communication . it include clarity of thought, intellectual, integrity, problem identification and solution, respect for evidence, internal coherence, intellectual standards, metacognition, questioning, deductive and

inductive reasoning, argument, mapping, and ethical reasoning. A more recent, psychological characterization is that critical thinking is the use of those cognitive skills that increase the probability of a desirable outcome. It is used to describe thinking that is purposeful, reasoned, and goal-directed. It is the kind of thinking involved in solving problems, formulating inferences, calculating likelihoods, and making decisions, in other words, critical thinking requires higher-order thinking skills that are relatively complex; require judgment, analysis, synthesis, and are not applied in a rote or mechanical manner (Gunn, Grigg, & Pomahac, 2006).

Critical thinking is self-directed, self-disciplined, self-monitored and self-corrective thinking. It presupposes assent to rigorous standards of excellence and mindful command of their use. It entails effective communication and problem solving. Critical thinking promotes creativity. To come up with a creative solution to a problem involves not just having new ideas. It must also be the case that the new ideas being generated are useful and relevant to the task at hand. Critical thinking plays a crucial role in evaluating new ideas. Critical thinking is the foundation of science and technology. Science requires the critical use of reason in experimentation and theory confirmation. Tsai, Chen, Chang, and Chang (2013) found that enhancing the critical thinking among students in science classes helped the students to understand the scientific process as well as encourage students to become more experimental and questioning of the different aspects of science.

II. CHARACTERISTICS OF CLASSROOM AND ACTIVITIES THAT PROMPT CRITICAL THINKING

- ✓ provide enough wait-time for students to reflect when responding to questions
- ✓ Prompt review of the learning situation, what is known, what is not yet known and what has been learned.
- ✓ Provide authentic task involving ill-structured data to encourage effective thinking during learning activities
- ✓ Prompt students reflection by asking questions that seek reasons and evidence
- ✓ Provide some explanations to guide students through processes during explorations
- ✓ Classroom activities should be relevant to real-world situation and provide integrated experiences
- ✓ Structure lesson plans to support reflective thinking
- ✓ Provide lesson components that prompts inquiry and curiosity
- ✓ Provide resources and hand-on activities to prompt exploration
- ✓ Provide reflective thinking activities that prompts students to think about what they have done, what they've learnt and what they still need to do
- ✓ Provide reflection activity worksheets for each lesson plan to promote students to think about what they know, what they need to know as they progress through their exploration
- ✓ Adopt conference style learning strategy. The teacher should avoid teaching in class but play the role of a facilitator in a conference, where the teacher guides the

class by allowing the students to do the thinking and teaching

- ✓ Return to roleplaying. Roleplaying has always been an excellent method for exercising critical thinking.
- ✓ Prompt students up a research on a concept
- ✓ Ensure collaboration integrating meaningful learning experiences that promotes critical thinking skills is essential in cultivating a classroom of 21st century learners. One way to do this is by actively engaging in their learning through collaborative work. This helps students take ownership the learning and think critically about issues.
- ✓ Create a foundation students cannot think critically if they do not have the information they need. Begin any critical thinking exercise with a review of related information. This ensures they can recall facts pertinent to the topic
- ✓ Use information fluency. Part of critical thinking is knowing when to pursue and when to discard information students must learn to amass the appropriate knowledge to inform that thinking. Teaching critical thinking skills can be supported by an understanding of information fluency.
- ✓ Problem-solving: Assigning a specific problem is one of the best avenues for teaching critical thinking skills. Leave the goal or "answer" open-ended for the wildest possible approach. This is the essence of asking essential questions that have no easy answer. It requires discovery and synthesis of knowledge through critical thinking.
- ✓ Return to roleplaying. Role playing has always been an excellent method for exercising critical thinking. It involves inhabiting another persona and its characteristics.
- ✓ Teach the concept of concepts. Explicitly teach the concepts of concepts. Concepts in particular content areas should be identified and taught. Teachers should make sure students understand the critical features that define a particular concept and distinguish it from other concepts.
- ✓ Teach inference. Students should be explicitly taught at a young age how to infer or make references. Start with "real life" example.
- ✓ Teach components of the learning process. To thinking skills, students need to become consciously aware of the learning process. This changes students from passive recipients of information to active, productive, creative, generators of information.

III. CREATIVITY

Creativity according to Robison (2011) is an original idea that has value. Klein (2008) similarly suggests that creativity involves originality and novelty combined with utility or value. Jackson (2006) offers creativity as the ability to move an idea from one state to another. Creativity capacity is seen as a rich human characteristic. Creativity has been linked with attitudes of curiosity; willingness to engage and explore; being proactive; being willing to take risk, having determination and even obsession Creativity is the act of turning new and imaginative ideas into reality. Creativity is characterized by the ability to perceive the world in new ways, to find hidden patterns, to make connections between seemingly unrelated

phenomena and to generate solutions. Creativity is a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, identifying the difficulty, searching the solutions, making guesses, or formulating hypothesis about deficiencies, testing and retesting these hypothesis and possibly modifying and retesting them, and finally communicating the results. (Paul, Pitcher, n.d. 2014) Every child is born with the potential of being creative. Creativity is a crucial aspect of any personality. It helps to analyze things in diverse and uncommon way. Creativity does not just happen. It needs to be cultivated, and the cultivation of creativity in every kid starts from the classroom. Creativity can be promoted or cultivated (Provenzano, 2015). Here is a list of strategies that can help teachers to promote or cultivate creativity in the classroom.

EMOTIONAL CONNECTION

Research show that creativity can be cultivated best through emotional contacts. For instance if teachers give project to student related to community problems such as diseases caused by water pollution. It can help in sprouting creativity because of the human touch and emotional connection in it.

CLASSROOM ENVIRONMENT

Classroom environment plays a crucial role in cultivating creativity and confidence in students. Teachers can make classroom environment where each students' voice matters a lot. Getting involved with the students in the community is the best way to give push to their creativity. There are ways teachers can make classroom environment more effective for their students'

- ✓ Permit frequent discussion and interaction amid students in the classroom
- ✓ Make time for informal class opportunities for students

USE OF DIFFERENT MODELS

The teacher can use various models to promote creativity in students: A perfect model can help in;

- ✓ Establishing connection amid the students' real lives and classroom. The Osborne-parnes model is the oldest, widely accepted model. It is often used in education to promote creativity. Each step involves a divergent thinking pattern to challenge ideas, and then convergent thinking to narrow down exploration
- ✓ Inspire innovation and create chances to resolve novel issues
- ✓ Spread learning prospects in the classroom and at home.

RISK-TAKING

Risk-taking thinking or ability automatically prompts creativity. Therefore, teachers must encourage risk-taking approach in the students. Here are some of the strategies that the teacher can follow to enhance risk-taking ability in the students

- ✓ Offer safe environment that permits risk-taking

- ✓ B. arouse willingness in the student to try new ideas
- ✓ Accept the mistakes made by the students while trying new things

ACTIVE LEARNING

Active learning includes use of creative stuff likes games, concepts, maps and study materials. Active learning can only be encouraged when students enjoy the learning environment. Here are some ideas through which teachers can cultivate creativity through active learning.

- ✓ Create interactions that provide students with a lot of problem-solving opportunities
- ✓ Give a lot of opportunities for hands-on field work
- ✓ Organize round table discussions from time to time on interesting topics

WEB BLOGS

Blogs are the great platform to enhance creative thinking in students. Teachers can encourage their students to use blogs to demonstrate their ideas on a particular topic.

BRAINSTORMING AND MAPPING TOOLS

Nowadays a lot of tools and apps are available over the web for brainstorming and mapping. Students should be helped to get the access of mind-maps, puzzles, visual graphs and much more.

INFOGRAPHICS

Infographics are the best way to give wings to students' imagination and creativity. Using various tools available on the web, students can express their creativity using graphs.

ONLINE GAMES

Online games endorse teamwork, creativity and cooperation among student. Some of the online games are specifically meant to assist students to learn specific lessons with fun.

OPEN-ENDED PROJECTS

A standard project has students completing a task set out by the teacher. With an open-ended project, the students get to choose the type of project they want to create. Students get excited to explore different passions and present their discoveries in ways that are comfortable to them. As a teacher guidelines should be provided for the students to follow. A topic is given and students are asked to create a presentation that addresses it.

GENUS HOUR TIME

The teacher can devote one hour, a day or a day a week over a set time period for letting students explore a concept they are passionate about. By encouraging students to work on

something they care about they begin making connections between their passions and their learning.

CREATIVE TEAM BUILDING

It is fun to get students together and do some team building. Teachers are so test- and grade- driven that they forget how class isn't actually a competition that pits student against student. A classroom should be a collaborative environment where students work together to support everyone's learning.

ALLOW SPACE FOR CREATIVITY

Design some classroom space for exploration such as the thinking table, or a space for group discussion.

TAPPING INTO MULTIPLE INTELLIGENCES

Creativity requires us to use different parts of our brain. We often bridge connections between seemingly unrelated areas to make new concepts emerge. Allow students to use their strengths to find new ways of approaching a topic or solving problems.

EMBRACE CREATIVITY AS PART OF LEARNING

Create a classroom environment that recognizes creativity. Design awards or bulletin boards to showcase different ways of solving a problem, or creative solutions to a real world scenario.

USE THE MOST EFFECTIVE STRATEGIES

Torrance performed an extensive meta-analysis that considered the most effective ways to teach creativity. He found that the most successful approaches used creative arts, media-oriented programs, or relied on the Osborn-Parnes training programs that incorporated cognitive and emotional functioning were the most successful.

THINK OF CREATIVITY AS A SKILL

Much like resourcefulness and inventiveness it is less a trait and more of a proficiency that can be taught. If we see it this way our jobs as educators becomes to find ways to encourage its use and break it down into smaller skill sets.

PARTICIPATE IN OR CREATE A PROGRAM TO DEVELOP CREATIVE SKILLS

Programs like Odyssey of the mind and thinkquest bring together students from around the world to promote creativity, design creative solutions, and bring them to competition.

CONSIDER HOW CLASSROOM ASSIGNMENTS USE DIVERGENT AND CONVERGENT THINKING

Standardized tests do a great job of measuring convergent thinking that includes analytical thinking or logical answers

with one correct response. Divergent thinking considers how learners can use different ways to approach a problem. It requires using association and multiplicity of thought. Teachers should design assignments that consider both types of thinking models.

CREATIVITY FLOURISHES IN "CONGENIAL ENVIRONMENT"

Creative thinking needs to be shared and validated by others in a socially supportive atmosphere.

USE A CULTURAL ARTIFACT

Research from experimental social psychology finds that artifacts can enhance insight problem solving. Consider using an object such as a light bulb to have students think about at a particular time period. The thought of the history of the light bulb can spur creativity.

ESTABLISH EXPRESSIVE FREEDOM

The classroom environment must be a place where students feel safe to share novel ideas. Allow for flexibility and create norms that promote creativity.

ENCOURAGE CURIOSITY

Consider what is important to students. Students' interest is a great place to start on what drives their thinking tank. Find inspiration from their world. Creativity is intrinsic in nature. Teachers should promote creativity by stepping into their view point to find what motivates them. Students are a great place to start on what drives their own thinking tank. Teachers should find inspiration from their view point.

INCUBATION MODEL

Heighten anticipation. Make connections between the classroom and students real lives. Create the desire to know. Deepen expectations. Engage the curriculum in new ways. Brainstorm and create opportunities to solve a novel problem. Keep it going. Continue the thinking beyond the lesson or classroom. Find ways to extend learning opportunities at home or even in the community.

USE A COLLABORATIVE CREATIVE THINKING MODEL TO SOLVE CLASSROOM PROBLEMS

Collaborative problem solving is catching on quickly many business schools have implemented creative thinking models into their curriculum.

DESIGN MULTIDISCIPLINARY LESSONS WHEN POSSIBLE

Relate scientific and technological concepts to other subject discipline creatively.

TEACH CREATIVE SKILLS EXPLICITLY

These encompasses: imagination, discipline and self-motivation, resiliency, collaboration and giving responsibility to students. Have students develop their own projects.

IV. CRITICAL THINKING FOR SUSTAINABILITY

Sustainable development can be seen as a process of improving the range of opportunities that will enable people to achieve their aspirations and full potential over a period of time while maintaining the resilience of economic, social and environmental systems. Basically it involves a knowledge base which revolves round three basic concepts which are the economy, the environment and the society. While many nations around the world have embraced the need for education to achieve sustainability, a lack of vision and awareness has impeded progress in Nigeria (Ohunene & Ozoji, 2014). Teaching for sustainability and making it a part of our daily living is vital and requires integration in the teaching pedagogy. A country with a large number of unskilled workers will have limited development options. If communities and nations hope to identify and work towards sustainability goals, they must focus on skills and values. To achieve this science education must be restructured to address sustainability and expanded to include critical thinking and creativity. For any nation to attain development there is the need to recognize science education as a priority area of education (Ogunmade as cited in Obianuju, Obiajulu & Ella, 2013).

V. BENEFITS OF CRITICAL THINKING

From solving problems in class assignments to facing real world situations, critical thinking is a valuable skill for students to master. Rather than relying on teachers and classroom time for instruction and guidance, students with critical thinking skills become more independent, self-directed learners. Learning critical thinking skills can also enhance academic performance (Morgan, 2016). Ultimately, critical thinking skills help the individual better understand the experience view of others enhancing the ability to work with different people. With critical thinking one of the crucial learning developments is an awareness of differing approaches to a problem, alongside an ability to assess those approaches critically, rather than relying on a standard, uniform problem – solving method. Critical thinking enhances language and presentation skills. Thinking clearly and systematically can improve the way we express our ideas. In learning how to analyze the logical structure of texts, critical thinking also improves comprehension abilities. Critical thinking promotes creativity. Critical thinking plays a crucial role in evaluating new ideas, selecting the best ones and modifying them if necessary. Critical thinking is crucial for self-reflection, in order to live a meaningful life and to structure our lives accordingly. Critical thinking provides the tools for the process of self- evaluation. Good critical thinking is the foundation of science. Science requires the critical use of

reason in experimentation and theory confirmation. A critical thinker knows to separate facts from opinions, how to examine an issue from all sides, how to make rational inferences and how to withhold personal judgment on biases.

A critical thinker has the self-awareness to know the difference between a rational thought based on careful consideration and an emotional response based on bias. A well-cultivated critical thinker raises vital questions and problems formulating them clearly and precisely, gathers and assesses relevant information, using abstract ideas to interpret it effectively, comes to well-reasoned conclusions and solutions, testing them against relevant criteria and standards, thinks open-mindedly within alternative systems of thought, recognizing and assessing as need be, their assumptions, implications, and practical consequences, communicates effectively with others in figuring out solutions to complex problems. Critical thinking is self-directed, self-disciplined, self-motivated, and self-monitored and self-corrective. It presupposes assent of rigorous standards of excellence and mindful command of their uses. It entails effective communication and problem- solving ability and a commitment to overcome our native egocentrism and socio-centrism. Critical thinking skills teach a variety of skills that can be applied to any situation in life that calls for reflection, analysis and planning. Critical thinking is important in the new knowledge economy. The global knowledge economy is driven by information and technology. The new economy places increasing demand on flexible intellectual skill, and the ability to analyze information and integrate the diverse sources of knowledge in solving problems. Good critical thinking promotes such thinking skills and is very important in the fast-changing workplace.

VI. CONCLUSION

Critical thinking has been an important issue in education. The common core state standard specifically emphasized a thinking curriculum and thereby requires teachers to elevate their students mental workflow beyond just memorization. Experts agree that in keeping up with the ever-changing technological advances, students will need to obtain, understand and analyze information on a much more efficient scale. As we strive to better prepare students for real world careers and challenges, we need to focus on developing students creative and thinking skills. Educators can encourage students to become 21st century problem solvers by introducing them to a wide variety of thinking tools. Affording students the opportunity to flex their creative and critical problem- solving skills offers them the chance to practice skills that are highly prized in real-world situations.

REFERENCES

- [1] Gunn, T., Grigg, L., & Pomahac, G. (2006). Critical thinking and bioethical decision making in the middle school classroom. *The International Journal of Learning*, 13 (5), 129-136.

- [2] Jackson, N. (2003). *Designing for creativity curriculum guide*. York: Learning and teaching. Support Network Generic Centre.
- [3] Kleiman, P. (2008). Towards transformation: conceptions of creativity in higher education. *Innovation and Teaching International*, 45 (3), 209 -217.
- [4] Morgan, K. (2016). *What are the benefits of critical thinking skills?* Retrieved from <http://www.classroom-synonyms.com/benefits-critical>.
- [5] Paul, T. E. (n. d.). *Verbal test: Torrance Test of creative thinking-Norms*. Technical Manual Research Edition. Princeton. New Jersey. Personnel Press.
- [6] Pitcher, R. (2014). *The importance of a creative and stimulating classroom environment*. Retrieved from <http://www.au.educationhq.com/.../the-importance...>
- [7] Provenzano, N. (2015). *Creativity in the classroom*. Retrieved from <http://www.edutopia.org/.../creativity>
- [8] Obianuju, O. S., Obiajulu, A. N., & Ella, F. A. (2013). Science education for sustainable development in Nigeria: Challenges and prospects. *Academic Journal of Interdisciplinary Studies*, 2 (6), 159-167.
- [9] Ohunene, O. C., & Ozoji, B. E. (2014). Science education and sustainable development in Nigeria. *American Journal of Educational Research*, 2 (8), 595-599. Doi:10.12691/education-2-8-6
- [10] Robinson, K. (2011). *Out - of- our minds: Learning to be creative*. 2nd ed. Capstone.
- [11] Tsai, p., chen, s., change, h., and change, w. (2013). Effect of prompting critical reading of science news on seventh graders' cognitive achievement. *International Journal of Environmental Science*, 8(1), 85-107. Doi 101002/tea 20385
- [12] Provenzano, N. (2015). *Creativity in the classroom*. Retrieved from <http://www.edutopia.org/.../creativity-in-the-classroom>.
- [13] Paul, T. E. (nd.). *Verbal test: The Torrance test of creative thinking-norms*. Technical manual Research Edition. Princeton. New Jersey. Personnel press.

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