1.0.0 Introduction

The theory of evolution of mankind lies in varied concepts of existentialism as well as pragmatism in terms of philosophy. The present scenario of globe invites our attention to its multiplicity, vividness, progressive front along with known and unknown, and told and untold complexities in the journey of science, technology, finance, politics and education as well. In the perspective of welfare and solidarity of the whole globe, besides numberless strategies being adopted, education especially the education of science, falls into legitimate realm of critical enquiry. Education, basically aims at imparting such a thought process and skill oriented elevation of mankind that could determine the higher goals of both mundane and ethereal journey.

Critically speaking, it is only education that penetrates into human mind, and affects the cognitive, psychomotor and affective domain and enables us to delve into higher order of thinking skills and creativity with which innovatory panorama of constructive society can be formed. But the irony is, as stated by Krishnamurti (1961), *what we now call education is a matter of accumulating information and knowledge from books, which anyone can do, who can read.* We produce, by the present education system, mainly technicians, not scientists or technocrats and feel proud to export such raw materials to the manpower-starved developed countries which are otherwise prosperous. This might lead to some degree of prosperity and benefit in the short term but we are going to loose in a big way in the long run unless we totally overhaul our basic education system at every level from primary to higher secondary level. There lies no meaning in cutting roots and then watering the top.

In the context of emerging challenges of globalization, cut throat competition among industries and human development worldwide, such as the pandemic, conflicts, environment degradation and climate change such as global warming, increasing inequality within and between nations, pressure to acquire and maintain a competitive edge through innovation in education and capacity to adopt new technology, it is, indeed, crucial to invest in education. Students should have the skills and ability to survive and excel in such an environment and for this purpose they need higher order thinking skills and creativity.

Scientific progress is the hallmark of every society. The scientific temper is the best answer to ignorance, superstition and hypocrisy. It gives rise to a logical and systematic approach to life, rapidly empowering and enriching everybody who embraces it in life. Wipro’s education initiative
conducted a survey namely Quality Education Study (QES) report (2012). It presents a depressing state of affairs regarding the quality of science education in India. According to QES report, there is a 5-10% drop in learning levels in the last few years in Mathematics and Sciences. This is disturbing mainly because the task of improving the learning levels becomes more discouraging as we have to first find ways to arrest this decline in the learning levels. The QES study was the hard work of 110 researchers, who assessed 23,000 students, 790 teachers and 54 principals of 89 English-medium private primary and secondary schools in the metropolitan cities of India, which lead to the conclusion that even the top schools of our country exhibit rote learning and perform much below the international average. Another international survey, Programme for International Students Assessment-PISA (2011) was conducted by the Australian Council for Educational Research. It shows that among 74 countries which include the US, UK, Canada, China, South Korea etc., Indian students are ranked at 73rd position with only Kyrgyzstan performing worse.

There is an empirical evidence that in many places around the world, science education is facing serious challenges (EU, 2004, 2007; OECD, 2006; OSTP, 2010), Osborne & Dillon, 2008, Roy. Soc., 2010; UNESCO, 2008). As the world has become more dependent on technological innovations and engineering solutions for every need while the population grows and consequences mount, the need for technology and engineering literacy has been recognized. We are living in a world surrounded by scientific discovery and new technologies, which are transforming the paradigm of communication, learning and economies. Innovations resulting from these discoveries and technologies give rise to entire new industries, creating a wide array of new jobs for workers that would otherwise not be available (NAS, 2010). One of the biggest tasks faced by the people addressing the challenge of sustainable development, both in developed and developing countries, is the need to generate the capacity to apply science and technology to the goal of a better future (ICSU, 2002). There is no doubt that effective education can serve as a vehicle for solving global problems (van Eijk & Roth, 2007a). Education in the scientific discipline combined with mathematical, technological and engineering disciplines is needed, which is utilized by the informed citizenry equipped with the tools required for the global knowledge society. (ICSU, 2011)

Researches on enrollment show that not many students are interested in pursuing careers in scientific disciplines, although it varies very widely from country to country (Schreiner & Sjøberg, 2005, 2007). Contrary to general expectation that high scores on the science achievement ranking for a country would translate into greater recruitment of scientists, the relationship seems to be the exact
opposite of the assumption: in the countries with a high achievement score, students respond rather negatively to questions regarding interest, motivation and further plans to pursue scientific studies and careers.

The alarming and crucial condition of present science education emphasizes the need for reformation. The researcher, in this regard, is of the view that the problems of terrorism, global warming, unsustainability, atomic threats etc being faced by the world of the day could, to a great extent be tamed with a marked change into the order of thinking skills. For this purpose we will have to change the way of imparting science education.

National Research Council also throws light on the fact that Science education reforms worldwide are derived from the constructivist views of teaching and learning. These reforms explicitly ask teachers to change their teaching strategies by shifting the emphasis from the traditional textbook-based, rote learning, to exploration, inquiry-based learning situated in real-world phenomena.

When analyzing the needs of society, it is so obvious that there is an urgent need to improve the preparation of the scientists of tomorrow, not only through widespread access to quality instruction, facilities, and research opportunities for all students, but also to improve the motivation and interest of students so that the creamy layer move toward scientific careers.

Present system of teaching of science has failed in fulfilling the need of the hour. The need of the hour is the teaching learning process which develops the analytical ability, critical thinking, application part of knowledge, ability to synthesize new knowledge, and the ability to evaluate synthesized knowledge. In short, we require a teaching learning process which promotes the higher order thinking skills of students (HOTS) and creativity. The traditional lecture method must be replaced by more proficient and more promising regarding the development of higher order thinking skills. Many innovative methods are applied in improving the status of science education viz constructivism, Problem Solving approach, Inquiry Based Teaching, Graphical Knowledge Display etc.

Graphic organizer is the visual or pictorial representation of the knowledge that displays relationship among facts, concepts and ideas. The visual display conveys complex information in easy-to-understand manner. It is an important tool in the area of problem solving, decision making and brainstorming. It enhances learning and understanding of the subject matter.
Graphic organizer helps the students to identify the area of focus in a broad topic. Webs, concept maps, mind maps and plots such as stack plots and Venn diagrams are some of the types of graphic organizers used in visual learning. The researcher used Mind Mapping and Concept Mapping for the present venture.

**Mind mapping** was developed by Tony Buzan and the inspiration for this technique arose from the notebooks of Leonardo da Vinci. Mind maps are like da Vinci’s notes, they are multi-sensory tools that make the use of visuo-spatial orientation to integrate information, and help students organize and retain information. The added dimensions of pictures and colors that is unique to mind maps have not only been shown to facilitate memory, but may appeal to the basic process of functioning of mind.

Experiments in educational neuroscience show that most children rank highly creative (right brain) before entering school. This is because our educational systems place a higher value on left brain skills such as mathematics, logic and language than it does on drawing or using our imagination, only ten percent of these same children rank highly creative on reaching the age of 7. By the time they are adults, high creativity remains in only 2 percent of the entire population. But using Mind Mapping Strategy caters to the need of both the left and right side of the brain developing logical as well as creative skills.
So Mind map exactly replicates the functioning of mind as it is radial and functions as a facilitator for the proper functioning of both the side of brain, as the colour, figure and pictures for right brain and logical arrangement, analysis and rationale for left brain.

Concept maps are two-dimensional representations of cognitive structures showing the hierarchies and the interconnections of concepts involved in a discipline or a sub-discipline” (Martin 1994:11). They are different from mind maps as concept maps are devoid of color and pictures, and are constructed in a top-to-bottom hierarchy. Mind maps, in contrast, use a central theme in the middle of a page with categories and subcategories that radiate peripherally, thus making them truly non-linear. The cross-links among categories highlight their intrinsic relationships, and allow the student to compare and contrast information.

Suthers (1999) maintains that when such tools (graphic organizers) are used in a collaborative context, the individual is less likely to ignore discrepancies between their own thoughts and the external representation, as they must attend to its shared. Therefore, such representations are
assumed to have a greater effect on individual cognition when used in a social context, especially when badly structured domains allowing for multiple perspectives are involved.

Graphic Organizer with Co-operative learning is the clubbing of a technique of teaching with a conducive environment suitable for the development of skills and creativity in students. In general, learning in the traditional schools is always a task which is one way from teacher to taught transformation of knowledge in a competitive environment. Johnson and Johnson (1999) are of the opinion that learning environments can be divided into three categories which are described in figure 3.

![Figure 3 Types of Learning Environment](image)

Among the different environments, co-operative learning is most suitable for the healthy and overall development of students. The variety of theories are given by the experts of diverse fields regarding the learning process given as anthropology (Mead, 1936), sociology (Coleman, 1961), economics (Von Mises, 1949), political science (Smith, 1759), psychology, and other social sciences, in psychology, the theory of social interdependence (Deutsch, 1962; Johnson & Johnson, 1989), cognitive-developmental (Johnson & Johnson, 1979; Piaget, 1950; Vygotsky, 1978), and behavioral learning theories (Bandura, 1977; Skinner, 1968) sets the foundation for co-operative learning.
Table 1
*Theories Underlying the Co-operative learning Strategy of Teaching*

<table>
<thead>
<tr>
<th>Theories</th>
<th>Social Interdependence Theory</th>
<th>Cognitive Development Theory</th>
<th>Behavioral Learning Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premise</td>
<td>The way in which social interdependence is structured determines who individuals interact with and determines outcomes.</td>
<td>Individuals cooperate, sociocognitive conflict occurs, creating cognitive disequilibrium, which stimulates perspective-taking ability and cognitive development</td>
<td>Actions followed by extrinsic rewards (group contingencies) are repeated.</td>
</tr>
<tr>
<td>Contributors</td>
<td>Kurt Koffka, Kurt Lewin, David and Roger Johnson, Dean Tjosvold</td>
<td>Piaget, Vygotsky, Kohlberg, Murray, Johnsons, Tjosvold</td>
<td>Skinner, Bandura, Homans, Thibaut &amp; Kelley, Mesch-Lew-Nevin</td>
</tr>
<tr>
<td>Assumptions</td>
<td>Co-operative efforts are based on motivation by interpersonal factors &amp; aspirations to achieve a significant goal. Focus on relational concepts.</td>
<td>Focus on what happens within a single person (e.g., disequilibrium, cognitive reorganization)</td>
<td>Co-operative efforts are powered by extrinsic motivation to achieve group rewards.</td>
</tr>
</tbody>
</table>

It is rare for an instructional procedure to be central to such a wide range of social science theories. *Co-operative learning* is a teaching learning technique in which small heterogeneous teams use a variety of learning activities to improve their understanding of a subject. Each member of a team is responsible not

*Figure 4* Elements of Co-operative learning
only for learning what is taught but also for helping teammates learn, thus creating an atmosphere of achievement. The elements of co-operative learning are presented in the figure 4. Co-operative learning has different ways of its processing in the classroom by its methods which differ in their group structure and function, but all of them focus on the same group processing for the achievement of a common goal enabling individual development also. The methods of co-operative learning are given in the table 2.

Table 2

*Methods of Co-operative learning*

<table>
<thead>
<tr>
<th>Researcher-Developer</th>
<th>Date</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Johnson &amp; Johnson</td>
<td>Mid 1960s</td>
<td>Learning Together &amp; Alone</td>
</tr>
<tr>
<td>Johnson &amp; Johnson</td>
<td>Mid 1970s</td>
<td>Constructive Controversy</td>
</tr>
<tr>
<td>Sharan &amp; Sharan</td>
<td>Mid 1970s</td>
<td>Group Investigation</td>
</tr>
<tr>
<td>Aronson &amp; Associates</td>
<td>Late 1970s</td>
<td>Jigsaw Procedure</td>
</tr>
<tr>
<td>Slavin &amp; Associates</td>
<td>Late 1970s</td>
<td>Student Teams Achievement Divisions (STAD)</td>
</tr>
<tr>
<td>Cohen</td>
<td>Early 1980s</td>
<td>Complex Instruction</td>
</tr>
<tr>
<td>Slavin &amp; Associates</td>
<td>Early 1980s</td>
<td>Team Accelerated Instruction (TAI)</td>
</tr>
<tr>
<td>Kagan</td>
<td>Mid 1980s</td>
<td>Co-operative Learning Structures</td>
</tr>
<tr>
<td>Stevens, Slavin et al</td>
<td>Late 1980s</td>
<td>Co-operative Integrated Reading &amp; Composition</td>
</tr>
</tbody>
</table>
Mohd Nasir Ismail, Nor Azilah Ngah & Irfan Naufal Umar (2003) of University Teknologi Mara Kelantan, Malaysia investigated the effects of mind mapping with co-operative learning (MMCL) and co-operative learning (CL) on: (a) programming performance; (b) problem solving skill; and (c) metacognitive knowledge among computer science students in Malaysia. The results showed that the students in mind mapping with co-operative learning and co-operative learning groups have significant positive overall effects in programming performance, problem solving skill, and metacognitive knowledge. This gives researcher a field of investigation to see how far Graphic Organizer with Co-operative learning proves to be the technique that can pave the way to higher order thinking skills and creativity which, ultimately scientifically as well as psychologically speaking, can lead to the gateway to the area broadest possible to erect and shape to the pedagogy for the goal or purpose aimed at.

1.1.0 Justification

If we critically evaluate the evolution of science in the schools in India, we see a clear trend of including more content, in the form of factual information in the syllabus. Laboratories have faced declination, and the demonstrations are now confined only to elite schools in the country. The factual information that forms the major portion the syllabi is generally not supported by activity, which can make it plausible or comprehensible. Students are left with no other option but to memorize the facts. The result of this comes out in the form of those students who find science difficult as well as boring. As a result, students don’t want to opt for science at the Class XI level (The Hindu). The education system today provides the food for the cramming process but nothing beyond that. The traditional system of teaching has many drawbacks like it is teacher centered making teacher the instructor, decision maker and master of the learning process, learning is in the four walls of classroom in a competitive environment and content is considered to be of utmost importance and is made to fill in the mind of the students. All these drawbacks can definitely be overcome by employing the graphic organizer with co-operative learning method of teaching which is child centered making him the decision maker and master of learning functioning with both sides of the brain. Teacher acts as a guide and learning goes beyond the classroom as the practical application of the learning in different situation is made possible by the construction of the various relationships among the parts and chunks of knowledge making it a whole process and concept permanent in the child’s memory.
Although the guiding ideas of science education reforms and the corresponding supporting teaching strategies have been, and are incorporated into teachers’ pre-service courses and in-service professional development programs, a substantial portion of these strategies are not implemented in the teachers’ classrooms (Barak & Dori, 2005; Windschitl, 2003). Indeed, the design and implementation of teaching strategies that enhance higher-order thinking and creativity among
students are not a simple endeavor; they challenge even the most expert teachers (Tobin, Kahle, & Fraser, 1990). There is, indeed, the need for changing the role of the school from an institution of knowledge generation and transmission to an institution, which can respond effectively to the skill requirements of the future world, i.e. making pupils communicate effectively in terms of culture, technology and language (Stromquist, 2002; Biswal, 2006) and there is need of such an instructional process which caters the development of higher order thinking skills and creativity in students. Graphic organizers with Co-operative Learning technique seem to be a ray of hope. To have a deep insight about this approach, the researcher has explored related literature and found some studies related with variables, which are as follows:

1.1.1 Researches related with Concept Mapping


![Figure 6 Researches of Concept Mapping with Different Variables](image)
Most of the researches are done on learning effectiveness and anxiety. Results obtained by the use of interviews, questionnaires, and student generated concept maps presented the fact that students enjoyed concept mapping for its organizational and relational properties but preferred sharing their concept maps and dialoguing with one another in a synchronous mode where immediate feedback and flow of thinking could be maintained when involved in constructing maps. Furthermore concept maps would be easy to implement as main vehicle for a knowledge repository. The results are not uniformly positive in all the researches as the research done by Sarah Blackwell and Kaye Pepper(2008) on preservice teachers revealed that no significant difference was found in the lesson plan quality of junior level preservice teachers using concept mapping and receiving traditional instruction and the lesson plan quality of junior level preservice teachers receiving only traditional instruction.

1.1.2 Researches related with Mind Mapping


![Figure 7: Researches of Mind Mapping with Different Variables](image-url)
The studies gave some interesting conclusions as; one of them demonstrates that medical students using mind maps can successfully retrieve information in the short term, and does not put them at a disadvantage compared to Standard Note Taking students and it was determined that there was a significant positive difference in students’ concept learning, overcoming misconceptions, academic achievement and attitudes towards science courses by taking notes through the mind-mapping method when compared to standard method. But not all the results are in favor of Mind Mapping as when it was compared with outlining, another technique of graphic organizers, the outlining group performed significantly better than the mind-mapping group.

1.1.3 Researches of Co-operative Learning with Mind/Concept Mapping (MMCL/CMCL)

The researches in the field of mind mapping with co-operative learning and concept mapping with co-operative learning as found by researcher are only three in number, two with Concept mapping by Chin-Yuan Lai, Cheng-Chih Wu, Hue-Ching Kao, and Sheng-Mei Chen (2008) showing enhanced interactions among students when proper class management and technology support were provided. Kamile et al concluded that co-operative and individual concept mapping conditions promoted the use of effective learning strategies more than traditional teaching. The only Study, as found by researcher, with Mind Mapping by Mohd Nasir Ismail, Nor Azilah Ngah, Irfan Naufal Umar suggest that mind mapping with co-operative learning method (MMCL) is preferred compared to Co-operative learning and Traditional methods in programming performance, problem solving skills, and metacognitive knowledge for students of all logical thinking levels.

Figure 8 Researches of Co-operative Learning with Mind/Concept Mapping
1.1.5 Researches related with Co-operative learning

Nayereh Baghcheghi, Hamid Reza Koohestani, Koresh Rezaei (2011), Andrew T. Lumpe, Jodi J. Haney, Charlene M. Czerniak (2010), Bobbette M. Morgan, Graciela P. Rosenberg (2008), Effandi Zakaria and Zanaton Iksan (2006) Nesrin ÖZSOY, Nazlı YILDIZ (2004), David W. Johnson, Roger T. Johnson, and Mary Beth Stanne (2000) Wallestad, Chizuko Konishi (2010), Lin L. L. (2010) McAlister Clare M (2009), Wang Tzu-Pu (2009), Brooks Aarti P. (2009) Liu Eric Zhi Feng et al (2009), Antil Laurence (2008) Ayhan Dikici, Yasemin Yavuzer (2006) left their footprints in the research field of Co-operative learning. The key findings indicates that Instructors can utilize unique instructional opportunities in order to maximize student learning and professional development, preparing them to cooperate and compete by structuring learning activities that requires cooperating in teams that compete against one another. It was found that Learning Together and many other techniques of co-operative learning method are more effective than traditional teaching methods. The multimedia instructional material for robotics education proved to be effective and achieved high student satisfaction. It was found that co-operative learning is an effective method for improving and increasing communication skills of nursing students especially in interactive skills and follow up the problems sub-scale, thereby it is recommended to increase nursing students' participation in arguments by applying active teaching methods. These researches are shown in figure 10.

![Figure 10](image.png)

*Figure 10* Researches of Co-operative Learning with Different Variables
The studies indicated that if teachers purposely and persistently practice higher order thinking strategies like, encouraging open-ended class discussions, and fostering inquiry-oriented experiments, there is a good chance for the development of creativity and higher order abilities. A contradiction in the findings shows that Students exposed to Creative Activities do not score higher than the students exposed to No Creative Activities in the test for higher order thinking skills group.

The researcher after an intense study did not find any research using Mind map and Concept map combined with co-operative learning used for the elevation of higher order thinking skills and creativity of secondary students. So the experimental nature of scientific enquiry combined with the present day need of education system motivated the researcher to work in this concerned field of investigation.

The thorough study of these researches gives the glimpses of the present situation of the variables in the field of investigation. None of the above research has the reference of using Graphic organizer with Cooperative learning to enhance higher order thinking skills of students. This gives the researcher an insight for the present endeavor. The mind mapping and concept mapping has been studied extensively but separately, neither with co-operative learning technique nor with higher order thinking skills, there is still a lot to be known in this field. So the present study is novel in every aspect. This kind of empirical didactic scientific research on concept mapping in combination with visualization in regular teaching settings for well-defined problem areas in the teaching methodology is part of a still largely unexplored research area (Francisco et al. 1998). After undergoing the process of reviewing the researches, following are the questions that arise:

1. What is the effect of the different Graphic Organizers on higher order thinking skills and creativity?
2. To what extent the mind mapping with co-operative learning and concept mapping with co-operative learning is applicable in teaching of science at secondary level?
3. Is there any difference in the development of higher order thinking skills by different types of graphic organizers?
4. Whether mind mapping with co-operative learning and concept mapping with co-operative learning is more efficient than traditional teaching technique when it comes to develop the higher order thinking skills and creativity of students?
To find out the answers of these questions, the researcher is moving forward in the concerned field of investigation.

1.2.0 Statement of the Problem

In the light of above justification, the research statement is:

Graphic Organizer with Co-operative learning: An efficient Tool to Strengthen Higher Order Thinking Skills and Creativity in Science

1.3.0 Operational Definitions of the term

1.3.1 Graphic Organizer

National Center on Accessing the General Curriculum at CAST (Center for Applied Special Technology) defines Graphic Organizer as “a visual and graphic display that depicts the relationships between facts, terms, and or ideas within a learning task.” Graphic organizers are also sometimes referred to as knowledge maps, concept maps, story maps, mind map, cognitive organizers, advance organizers, or concept diagrams.

Operational Definition

Graphic organizer, in the present study, is the term used for mind mapping and concept mapping techniques of graphical and pictorial representation of knowledge.

1.3.2 Mind Map

![Mind Map of the Concept of Mind Map](image-url)
Mind Mapping is a popular technique invented and copyrighted by Tony Buzan from the United Kingdom in 1995. He describes mind maps as, “a visual-spatial map consisting of a central word or concept, around which you draw the five to ten main ideas that relate to that word or concept. You then take each of those words and again draw the five to ten main ideas and/or supporting details that relate to each of those words” (Buzan, 1995).

**Operational Definition**

Mind Mapping is the technique of pictorial representation of knowledge having the main topic in centre and the concepts related are then arranged and connected in radial fashion using colours pictures and shapes suitable to the context from abstract to concrete. The information is structured exactly in the manner as the brain functions, radial rather than linear manner.

### 1.3.3 Concept Map

Concept maps are two dimensional graphic displays that make use of labeled nodes to represent concepts, and lines or arcs to represent relationships between pairs of concepts (Ferry et al 1997).
Operational Definition

A concept map is a diagram of nodes, each containing concept labels, which are linked together with directional lines, also labeled. The concept nodes are arranged in hierarchical levels that move from general to specific concepts, from abstract to concrete and from concepts to their types etc.

1.3.4 Co-operative Learning

Dictionary of Education defines co-operative learning as changes in behavior resulting wholly or in parts from shared experience of two or more persons.

Co-operative learning is the instructional use of small groups so that students work together to maximize their own and each other’s learning. Each student can then achieve his or her learning goal if and only if the other group members achieve theirs.

Continuity of group interaction is one of features of co-operative learning. Members have regular group meeting to deal with the assignment and, in turn, a social network develops (Johnson, 1992). It has been argued that co-operative learning experiences are crucial to preventing and alleviating many of the social problems related to children, adolescents, and young adults.

1.3.5 Higher Order thinking skills

Several authors have offered their descriptions of higher order thinking skill in various ways. (Lawrenz, 1990; Callison, 2002; Presseisen as cited by Hernandez, 1991; Zoller, 1993; Zoller,
Lubezky, Nakhleh, Tessier, & Dori, 1995). Bloom’s taxonomy is most widely used and Anderson and Krathwohl (2001) revised this taxonomy. The present research will consider the top four cognitive processes as higher order thinking skills.

**Operational Definition**

According to Bloom, the development of intellectual skills is movement through a series of levels, from the simplest to the most complex. Learning often progresses upward through the levels. The following are the four levels of Bloom’s Taxonomy for the cognitive domain constituting higher order thinking skills:

<table>
<thead>
<tr>
<th>Knowledge Acquisition</th>
<th>Remembering</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Understanding</td>
</tr>
<tr>
<td>Knowledge Deepening</td>
<td>Applying</td>
</tr>
<tr>
<td></td>
<td>Analysing</td>
</tr>
<tr>
<td>Knowledge Creation</td>
<td>Evaluating</td>
</tr>
<tr>
<td></td>
<td>Synthesizing</td>
</tr>
<tr>
<td></td>
<td>Lower Order Thinking Skills</td>
</tr>
<tr>
<td></td>
<td>Higher Order Thinking Skills</td>
</tr>
</tbody>
</table>

*Figure 14 Higher Order Thinking Skills Defined Operationally*

The skills of application, analysis, evaluation and creating knowledge combined to form Higher Order Thinking Skills indirectly they also contain procedural knowledge, creativity, insight, intelligence, problem solving and critical thinking.

**1.3.6 Scientific Creativity**

Moravcsik (1981:222) defined the scientific creativity by saying, “it can explain itself in comprehending the new ideas and concepts added to scientific knowledge, in formulating new theories in science, finding new experiments presenting the natural laws, in recognizing new regulatory properties of scientific research and the scientific group, in giving the scientific activity plans and projects originality, and many other areas”.
Operational Definition

Scientific Creativity is the ability to synthesize knowledge based on the analysis and application of the knowledge and information present in our surrounding environment applying flexibility, fluency and originality.

1.4.0 Objectives of the study

The objectives of the study are given as:

1. To analyze the content of class XI science (Chemistry & Biology) text book with reference to graphic organizer with co-operative learning technique.
2. To develop instructional material for applying graphic organizer with co-operative learning approach in the classroom.
3. To implement the developed instructional material in the class.
4. To study the effect of mind mapping with co-operative learning technique on higher order thinking skills and creativity of students.
5. To study the effect of concept mapping with co-operative learning technique on higher order thinking skills and creativity of students.
6. To study the effect of graphic organizer with co-operative learning technique on the higher order thinking skills and creativity of students.
7. To study the effect of co-operative learning technique on higher order thinking skills and creativity of students.
8. To compare the effect of different treatments on higher order thinking skills and creativity.

1.5.0 Hypotheses of the study

To achieve the above objectives, the following hypotheses will be tested:

$H_{01}$ There will be positive effect of mind mapping with co-operative learning technique on the higher order thinking skills and creativity of the students.

$H_{02}$ There will be positive effect of the concept mapping with co-operative learning technique on the higher order thinking skills and creativity of the students.
$H_{03}$ There will be positive effect of the graphic organizers with co-operative learning technique on the higher order thinking skills and creativity of the students.

$H_{04}$ There will be positive effect co-operative learning technique on the higher order thinking skills and creativity of the students.

$H_{05}$ There will be difference in the effect of different treatments on the higher order thinking skills and creativity of the students.

### 1.6.0 Delimitations of the study

Due to limited time and resources, the study will be limited to:

1. Senior Secondary schools of Agra City having Science Stream.
2. Schools of U.P. Board of Agra City.
3. Class XI Science Subject.
4. 150 Students of Class XI

### 1.7.0 Methodology of the study

#### 1.7.1 Variables of the Study

The *Independent Variables* of the study are:

1. Mind Mapping
2. Concept Mapping
3. Co-operative Learning Technique

The *Dependent Variables* are:

1. Higher Order Thinking Skills of Secondary Students
2. Creativity of Students

The *Extraneous Variables* will be controlled by identification of effective variables and using effective strategy of controlling as:

1. Subject Relevant Variables: This includes age, grade, anxiety and motivation. They can be controlled by random sample selection.
2. Environmental Variables: The classroom climate, noise, light and condition of school act as the environmental variables which will be controlled by providing similar conditions.

3. Sequence Relevant Variables: Practice, fatigue and cooperation are included which will be controlled by the researcher.

1.7.2 Method

The method of this study is Development cum Quasi Experimental, used to develop instructional material based on graphic organizer with co-operative learning technique and to know their effects on the Higher Order Thinking Skills and creativity of students.

1.7.3 Research Design

The design of the experiment will be Randomized Pre Test Post Test Multi Group Design which will consist of four experimental groups and one control group giving different treatments to the experimental groups as shown in the table 3. The design will consist of four phases:

Phase 1: Planning Phase

The methods based on which the instructional material will be constructed will be studied thoroughly in this phase understanding the underlying concepts and the different ways of constructing mind maps and concept maps. The content analysis of the Chemistry and Biology Text book will be done keeping in mind the graphic organizers.

Phase 2: Development Phase

The content analysis of the Science text book will be done keeping in mind the different graphic organizers, based on which the instructional material will be constructed in accordance with the mind mapping with co-operative learning & concept mapping with co-operative learning technique.

Phase 3: Execution Phase

The implementation of the constructed material will be done in this phase. The intervention period will be of 40 days and four experimental groups will be given treatments as: Group 1 will be taught by Concept Mapping with Co-operative learning, Group 2 by Mind Mapping with Co-operative learning, Group 3 by Graphic Organizer with Co-operative learning and Group 4 by Co-operative learning only.
Phase 4: Testing of Hypotheses

The effect of graphic organizer with co-operative learning technique on the higher order skills of students & creativity will be seen by testing the hypotheses and the comparison of the effect of the teaching methods used will also be done.

Table 3

The Randomized Pretest Posttest Multi Group Design of the Study

<table>
<thead>
<tr>
<th></th>
<th>Experimental Groups</th>
<th>Controlled Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 N- 30</td>
<td>2 N- 30</td>
</tr>
<tr>
<td>Pre-Test</td>
<td>Test of Higher Mental Ability in Science</td>
<td>Self Constructed Tool for Scientific Creativity</td>
</tr>
<tr>
<td>Treatment (40 Days)</td>
<td>CMCL</td>
<td>MMCL</td>
</tr>
<tr>
<td>Post-Test</td>
<td>Test of Higher Mental Ability in Science</td>
<td>Self Constructed Tool for Scientific Creativity</td>
</tr>
</tbody>
</table>

1.7.4 Sample

The sample for the experimental study will consist of about 150 students studying in class XI, of a UP Board school having Science at Intermediate level in Agra.

Figure 15 Sample of the Study
1.7.5 Tools and techniques

To measure the Higher Order Thinking Skills and creativity of Students, following tools will be used:

1. Test of Higher Mental Ability in Science (THMAS) by Dr. D.N. Sansanwal & Dr.(Mrs.) Anuradha Joshi, 1989
   It is based on Bloom’s cognitive domains and assesses four levels-application, analysis, synthesis and evaluation.
2. Self Constructed tool for the measurement of Scientific Creativity of Students

1.7.6 Statistical design

The following Statistical measures will be used in the present study:

1. Descriptive Statistics: Mean, Median, Standard Deviation & Graphical Representation
2. Inferential Statistics: t Test to compare the groups.

1.7.7 Structural design of the Study

The structural design of the Study is given in figure 16.

![Structural Design of the Study](image)

*Figure 16 Structural Design of the Study*
1.8.0 Significance of the study

Generally it is observed that students do not understand the sense rooted in most of the terms in science, i.e. they lack the capacity to grasp knowledge learned in one setting and apply it appropriately to a different setting. It has been found study after study that, by and large, even the best students in the best schools have difficulty in doing that. The reason for students’ poor performance is simple. The traditional approach to teaching reduces education to a transfer of information. Education is so much more than just information transfer, especially in science. New information needs to be added to preexisting knowledge in the student’s mind. Students need to develop models to see how science works. Instead, students are relying on rote memorization. The present study has multifold significance in the same line of improvement in the field of learning. The instructional material to be developed would be very useful for students as they will get an idea of the actual meaning of science and scientific processes, their relationship with each other and how everything is related making a whole. Students further get advantage of development of their higher order thinking skills which is very crucially needed in the present era as it is very much neglected in the present education system.

The study will prove to be a milestone in shifting the focus of teachers from the rote learning to the development of higher thinking skills. This will lead them to the actual meaning of learning and will provide the technique which can be successfully used for catering such learning. Actually, the design and implementation of teaching strategies that promise to strengthen higher-order thinking among students are not a simple endeavor; they challenge even the most expert teachers (Tobin, Kahle, & Fraser, 1990). The research will provide them with hands on material to develop such environment in class that is conducive to the development of higher order thinking skills.

The present research is an effort in the direction of transformation of schools from teaching basic skills towards schools for thought to enhance students’ skills. The youth of the day are the voting public of tomorrow, the consumers, and the workforce in the near future, they must have the abilities to critically analyze the situation and develop their own hypothesis of things which is possible if their thinking skills are developed, which is the main motto of the researcher.

The parents will also be benefitted by this endeavor as they will get to know which type of skills their offspring actually need and after having the knowledge of the failure of their children in many
walks of life they would be on the plus side knowing the method to improve the higher order thinking skills and creativity of their wards in a very economic way.

The school administration & curriculum developers will get to know the place of such methods of teaching in the development of the students and they will be likely to place some of these strategies in the curriculum for the development of skills of students.

Thus the study venture undertaken by the researcher is expected to prove its significance as well as relevance to the needs arising in the 21\textsuperscript{st} century to make the students much better, more efficient and more wisdomful in the sphere of science.
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