

Productive Thinking Model (Fiesi): To Make Science Education More Scientific And Innovative

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ABSTRACT

Science is not a set of facts and vocabulary to memorize rather it is an ongoing journey and a quest for knowledge about the natural world (Custraro, 2012). Science is a discipline that provide a lot of scope for analysis, synthesis, evaluation, decision making, critical thinking, creative thinking and logical reasoning. But a mismatch between curriculum objective and its transaction is observed (Sreehari, 2011). As emphasized by the National Policy on Education (1986) "Education should be visualized as the vehicle to train the child to think, analyze, reason and articulate logically". Putting light on recommendation given by advisory body we need to think of new ways to approach problems in science rather than relying on single correct answer. In this direction productive thinking is the construct which is the combination of higher order thinking components and it can be defined as "Productive thinking is a process involving in the creation of something new by applying higher order thinking skills". For this productive thinking model (FIESI) can be used in science teaching-learning process to make science education more scientific and innovative. It is a way by which students can think out of the box to strengthen body of knowledge of science. It is based on the principle of evaluating creative thinking by critical thinking to make it productive. This model consist of five steps: Foundation, Ideation, Evaluation, Stabilization and Implication. This paper will put light on this model, how it can be integrated in classroom instruction to teach science in innovative way, how to avoid functional fixedness and how to give emphasis on ideational fluency. This is the area which need to be introduced in teacher training programme also so that teachers can use it efficiently in the classroom instruction.

Keywords: *Productive thinking, creative thinking, critical thinking, functional fixedness, ideational fluency*

Introduction :

Growth of science and technology supported by innovation decides growth of a nation therefore education is one of the focus of government from the independence.

India's development can be better met by our scientists and this can be done by introduction of work experience as an integral part in science teaching (Kothari commission, 1964-68). Local knowledge

and children's experiences are essential components that can be used in the classroom for better learning of science (NCF, 2005). We are in 21st century and we have so much challenges in the field of science education. It demands reform in curriculum and examination system by moving away from lower order thinking components to the critical understanding by inculcating higher order thinking components (National Knowledge Commission, 2009). It laid stress on the need for a radical construction of the education system to improve its quality at all stages and gave much greater attention to science and technology (NPE, 1968). Quality is one of the major issue facing our country today. Quality in science education can be met by changing teachers' attitude towards science, changing school and classroom environment, by using child centered and activity centered teaching methodology (NPE, 1986).

In this direction, thinking is the major concern which is lack in the classroom. It is the concept without which progress in science and technology or in any subject cannot be imagined. It cannot be done by simply reproducing already existing facts. We need to train our children to think divergently, consider multiple perspective and generate something new which will be beneficial for the society.

In Vision 2020, J.S. Rajput reported that there is a wide spread decline in demand for higher education in basic sciences. This may affect the scientific advancement in this field. This low demand is due to either curriculum and teaching-learning processes or the attraction towards professional courses. In order to attract and retain the bright minds in basic sciences we need to improve our instructional strategies at school level. Having achieved near universal access at the primary level (by SSA), the focus is now on quality improvement and enhancing student learning (World Bank, 2014). For qualitative change from the present situation, science education in India must undergo a paradigm shift where rote learning will be discouraged and schools will give greater emphasis on co-curricular and extracurricular elements aimed at stimulating *investigative ability, inventiveness and creativity* (position paper NCERT, 2006). Similarly, according to OECD, we should improve our practices of teaching science, that lead to foster creativity and thinking skills because thinking is an integral part of the teaching-learning process. NCF (2005) who is the operational guide of the school education provides the direction for the teachers to choose the content and methods of education to teach in the school.

Present instructional strategy for knowledge management in India must be

examined for its adequacy to develop thinking skills required for higher education. In the higher secondary examination questions are knowledge oriented whereas in the admission tests more weightage is given to the cognitive skills (Sreehari, 2011). Many students fail to secure ranks in admission tests conducted for professional courses, arts and sciences. It indicates we need to introduce pedagogy that gives emphasis over cognitive abilities of the students and to change their level of the learner from knowledge level to that of knowledge generating. As we have entered in the new millennium we cannot neglect the need of the hour i.e. individual must gain the capacity to be creative, having ability for critical thinking, reflective thinking, logical thinking and producing knowledge rather than receiving and reproducing it. The problem which we are facing today is “how to make students capable of generating new knowledge or ideas, planning and problem solving.” It can be done by inculcation of productive thinking among students. Gini-Newman and Case (2015) emphasized inappropriate use of Bloom’s taxonomy of the cognitive domain in the classroom. The proposed model is an attempt to give emphasis over the higher levels of Bloom’s taxonomy along with the lower levels. As Tsai, Chen, Chang & Chang (2013) emphasized that critical thinking in science classes make

instruction fruitful. Chine (2006) and Wardrop et al (1969) developed productive thinking by self-instructional lesson and found positive result in elementary school. Present model is beneficial for the students to learn science through developing productive thinking.

Productive Thinking :

Gestalt psychologists were the first to provide a description of productive thinking. They identified two processes: reproductive thinking and productive thinking. **Reproductive thinking** is consisting of a mechanical application of chains of associations which have already been learned and reinforced by experience and habits. It is associated with repetition, conditioning, habits or familiar intellectual territory. **Productive thinking** is a process involving in the creation of something new by applying higher order thinking skills. Productive thought covers a variety of forms of cognitive activity: deduction; understanding and causal reasoning; creative thinking and problem solving; evaluative or critical thinking; and decision making and wise thinking (Newton, L., 2013). Higher order thinking, through the combination and integration of information, enables the construction of meaningful and more comprehensive ideas that go beyond the information presented. The practice of productive thinking in academic contexts is often directed at

reasoning, understanding, creative thinking, evaluative thinking and decision making. Romiszowski (1981) also applied the term productive thinking to Bloom's (1956) higher level thinking – the analysis, synthesis and evaluation processes. According to him productive thinking is what can successfully generate ideas, develop plans, guide decision making and problem solving, and lead to actions. It is a valuable asset for people setting out to engage with and survive in the world and is the kind of thinking that has the potential to generate actions that can change minds and lives.

Considering the definitions given by the researchers, productive thinking can be define as “*the cognitive ability to plan, reason logically, analyze, synthesize, evaluate, and make decision to reach at the solution of the problem*” where newton (2013) focused on deduction, understanding, reasoning; creative thinking, problem solving, evaluative thinking, decision making and wise thinking, Cunningham & Macgregor (2014) consider Productive thinking as mechanism of shifts in perspective to solve a problem, Craig Rusbult (1997) describe it as combination of critical and creative thinking , Tim Hurson (2007) define it as problem solving approach.

Conceptualizations Of Productive Thinking In Science Teaching :

Productive thinking is not a new concept in the teaching-learning process rather it is an indispensable part of it as it combines higher order thinking components. In science teaching our prime focus is to develop analysis, synthesis and evaluation capacity in the students because science provides tremendous scope for these elements. In science teaching, productive thinking is the area which provides a balance between these elements to have something new rather than relying on drill and practice. As fig I showing opposite nature of creative thinking and critical thinking and it is also believed that persons who are creative will be comparatively less critical or vice-versa. In science we require both the skills. As fig I showing, it is the combination of creative thinking with critical thinking in such a synchronized manner having a wonderful product called productive thinking.

In science we need higher order thinking components and these components are integral part of the research and technology. Science is dead without creative and critical thinking. Productive thinking is an element where all the higher order thinking components can be enriched in the students in specifically science subject. It is the combination of creative thinking with critical thinking in a synchronized manner to make creativity wonderful and to make something new and valuable also.

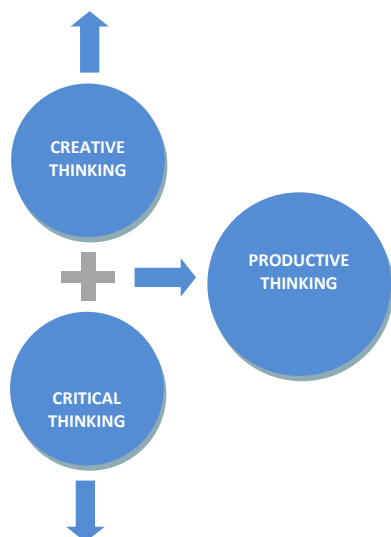


Fig I showing combination of creative and critical thinking (opposite nature) to result productive thinking

SCOPE FOR FIESI MODEL

Development of productive thinking among students through science teaching is very important aspect. It is the way by which we can achieve the expected objectives. It has its scope in the following area :

- Productive thinking give value to the creative thinking by evaluating through critical thinking.
- It provides a platform upon which creative thinking and critical thinking go hand in hand.
- It enhances scientific temper among students and develop the tendency of inquiry based learning.
- It is the foundation of science as it require the critical use of reason in experimentation and theory configuration.

- Students with productive thinking never rely on teachers and classroom time for instruction and guidance rather they are more independent and self-directed learners.
- Analytical reasoning, logical reasoning and ability to think critically are the basic component of today's entrance examination and productive thinking make them prepare for these type of examination.
- Productive thinking is the important component of research and development in science and technology.
- It provides scope to the students to develop research aptitude.

FIESI Model

The proposed model is developed by considering the other existing models of productive thinking, creative thinking and critical thinking. Rusbult (1997) gave emphasis on the implementation of the ideas in the model given by him but in the classroom it is not possible to implement all the ideas therefore in FIESI model emphasis is given over implication of the ideas. Similarly, Hurson (2007) also gave model ThinkX for productive thinking but it is for management studies. Therefore, presenter has developed model for productive thinking (FIESI) by considering the available models and adding the needed component.

This model can be integrated with the syllabus to teach the content of science. The productive thinking model (FIESI) is having the following steps as mentioned in the fig II :

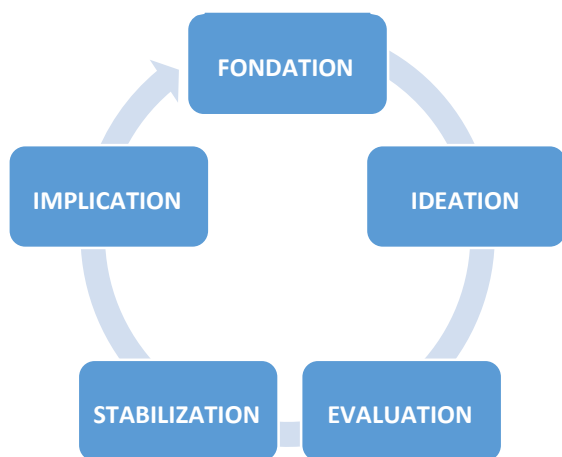


Fig. II Model of productive thinking (FIESI).

A.Foundation

This step is based on the principle that *creativity never comes in vacuum*, for this we need to provide a knowledge foundation upon which productivity can be drawn. As productive thinking is the combination of motivation, memory, creative thinking and critical thinking, a foundation stage is necessary in which teacher motivate students to get engaged in the content by manipulating their prior understanding and teach them with the help of student centric strategies like: activities, demonstration and teaching with technology.

B.Ideation

This step emphasizes over creative aspect of productive thinking where

ideational fluency is emphasized. Ideation is based on the following principles:

- Quantity precedes over quality.
- Functional fixedness inhibits novelty.
- Criticism is the barrier in the way of creativity.

By keeping in mind above discussed principles, students are allowed to think out of the box by considering multiple perspectives. Here the role of a teacher is to present a problem in such a challenging way that disturb the equilibrium and engage students in idea generation. For this we need to minimize criticism i.e. self-criticism or criticism by others as it hinders creativity and avoid giving emphasis on drill, skill and rote learning. In science teaching using this model SCAMPER, forced connection, brainstorming, creative free writing and cognitive questioning can be used in this step.

C.Evaluation

This step is the critical thinking aspect of the productive thinking. It involves evaluation of the creative thinking through critical thinking to modify the concept to make it feasible. As critical thinking provides value, strength, potential, usefulness and appropriateness to the embryonic ideas by considering the criteria of domain. In classroom science teaching peer evaluation and presentation are the strategies that can be used to evaluate the immature ideas.

D.Stabilization

This phase is to stabilize the concept. Students may have developed some doubts on their developed ideas. This step will allow them to clear all the doubts related to their creative ideas and taught content to make it stabilize.

In classroom science teaching concept map and conclusion writing are two strategies can be used.

E.Implication of the concept:

Success of the productive thinking process depends upon the link between creativity and implication of the creative ideas. In creative thinking generation of ideas are more prevalent than its implication whereas in this, usefulness is necessary criteria for ideas to be considered as productive. Thus, this step is to satisfy the usefulness criteria for the productive thinking. At this step students are allowed to imply the generated ideas logically. In this component concept map and foresight can be used in the classroom science teaching.

Conclusion:

Knowledge of science and scientific ways of thinking both are necessary for the students to contribute to nation's growth. This start from the school science education. Today there is a mismatch between the curriculum objectives and curriculum transaction. This results in the disparity between the standard of the science

education achieved by the students and the expected one. To achieve the expected objectives and draw our students' attention towards research we need to introduce productive thinking in the classroom instruction. Productive thinking allow the students to think creatively and at the same platform critically evaluate it to provide value and strength to the creative idea. This is the component which is to be included in teacher training programme, as teachers use this component in the classroom to make it feasible.

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