

# Role of Science in Developing Critical Thinking

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**Abstract-** The 4 C's of 21<sup>st</sup> Century learning skills are critical thinking, creativity, collaboration and communication. Critical thinking is an intellectual process of thinking for a purpose, and involves reflection of ideas. It is one of the fundamental life skills necessary for human survival. Inference, explanation, evaluation, self-regulation, interpretation and analysis are the six core critical thinking skills. One should be a critical thinker for solving problems. Good critical thinking decides once success or failure in life. It helps to analyze a situation or problem to most basic parts and find the truthfulness of information that we come across in everyday life. It leads to success in career and life, and boosts self-reflection. A good critical thinker would be able to make sound decisions and will be a good problem solver. Lack of critical thinking skills in society can lead to various social and personal problems. It is crucial in the field of education. It has emerged as one of the learning outcomes of education. Employers prefer to hire people who are strong critical thinkers. It prevents student from taking wrong decisions. Education is the process of acquisition of knowledge and skills and critical thinking supplements the process of education. Developing strong critical thinking skills among students helps them to analyze facts, evaluate statements, separate myths from facts and how to use information to deduce facts. Good critical thinkers make better decisions, better choices in life and contribute to the betterment of society and nation. The critical thinking skills have to be cultivated and practiced at school level itself so that students grow intellectually so as to analyze the context and deduce information without bias and form their own opinion. The lack of good critical thinking skills leads to making wrong choices and taking wrong directions in life. Critical thinking skills are vital in the field of science. Science has to be taught in such a way that it encourages critical thinking. A science teacher has to adopt different strategies while transacting the topics in regular teaching learning process in order to foster critical thinking skills among students. The science teacher has to ensure that all the six core critical thinking skills and the respective subskills are developed through the incorporating different activities and teaching learning strategies in science classrooms. Blended learning is very important in the 21<sup>st</sup> century learning. It combines the benefits of both electronic and online media along with the traditional face-to-face teaching. Blended learning has to be incorporated in science classrooms to develop the critical thinking skills among students. A science teacher can adopt the various blended learning models based on the curriculum, age of the students and the available infrastructural facilities to sharpen the critical thinking skills. Different teaching learning strategies, activities and various models of blended learning can be wisely used in science classrooms for enhancing the critical thinking skills of the students. The experts, policy makers, curriculum developers and teachers have to work in unison to mould good critical thinkers through the use of various strategies, models of blended learning and also through different activities in science classrooms.

**Index Terms**— Critical thinking, core critical thinking skills, critical thinker, education, strategies, blended learning

## I. INTRODUCTION

Thinking is a natural process which is done by every human being. An individual's behaviour is shaped by his/her thinking and reflection. Hence, it is important that one should think. Quality of human life depends on quality of our thinking. We are living in a world where we get information at our finger tips anytime, anywhere. In this digital era, human beings are overloaded with information that comes across in our day-today life. A person has to think analytically, evaluate the information and make judgements without any bias. One should consider the information in an analytical and critical manner. Critical thinking is significant in this context. If every individual in the earth is a critical thinker then the world would be a better place to live.

The 21<sup>st</sup> Century learning skills are essential to thrive in today's world. They are the skills or abilities required to be successful in the 21<sup>st</sup> Century. The 4 C's of 21<sup>st</sup> Century learning skills are critical thinking, creativity, collaboration and communication.

## II. CRITICAL THINKING

'Critical thinking is the capability of objective analysis of information which include the following qualities: fairness and open-mindedness; activeness and being informed; willingness to question or to entertain doubts; being independent; recognizing and assessing values, peer pressure and the media influences' (CBSE, 2020).

"Critical thinking is defined as the process we use to reflect on, access and judge the assumptions underlying our own and others ideas and actions. This includes: "the thinker's dispositions and orientations; a range of specific analytical, evaluative, and problem-solving skills; contextual influences; use of multiple perspectives; awareness of one's own assumptions; capacities for metacognition; or a specific set of thinking processes or tasks" (Stassen, et al, 2011).

"Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action" (Scriven & Paul, 1987).

The APA Delphi Report (1990) defined "Critical thinking (CT) to be purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological,

criteriological, or contextual considerations upon which that judgment is based. CT is essential as a tool of inquiry. As such, CT is a liberating force in education and a powerful resource in one's personal and civic life”.

Critical thinking is an intellectual process of thinking for a purpose, and involves reflection of ideas, analytical and evaluative thinking. It can be considered as reflective thinking to decide what to believe and how to behave. It is thinking about thinking.

**Core Critical Thinking Skills:** The six core critical thinking skills according to the consensus statement of the national panel of experts (Facione, 1990) are inference, explanation, evaluation, self-regulation, interpretation and analysis. The consensus lists of core critical thinking skills and their sub-skills are as follows:

1. Inference - Querying evidence, Conjecturing alternatives, Drawing conclusions
2. Explanation - Stating results, Justifying procedures, Presenting arguments
3. Evaluation - Assessing claims, Assessing arguments
4. Self-Regulation - Self-examination, Self-correction
5. Interpretation – Categorization, Decoding significance, Clarifying meaning
6. Analysis - Examining ideas, Identifying arguments, Analysing arguments

### III. SIGNIFICANCE OF CRITICAL THINKING IN LIFE

The World Health Organization identifies the fundamental life skills as decision making and problem solving, creative thinking and critical thinking, communication and interpersonal skills, self-awareness and empathy and coping with emotions and stress. Critical thinking is one of the fundamental life skills identified by the WHO. These life skills are abilities that help an individual to face and deal with the challenges of everyday life (WHO, 1996).

Critical thinking is a fundamental and key skill necessary for human survival. It is a crucial life skill a person should develop in life. An individual has to make use of this skill in day to day life and in almost every situation to deal with myriad of issues. One should be a critical thinker for solving problems effectively and efficiently. Good critical thinking decides once success or failure in life. It helps to analyse a situation or problem to most basic parts and find the truthfulness of information that we come across in everyday life. It aids and improves the decision-making power in an individual. It leads to success in career and life. It boosts self-reflection. It helps to logically connect with ideas. A good critical thinker would be able to make sound decisions and will be a good problem solver.

Critical thinking is needed for fast growing economies for quick, efficient and effective problem solving. It prevents a person from blindly accepting facts. It helps in any circumstances and in any profession. It motivates a person to think widely and deeply. It is very important in the new knowledge economy. The new economy places increasing demands on intellectual skills, and the ability to analyse information and integrate diverse sources of knowledge in solving problems. Good critical thinking promotes such thinking skills, and is very important in the fast-changing workplace.

Lack of critical thinking skills in society can lead to various social and personal problems like failure in academics, mental and emotional problems, drug abuse, suicidal tendencies, depression, youth turning to anti-social activities, law and order problems, inability to solve problems in life etc.

### IV. DEVELOPING CRITICAL THINKING THROUGH EDUCATION

Education is a purposeful and goal-oriented activity of training people and moulding their personalities. It is nothing but disciplining of a human being. Overt actions are given much importance in a disciplining process. But, thinking is a covert process and requires lot of intellectual discipline. Critical thinking is an intellectually disciplined process. It has emerged as one of the learning outcomes of education. It is crucial in the field of education and also for success in the career.

Critical thinking is not specific to a particular field. It is a domain of general skills that is necessary for every profession. It helps learners to come up with novice ideas, which in turn promote creativity. Employers prefer to hire people who are strong critical thinkers. It ensures success not only in career but also in all aspects of life. Critical thinkers come up with novel solutions than non-critical thinkers. They are able to evaluate themselves through self-reflection.

Critical thinking enhances language and presentation skills. Thinking clearly and systematically can improve the way we express our ideas. In learning, critical thinking helps how to analyse the logical structure of texts, but also improves comprehension abilities. It aids the ability to comprehend, analyse and evaluate information. It helps to think logically so as to make sense out of the world. It prevents student from taking wrong decisions. It helps in acquiring knowledge, improve our theories, and strengthen arguments. Education is the process of acquisition of knowledge and skills and critical thinking supplements the process of education.

### V. STUDENTS AS CRITICAL THINKERS

Consensus statement regarding the ideal critical thinker is that “The ideal critical thinker is habitually inquisitive, well-informed, trustful of reason, open-minded, flexible, fair-minded in evaluation, honest in facing personal biases, prudent in making judgments, willing to reconsider, clear about issues, orderly in complex matters, diligent in seeking relevant information, reasonable in the selection of criteria, focused in inquiry, and persistent in seeking results which are as precise as the subject and the circumstances of inquiry permit” (Facione, 1990).

Decisions that one takes in his/her life determine the quality of life and in turn determine the success or failure in life. Hence, it is very important for a person to make conscious choices in life. Developing strong critical thinking skills among students helps them to analyse facts, evaluate statements, separate myths from facts and how to use information to deduce facts. Good critical thinkers make better decisions, better choices in life and contribute to the betterment of society and nation. They solve problems creatively and come up with practical solutions. Critical thinkers are curious and reflective people who behave rationally. They are

reflective, independent, competent people and are better problem solvers than non-critical thinkers. Hence, it is very important to develop critical thinking spirit among students to build a better future.

The critical thinking skills have to be cultivated and practiced at school level itself so that students grow intellectually so as to analyse the context and deduce information without bias and form their own opinion. Sharpening critical thinking skills in student life will mould them into good citizens who are open-minded with good decision making skills, who in turn positively contribute to the society and towards nation building.

Many youths are turning towards drugs and antisocial activities due to lack of critical thinking. The lack of good critical thinking skills leads to making wrong choices and taking wrong directions in life. This tendency among the present generation affects the personal life and society.

## VI. DEVELOPING CRITICAL THINKING THROUGH LEARNING OF SCIENCE

In Learning Indicators and Learning Outcomes at the Elementary Stage a report by NCERT (2014), 'Science is said to be a human endeavor to understand the world by building-up conceptual models on the basis of their own observations of surroundings and connect it to meaningful patterns and relations to interact with nature. It involves processes like observations, making hypotheses, performing activities, collecting and analyzing data, drawing inferences and making generalization'.

Position Paper of National Focus Group on Teaching of Science (2006) defines 'Science is a dynamic, expanding body of knowledge covering ever new domains of experience'. It is the key to human advancement and innovation. Science plays an important role in the modern society. People use the methods and principles of scientific thinking in everyday life. Scientific discoveries shape the way we view the world and influence our decisions. The application of learning science aims at giving students a better understanding of science as a discipline, enhancing students' learning of science subject matter and decision-making on scientifically based personal and social issues. Thus, science is an integral part of our lives. Science covers all aspects and all areas of human life and that of the nature.

Science is the study of the universe and the beginning of that study is in critical thinking. A person who thinks critically asks questions about nature and attempts to find answers. When a person thinks critically he/she is trying to explain the events and solve problems. Critical thinkers strive to find objective truth in facts and science is the search for truth. Science teaches people how to think critically in all walks of life. Critical thinking motivates a learner to think rationally and clearly, science teaches a person to think rationally.

Critical thinking skills are vital in the field of science. Science should be taught in such a way that it encourages critical thinking. It also improves students' abilities to think their way through content using disciplined skill in reasoning. Critical thinking is a process, a skilled activity of thought. All the six core critical thinking skills inference, explanation, evaluation, self-regulation, interpretation and analysis can be developed through different methods of teaching and learning of science. One of the main aims of science education is to cultivate scientific temper-objectivity, critical thinking and freedom from fear and prejudice. Bailin (2002) reported that developing critical thinking is one of the goals of science education.

A handbook developed by CBSE, (2020) on the 21<sup>st</sup> Century Skills has listed following activities for developing critical thinking:

- Debate
- Ask yourself (Self-made Questions)
- Gap Fill In
- Cross-Questioning
- Asking Riddles

These different activities can be wisely used in science classrooms to mould the students as good critical thinkers.

A science teacher has to adopt different strategies while transacting the topics in regular teaching learning process in order to foster critical thinking skills among students. Different research studies have shown that the different teaching and learning strategies lead to the development of critical thinking abilities. (Ambily, 2018; Susan, 2018; Yue et.al, 2017; Sukaesih & Sutrisno 2017; Abrami et.al, 2014; Manjula, 2013; Seeja, 2012; Eren & Akinoglu, 2013).

From the review of literature, it is evident that the different strategies used in teaching and learning can influence the enhancement of critical thinking skills of learners. It is important for instructors to understand how the various strategies can impact students' critical thinking level (Richardson & Ice, 2010). The science teacher has to ensure that all the six core critical thinking skills inference, explanation, evaluation, self-regulation, interpretation and analysis and the respective subskills are developed through the incorporating different activities and teaching learning strategies in science classrooms. If teachers purposely and persistently practice higher order strategies there is a good chance for development of critical thinking capabilities (Miri, 2007). We can conclude that, critical thinking skills of students have to be developed through learning of science because of the nature of science as a subject and the processes involved in it.

## VII. DEVELOPING CRITICAL THINKING THROUGH BLENDED LEARNING

Technology has immense potential which can be maximised in science classrooms to motivate students to become active learners. ICT is an integral part of learning science. Blending digital technology into the regular science classroom promotes critical thinking skills among learners. Blended learning is very important in the 21<sup>st</sup> century learning. It combines the benefits of both electronic and online media along with the traditional face-to-face teaching. The National Education Policy (2020) stresses the need for blended models of learning. "Blended learning" designates the range of possibilities presented by combining internet and digital media with established classroom forms that require the physical co-presence of teacher and students. (Friesen, 2012)

Blended learning as a pedagogical approach sharply enhances the learning experience and in turn enhances critical thinking skills. Blended learning strategy is effective in enhancing critical thinking among secondary school students (Krishnan, 2011). Different studies have shown that blended learning is effective in improving the critical thinking of students (Stockwell et al., 2015; Guiller et al., 2008). From the review of studies conducted reveals that blended learning has to be incorporated in science classrooms to develop the critical thinking skills among students. A science teacher can adopt the various blended learning models based on the curriculum, age of the students and the available infrastructural facilities to sharpen the critical thinking skills

## VIII. CONCLUSION

Science is considered as a process for producing new knowledge. It is an intellectual activity which arises from personal experience and takes place in the minds of human beings. It is a way of using human intelligence to achieve a better understanding of nature and nature's laws. The ultimate aim of science education is, understanding the concepts meaningfully and applying them in the right context. Science teaches people how to think critically not only on scientific subjects but in all walks of life. Different teaching learning strategies, activities and various models of blended learning can be wisely used in science classrooms for enhancing the critical thinking skills of the students. The experts, policy makers, curriculum developers and teachers have to work in unison to mould good critical thinkers through the use of various strategies, models of blended learning and also through different activities in science classrooms.

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