Effectiveness of an Instruction Based on SOLO Taxonomy, Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on Certain Learning Outcomes of Secondary School Students

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Thesis

Submitted for the degree of

DOCTOR OF PHILOSOPHY IN EDUCATION

DEPARTMENT OF EDUCATION
UNIVERSITY OF CALICUT

2018

DECLARATION

I, Revati N**.,** do hereby declare that this thesis, entitled **"EFFECTIVENESS OF AN INSTRUCTION BASED ON SOLO TAXONOMY, BLOOM'S TAXONOMY AND MC CORMACK AND YAGER'S TAXONOMY ON CERTAIN LEARNING OUTCOMES OF SECONDARY SCHOOL STUDENTS"** has not been submitted by me for the award of any Degree, Diploma, Title or Recognition before.

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Certificate

This is to certify that the thesis entitled **"EFFECTIVENESS OF AN INSTRUCTION BASED ON SOLO TAXONOMY, BLOOM'S TAXONOMY AND Mc CORMACK AND YAGER'S TAXONOMY ON CERTAIN LEARNING OUTCOMES OF SECONDARY SCHOOL STUDENTS"** is an authentic record of research work carried out by **Smt. Revati N.,** for the Degree of Doctor of Philosophy in Education of the University of Calicut, under my supervision and guidance and that no part thereof has been presented before for any other Degree, Diploma of Associateship in any other University.

The thesis is revised as per modifications and recommendations reported by the adjudicators and resubmitted. Soft copy attached is the same as that of the resubmitted revised copy.

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Certificate

I, Dr. K. P. Meera, do hereby certify that this dissertation entitled **“EFFECTIVENESS OF AN INSTRUCTION BASED ON SOLO TAXONOMY, BLOOM’S TAXONOMY AND Mc CORMACK AND YAGER’S TAXONOMY ON CERTAIN LEARNING OUTCOMES OF SECONDARY SCHOOL STUDENTS”** is a record of bonafide study and research carried out by **Mrs. Revati N.** under my supervision and guidance.

Calicut University **Dr. K. P. Meera**

Date (Supervising Teacher)

ACKNOWLEDGEMENT

The investigator expresses her sincere gratitude to God Almighty for all the blessing showered on her throughout this endeavour

The investigator considers it a blessing and good fortune of enjoying the scholarly guidance of her supervising teacher Dr.K. P. Meera, Professor and Former Head, Department of Education, University of Calicut, for her motherly approach, valuable guidance and constant encouragement throughout the study. The investigator expresses her deep sense of gratitude and indebtedness to the great teacher.

The investigator is deeply obliged to Dr. P. K. Aruna, Head, Department of Education, University of Calicut, for providing all the necessary facilities to conduct the study.

The investigator extends her profound gratitude to Dr.V. Sumangala, Professor and Former Head, Department of Education, University of Calicut, for providing her expertise advice and profound knowledge in research methodology to carry out the study.

The investigator extends her sincere thanks to all the faculties of the Department of Education, University of Calicut, Dr. Naseema, Dr. Abdul Gafoor, Dr. P. Usha, Dr. Vasumati, Dr. Baiju Nath, Dr. Hameed and Dr. Bindu C. M. for their suggestions and encouragement in the submission of the study.

The investigator expresses her sincere gratitude to Dr. K. S. Girija, Principal, and all her colleagues of NSS Training College, Changanacherry and NSS Training College, Ottapalam, for their constant support and concern throughout the study.

The investigator extends her profound gratitude to Dr. N. Gopinathan Nair, Retd. Professor & Head, Dept. of Malayalam, Calicut University, Dr. K. Karunakaran, Former Director, Dept. of Lifelong Learning and Extension, Calicut University, Dr. G. Saratchandra Raju, Director, MET Educational Institutions, Nagarcoil, Dr. V. T. Mathew, Former Principal, St. Joseph's Training College Mannanam, Prof. Somanathan Nair, Former Principal, M.

G. College, Thiruvananthapuram, for their help and encouragement for the accomplishment of the study.

The investigator is highly thankful to Mr. Suchithran , Assistant Professor, St. John's College of Teacher Education, for his brotherly guidance, valuable advice and constant inspiration throughout the period of study.

The investigator extends her gratitude for the timely help and support provided by all the office staff, the Librarian of the Dept. of Education and Librarian of the Central Library, University of Calicut for providing all necessary facilities and encouragement to accomplish the work.

The investigator thanks the Principals, teachers and students of the selected schools for their whole hearted co operation at the stage of data collection.

In this context the investigator would like to acknowledge the role of her family members, especially the sweet memories of her beloved parents, Dr. V. C. Narayana Das and Ammukutty Amma, the real motivation and moral strength throughout her life and studies. The morale and values of her parents were the guidelines for her achievement.

The support, encouragement, and patience of her husband Mr. Anil Kumar were invaluable during the preparation of this thesis. The investigator is especially thankful to her daughter Navaneetha and son Narayan for their patience and constant support during the accomplishment of this task. She is also greatly indebted to her in-laws, Prabhakaran Nair and Radha P. Nair and her brother Girish Kumar for their valuable help and affectionate concern throughout this study.

The investigator thanks all those, who have been of great help from behind the scenes, during various stages of the research, especially whose contribution may appear insignificant, but without their timely help, the study would not have been completed successfully.

Revati N.

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Introduction

While delivering a convocation address at Allahabad University in 1947, Nehru said, “It is science alone that can solve the problems of hunger and poverty, of insanitation and malnutrition, of illiteracy and obscurantism, of superstition and deadening customs, of rigid traditions and blind beliefs of vast resources going to waste of a rich country inhabited by starving millions”. Science is of great importance for people and society that people live in an “age of science”. We are living in a world of scientific discoveries. There is application and influence of science in every field. Understanding the concepts and theories of science is a growing necessity. Science as a field of knowledge influenced our existence, culture and civilization. It is the building block for personal and social development and its products advances human society and offer prosperity (Cobern, 1998). Because of the utility and significance of science, importance of science education has tremendously increased.

The discoveries have added to the prosperity of human race with vast increase of knowledge. Herbert Spencer in his, "What Knowledge is of Most Worth" gives information which study of Science furnishes. According to him, Science learning is incomparably more useful for our guidance in life. Other chief subjects too provide an intellectual training not inferior to that of Science. Practically, we live in a world of scientific discoveries. So science education cannot be neglected. Science education develops certain abilities, which every student requires like, reasoning, curiosity, creativity, scientific attitude, problem-solving approach etc. Science and technology education is the backbone of countries’ economic stability and growth (Kalra, 1995). Scientifically literate peoples all over the world are known to be more reliable in decision-making areas like agriculture production, nutrition and health, land and resource management, population control and industrial growth.

For the achievement of broad aims of education, objectives are set which are specific and realizable portions of aims. By framing objectives, a teacher gets description of abilities and values, which should be inculcated, in students. It acts as a frame of reference in making decisions regarding content, method of teaching, learning experiences and evaluation. Classification of learning objectives in an ordered system is called Taxonomy of Educational Objectives. SOLO taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy are three different taxonomies of learning objectives.

Aims of Science Education

To quote Albert Einstein, the goal of education is "to produce independently thinking and acting individuals". The basic goal of science education is to produce individuals capable of understanding and evaluating information and producing sufficient number of skilled and motivated scientists, engineers and other science based professionals. It is often said that children are natural scientists. Therefore, a teacher should evaluate each child's knowledge, creativity, scientific attitude and level of metacognition. There comes the need of an instruction to adapt the instructional goals and skills of the learner.

For an effective science teaching, its aims should be in consonance with the general aims of education (Dushi, 2006). General aims of science education are development of knowledge (fundamental principles and concepts useful in daily life, scientific facts, interdependence between different branches of science, nature etc.), skills (doing experiments, construction, observation and drawing etc.), abilities (sensing a problem, analysis, generalisation, interpretation, prediction etc.), scientific attitude (critical thinking, open mindedness, respect for others opinions, aversion towards superstitions, intellectual honesty, rationality etc.), reflective thinking (solving a problem, sensing a problem, defining it, collecting evidence, organisation and interpretation of data, formulation of hypothesis, drawing conclusions etc.), habits (honesty, truth, tolerance ,self confidence self reliance etc),interests(reading scientific literature, doing scientific hobbies, conducting science club activities etc), appreciation (natural beauty, scientific inventions, work of scientists etc), providing work for leisure (making inks, soaps, boot polishes, etc. collection and preservation of animals and plant parts, photography, gardening, etc.), training for better living (basic ideas of health and hygiene and adjusting with the economic and cultural conditions of the society) and choosing a career.

Objectives of Science Education

Although aims give direction to educational system, and bring all round development of students, all these aims cannot be attained by a teacher. To make a teacher's task easy, aims are narrowed down to objectives which are specific and realisable portions of aims. Thus objectives are a set of achievable ends which are acquired in pursuit of overall aims (Ball & Washburn, 2001). By framing objectives or outcomes of learning, a teacher gets description of abilities and values which he or she intends to instil among the students. It acts as a frame of reference to take various decisions regarding content, method of teaching, learning experiences and evaluation (Krathwohl,2002). In a teaching learning process, teacher first sets certain objectives according to the nature of content and ability of the learner; then selects, kind of learning experiences for the attainment of the objective; after that, appropriate evaluation techniques are adopted to check the attainment of the objectives set earlier. Objectives vary with aims of education, nature of the society, culture, nature of the discipline, age and ability of the learner, nature of the content, availability of the resources, quality of the teaching, teaching methods etc. So it becomes a necessity to organize objectives of education in a better way that teachers can get guidance in choosing an objective. Classification of learning objectives in an ordered system is called Taxonomy of Educational Objectives. There are various taxonomies put forwarded by many experts in education, according to their ideals. Some of the important taxonomies in science education are as follows,

Blooms Taxonomy

Bloom's taxonomy is a classification of learning objectives in education developed by a committee of educators chaired by Benjamin. S. Bloom in 1956. It is a set of three models used to classify learning objectives on the basis of level of complexity and specificity (Bloom, 1956). These objectives or behavioural outcomes of individuals resulting from instruction are classified into three domains.

1. Cognitive domain: Includes those objectives, which deal with recall and recognition of knowledge and development of intellectual abilities. The objectives coming under this domain are knowledge, comprehension, application, analysis, synthesis and evaluation.
2. Affective domain: This domain deals with interests, attitudes, opinions, appreciations, values and emotional sets. Objectives coming under this category are, perception, set, guided response, mechanism, complex overt response, adaptation and organisation.
3. Psychomotor domain: Includes physical and motor skills. Objectives of this domain are receiving, responding, valuing, organisation and characterisation.

Goal of Blooms Taxonomy is to motivate educators to focus on all the three domains creating a more holistic form of education. The cognitive domain objectives are the primary focus of all traditional education and it is commonly used to structure curriculum, learning objectives, learning experiences and assessment.

Bloom's Revised Taxonomy

In 1990's, Lorin Anderson, a former student of Benjamin.S. Bloom revised the original Bloom's Taxonomy and named it Revised Bloom's Taxonomy. In the new version of Bloom's Taxonomy, the names of the six categories were changed from noun to verb forms, because thinking is an active process (Anderson & Krathwohl 2001). There was a change in terminology also ie, knowledge changed into remembering, comprehension became understanding and synthesis into creating. Anderson rearranged the six categories with higher objective as creating. The knowledge level of the original taxonomy is divided into four levels; factual, conceptual, procedural, and metacognitive. Objectives of Revised Bloom's taxonomy are remembering, understanding, applying, analysing, evaluating and creating.

Mc Cormack and Yager's Taxonomy

Mc Cormack and Yager in 1989 developed a new "Taxonomy for Science Education" that broadens the view of science education beyond the two domains of content and processes. The basic aim behind the designing of taxonomy was to make the students scientifically and technologically literate. They incorporated five categories or domains of science education. The domains coming under Mc Cormack and Yager's taxonomy are,

1. Knowing and understanding (Knowledge Domain) : Facts, laws, principles, theories and the internalised knowledge held by the students fall under knowledge domain.
2. Exploring and discovering (Process Domain): This domain includes 13 process skills identified by the American Association

for Advancement in Science in 1968. These processes are coming under knowing, doing and thinking in science.

3. Imaging and Creating (Creativity Domain): Creativity domain consists of experiences that promote divergent thinking, imagination, novelty, problem solving etc.
4. Using and Applying (Application Domain): This domain includes the extent to which students can transfer the learned knowledge and its effective use in their own daily life.
5. Feeling and valuing (Attitude domain): This domain consists of human feelings, values, and decision-making skills.

SOLO Taxonomy

This taxonomy was developed by John Biggs and Kevin Collis in 1982. SOLO helps the learner to have total control over their learning; and to decide what steps have to be taken while learning. Structure of Observed Learning Outcomes or SOLO Taxonomy gives a simple, reliable and strong model for three levels of understanding; surface, deep and conceptual (Biggs & Collis 1982). SOLO provides structured framework and direction to progress their thinking and learning. This taxonomy explains the growing complexity of a learner's activity.

SOLO taxonomy has five main stages

1. Pre-structural: In this level, student understands, or existing knowledge is limited or nonexistent or the task is approached from a different angle.
2. Uni-structural: Students might know one key piece of knowledge but they are unable to connect it to anything else in this level.
3. Multi-Structural: At this level, students can show an understanding of several piece of knowledge but they do not know how to connect them together.

4. Relational: At this level, student's understanding of the several elements is strong and they can make connections between them.
5. Extended Abstract: Now students can apply their learning in new contexts and can visualise it, as part of a greater whole.

Need and Significance of the Study

Science is of great importance to 21st century secondary school students, because in an education system it is a gateway of opportunities, which leads to economic and social development (Handelsman, 2004). Science along with its educational purposes develops reasoning, curiosity, creativity, positive attitude and problem solving attitude which are essential for every citizen. Science is needed for the betterment and development of every country. We interact daily with scientific machineries which makes our life easier and safe. Today India is one among those prestigious countries which are famous for its scientific outputs and effective performance in the IT field.

Our country is facing many challenges in science education like overcrowded class size, lack of fund and student interest etc. A huge amount of economy is spent for the development of science education; unfortunately the quality of science education and research is going down at an alarming rate. Science education of our country at primary and secondary stages is inadequate compared to the velocity of discoveries around the globe. Present curriculum and methods do not convey the fascination of scientific research and do not transmit the values and approaches that make science relevant to everyday life, which leads to responsible citizenship (Alves, 2007). Alignment of course activities and testing strategies with learning outcomes is critical for effective course designing.

Among people, an education system should create skills and competence in diverse fields and thereby improve the overall preparedness of the country in the long run. Indian education system is at the cross roads trying to find a way to enhance the number and quality of future researchers of the country, along with educating large masses of relatively unprivileged people. By developing innovative approach of teaching science, like learning by doing, learning by inquiry method, and discovery method promotes understanding of science as a process and an inquiry system that help learners to deal with the significant problems of their life. According to NCERT, science textbooks are overloaded with scientific facts, it is lagging behind in achieving enshrined values like humanism, scientific temper and social justice in our constitution, does not encourage inventiveness, scientific attitude and creativity, overpowering examination system, school science is full of content which is socially sterile, intellectually boring, and dismissive of student's life; students don't able to correlate with what is being taught in the classroom with their personal life, and popularity of science as a brainy and difficult subject. Even though our present education system follows a taxonomy which encourages process aspect of science, the expected outcomes are not achieved due to lack of awareness among teachers about the proper methodology, lack of facilities and funds, inappropriate assessment practices, gap between policy makers and teachers etc.

Although aims give direction to educational system, and bring all round development of students, aims are narrowed down to objectives, which are specific and realisable portions of aims. Objectives vary with aims of education, nature of the society, culture, nature of the discipline, age and ability of the learner, nature of the content, availability of the resources, quality of the teaching, teaching methods etc. Aim of science education is not just to make learners aware of the scientific facts and concepts but to develop, curiosity, independent thinking, creativity, rationality, critical thinking scientific attitude and scientific world views which are essential for the growth of an individual as well as society as a whole. Science education is witnessing lack of interest in innovations and deficiency in creativity. Children lose childhood curiosity in natural phenomena due to schooling they receive. Teachers discourage questioning of accepted laws. Existing education structure has not been able to imbibe a proper scientific culture than narrowing down to the field of examinations, marks and degrees. Science education must make scientists who work and unlock the laws of nature with their own efforts.

Educational objectives give direction to education process. These are some standards set for an effective teaching learning process (Mc Cormack and Yager, 1989). Taxonomy helps in the development and organisation of educational objectives in a hierarchical order. Taxonomies of education define goals, standards of curriculum and learning objectives. It facilitates the exploration of curriculum from four areas, learning content, method of teaching, evaluation process and effectiveness of education. Bloom has stated that, “the major purpose in constructing a taxonomy of educational objectives is to facilitate communication”. Through the systematic use of taxonomies an educator can develop certain specific languages which acts as a vehicle for communication of curriculum design, sequencing, integration of experiences etc. (Bloom,1956). A taxonomical scheme classifies all the educational objectives stated in terms of student behaviours. They are useful tools for assessing and analysing curriculum objectives. All levels of planning in teaching and assessment are based on educational objectives and educational taxonomies provide a reference for selection of objectives. Taxonomies of learning objectives define goals of training because, after training session, students acquire new skills, knowledge and attitudes. It acts as a quick and easy checklist to plan learner outcome, to analyse all the possibilities of content and to suggest variety of teaching methods. It also helps the teacher to concentrate upon certain higher order abilities of the learner. There is much taxonomy based on different perspectives. The investigator took three different taxonomies, Revised Bloom’s taxonomy, Mc Cormack and Yager’s taxonomy and SOLO Taxonomy for comparing their effectiveness on certain learning outcomes of students at secondary level.

Scientific attitude is the desire to know and understand, questioning to all statements, search for data and their meaning, search for verification, and consideration of consequences (Gardner, 1975; Osborne, Simson & Collins, 2003). Attributes of scientific attitudes are, rationality, curiosity, open mindedness, aversion to superstition, objectivity, intellectual honesty and suspended judgement. These attributes are important in everyone’s life. According to Lawson (1982), scientific attitude is necessary to dispel ignorance and backwardness; it will bring a balanced perspective to bear on social evils and conflicts and could lead to a better world. If we act favourably or unfavourably towards some external class of stimuli, according to the ethics of science it is called scientific attitude (Munby,1983). An individual with scientific attitude consciously or unconsciously thinks and displays traits, which are common to scientists. It is the ability to do things based on proven principles. A student having scientific attitude is always free from superstitions, unverified assumptions and popular opinions that has no empirical basis. Every science teacher should undertake the responsibility to develop scientific attitude in their children through planned activities and teaching strategies.

To develop fundamental understanding about science, children need to think and act creatively. Scientists utilise their creativity in every stage of their work (Lederman,2000). That is why science is said to be a process containing creativity components in its each step (Saxena,1994).Only a creative scientist can find useful solutions to problems in daily life. Children who practiced creativity in science classes usually apply it in other areas also (Meador, 2003). Creativity can be defined as finding gaps in the problem or information, creating hypotheses and transmitting the data (Torrence, 1995, Dass 2004). While examining this definition it becomes clear that creativity and scientific method are having similar step. So it can be concluded that science and creativity are two sides of a coin. Scientific creativity helps an individual in many areas like, comprehending new ideas and concepts of scientific knowledge, formulation of new theories in science, doing new experiments to prove natural laws, giving originality to scientific plans and projects etc. The individuals who use creativity can make their science education functional, and therefore the scientific information can be the basis for producing a valuable product instead of just giving amazing information (Aktamis & Ergin, 2008).Therefore one of the important aims of science education must be to inculcate creative thinking skills in children from elementary school onwards.

A metacognitive approach to instruction can help students, learn how to take control of their own learning by defining learning goals and monitoring their progress in achieving them (Bransford et al., 2000).Children needs both cognitive and metacognitive strategies for learning. Learners construct knowledge using their cognition but they guide, regulate and evaluate their learning through metacognition. Metacognition refers to one’s knowledge concerning one’s own learning process or anything related to that (Flavell, 1976). As a learner acquires skill in metacognition, they gain confidence in their learning and this motivates independent learning and acquires permanent knowledge and higher achievement (Koutselini, 1995). Students think about their own thinking strategies and start learning from mistakes and inaccuracies. Through the metacognitive process, children go beyond the classroom teaching and apply their learning in life situations. Systematic planning, effective management of time and resources, monitoring of progress etc. are characteristics of metacognitive learning. All these are essential features of science learning also. The task of the educator is to acknowledge, cultivate, exploit and enhance the metacognitive abilities of the learner.

Kerala state has been going through a series of educational reforms over the last decade to make the school education more effective. This includes constructivist paradigm along with continuous and comprehensive system of evaluation. But its over emphasis on activity oriented pedagogy resulted in degradation of content knowledge. Scientists and science educators believe in approaches and attitudes, which are parallel with the procedures and attitudes of scientists. With the help of Taxonomy of Educational Objectives, a teacher can define and translate the objectives accordingly. This improves the quality of educational outcomes, curriculum, and transaction and evaluation procedures. In the present scenario, the society is facing many social, political and environmental issues; it is science alone, which can make a difference (Bhattacharyaya et al. 2013). So it is the duty of the teacher to inculcate certain abilities for knowing and doing of science by which they can solve the above-mentioned issues to make earth a better planet to live. An educational Taxonomy is an aid to teacher in selection of better objectives for learning. But there exist lot of confusions regarding the selection of a suitable taxonomy for science education in Kerala. Some taxonomy gives importance to product aspect of science while some gives importance to process aspect.

The investigator reviewed a number of studies based on educational taxonomies conducted in India and could find that not much has been done in the field of comparison of taxonomies. Since educational taxonomies and objectives are the backbone of every educational system, a science teacher should possess a deeper knowledge of the learning outcomes related to the subject. Nowadays students are far away from the deeper level understanding of both process and products of science. Therefore, the investigator felt the need to analyse different taxonomies thoroughly and measure and compare its effectiveness in developing Scientific Attitude, Scientific Creativity and Metacognitive Awareness. Thus, the study is envisaged for understanding the effectiveness of an instruction based on SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on certain learning outcomes of secondary school students.

Statement of the Problem

The study was undertaken with the aim of finding out the effectiveness of instructions based on SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on secondary school student's metacognitive awareness, scientific attitude and scientific creativity. Hence, the study is entitled as "EFFECTIVENESS OF AN INSTRUCTION BASED ON SOLO TAXONOMY, BLOOM'S TAXONOMY AND Mc CORMACK AND YAGER'S TAXONOMY ON CERTAIN LEARNING OUTCOMES OF SECONDARY SCHOOL STUDENTS".

Definition of Key Terms

The key terms that need clarification are defined below:

Effectiveness

Effectiveness is the ability to achieve desired results with economy of time and effort in relation to the amount of works accomplished (Good, 1959).

Operational definition

In this study, effectiveness implies significant difference in the mean scores of metacognitive awareness, scientific attitude, and scientific creativity of students who were taught by SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy.

Instruction

Instruction is a statement or explanation of something that must be done often given by someone in authority.

Operational definition

Teaching based on SOLO taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy.

SOLO Taxonomy

The structure of observed learning outcomes (SOLO), is a cognitive processing taxonomy, developed in 1982 by two Australian academics, John Biggs and Kevin Collis, which categorises mental activity by quantity and quality attributes of activities required by students or by the observable products of student works. This taxonomy consists of 5 levels of understanding, pre structural, uni structural, multi structural, relational and extended abstract.

Operational definition

Teaching based on SOLO Taxonomy for the five levels; pre structural, uni structural, multi structural, relational, extended abstract to give a deeper understanding of science.

Bloom's Taxonomy

Bloom's taxonomy is a classification of learning objectives within education proposed in 1956 by a committee of educators chaired by Benjamin. S. Bloom .The behavioural changes of individuals resulting from instruction can be classified into three domains, cognitive domain ,affective domain and psychomotor domain.

Revised Bloom's Taxonomy

In 1990's, Lorin Anderson, a former student of Benjamin. S. Bloom revised the original Bloom's Taxonomy and named it Revised Bloom's Taxonomy. Objectives of Revised Bloom's Taxonomy are remembering, understanding, applying, analysing, evaluating and creating.

Operational definition

Instruction based on Revised Bloom's Taxonomy for the five levels of objectives; remembering, understanding, applying, analysing, evaluating and creating.

Mc Cormack and Yager's Taxonomy

Mc Cormack and Yager in 1989 developed a new "Taxonomy for Science Education". They incorporated five categories or domains of science education. The domains coming under Mc Cormack and Yager's taxonomy are, knowing and understanding (knowledge domain) exploring and discovering (process domain), imaging and creating (creativity domain), using and applying (application domain), feeling and valuing (attitude domain): this domain consists of human feelings, values, and decision making skills.

Operational definition

Instruction based on five domains of Yager's taxonomy; knowledge domain, process domain, application domain, attitude domain and creativity domain.

Learning outcomes

Learning outcomes are statements of what a learner is expected to know, understand or be able to demonstrate after the completion of learning process.

Operational definition

In this study learning outcomes are expressions of metacognitive awareness, scientific attitude and scientific creativity which students will acquire after the successful completion of process of learning and is obtained by standardised test of metacognitive awareness, scientific creativity and scientific attitude.

Secondary school students

The term denotes students studying in class VIII, IX and X of a recognised school, following Kerala state syllabus

Operational definition

Here the term denotes students studying in class VIII of a recognised School following Kerala State syllabus.

Objectives of the study

1. To find out the effectiveness of instructions based on SOLO taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on Scientific Attitude of secondary school students.

2. To find out the effectiveness of instructions based on SOLO taxonomy, Revised Bloom’s Taxonomy and Mc Cormack and Yager’s Taxonomy on Scientific Creativity of secondary school students.
3. To find out the effectiveness of instructions based on SOLO taxonomy, Revised Bloom’s Taxonomy and Mc Cormack and Yager’s Taxonomy on Metacognitive Awareness of secondary school students.
4. To compare the effectiveness of instructions based on SOLO taxonomy, Revised Bloom’s Taxonomy and Mc Cormack and Yager’s Taxonomy on Scientific Attitude, Scientific Creativity and Metacognitive Awareness of secondary school students.

Hypotheses

1. There will be no significant difference between the mean pre-test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom’s Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager’s Taxonomy) for Scientific Attitude of secondary school students.
2. There will be no significant difference between the mean post test scores of Experimental group I, Experimental group II, and Experimental group III for Scientific Attitude of secondary school students.
3. There will be no significant difference between the mean pre test and post test scores of Scientific Attitude of Experimental group I.

4. There will be no significant difference between the mean pre test and post test scores of Scientific Attitude of Experimental group II.
5. There will be no significant difference between the mean pre-test and post test scores of Scientific Attitude of Experimental group III.
6. There will be no significant difference between the mean gain scores of Scientific Attitude of Experimental group I and Experimental Group II.
7. There will be no significant difference between the mean gain scores of Scientific Attitude of Experimental group I and Experimental Group III.
8. There will be no significant difference between the mean gain scores of Scientific Attitude of Experimental group II and Experimental Group III.
9. There will be no significant difference between the mean pre test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom’s Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager’s Taxonomy) for Scientific Creativity of secondary school students.
10. There will be no significant difference between the mean post test scores of Experimental group I, Experimental group II, and Experimental group III for Scientific Creativity of secondary school students.
11. There will be no significant difference between the mean pre test and post test scores of Scientific Creativity of Experimental group I.

12. There will be no significant difference between the mean pre test and post test scores of Scientific Creativity of Experimental group II.
13. There will be no significant difference between the mean pre test and post test scores of Scientific Creativity of Experimental group III.
14. There will be no significant difference between the mean gain scores of Scientific Creativity of Experimental group I and Experimental Group II.
15. There will be no significant difference between the mean gain scores of Scientific Creativity of Experimental group I and Experimental Group III.
16. There will be no significant difference between the mean gain scores of Scientific Creativity of Experimental group II and Experimental Group III.
17. There will be no significant difference between the mean pre test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom’s Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager’s Taxonomy) for Metacognitive Awareness of secondary school students.
18. There will be no significant difference between the mean post test scores of Experimental group I, Experimental group II, and Experimental group III for Metacognitive Awareness of secondary school students.
19. There will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group I.

20. There will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group II.
21. There will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group III.
22. There will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group I and Experimental Group II.
23. There will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group I and Experimental Group III.
24. There will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group II and Experimental Group III.

Methodology

For finding out the effectiveness of an instruction based on SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on certain science learning outcomes, experimental method was adopted. Experimental design selected for the study is Pre test post test non equivalent group design.

Variables selected for the study

Experimentation involves independent variable, dependent variable.

Independent variables

Instructional procedure was taken as the independent variable, with the following levels of treatment.

a) SOLO taxonomy
b) Revised Bloom's Taxonomy
c) Mc Cormack and Yager's Taxonomy

Dependent variables

Dependent variables selected for the study are following

1. Scientific Attitude
2. Scientific Creativity
3. Metacognitive Awareness

Design of the study

Experimental Design

In order to test the effectiveness of an instruction based SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy for teaching science to secondary school students', Quasi-experimental design (pre test post test non equivalent group design) was employed.

Sample used for the study

The present study was conducted on a sample of 210 students of standard VIII drawn from three schools of Kottayam. The schools selected for the study were NSS Boys High school, Perunna, NSS Girls High School Perunna and NSS High School Kidangoor. Among the 210 students of Experiment group, 70 students were treated with instruction based on SOLO Taxonomy (Experimental Group I), and 70 were treated with instruction based on Revised Bloom's Taxonomy (Experimental group II), and the other 70 students were treated with instruction based on Mc Cormack and Yager's Taxonomy (Experimental group III).

Tools used for the study

The following tools were developed and used in the experimentation.

1. Raven's standard progressive matrices
2. Scientific Attitude Scale (Meera and Revati,2016)
3. Scientific Creativity Test (Weiping Hu and PhilipAdey,2002)
4. Metacognitive Awareness Inventory (Meera and Revati,2016)
5. Lesson transcripts based on SOLO Taxonomy (Meera and Revati,2016)
6. Lesson transcripts based on Revised Bloom's Taxonomy (Meera and Revati,2016)
7. Lesson transcripts based on Mc Cormack and Yager's Taxonomy (Meera and Revati,2016)

Statistical Techniques employed

- Descriptive statistics like Mean, Median, Mode, and Standard deviation
- Test of significance of difference between the means scores of three dependent groups
- Analysis of Variance (ANOVA) followed by Scheffe's Test of Multiple Comparison.
- Analysis of Co Variance (ANCOVA)

Scope and limitations of the study

The investigator hopes that the findings of the study will be useful to educational administers, educationists, teachers and research scholars to modify the teaching learning process. The findings will fill the gaps if any, in the studies conducted so far and would trigger deeper studies by the future researchers in this area.

The present study is to compare the effectiveness of instruction based on three different taxonomies on certain learning outcomes related to science subject of secondary school students. It is expected that the present study will be helpful to determine the effectiveness of SOLO Taxonomy, Revised Bloom’s Taxonomy and Yager’s taxonomy on learning outcomes like Scientific Creativity, Scientific Attitude and Metacognitive Awareness. The investigation in to the effectiveness of these three taxonomies will be helpful to identify which type of taxonomy is efficient in developing and enhancing science related learning outcomes. Comparison of the effectiveness of different taxonomies help practitioners to choose a taxonomy to select suitable learning outcomes and plan their instruction accordingly.

The investigation in to the interactive effects of these three independent variables will be highly fruitful to educators to identify how instruction based on these three taxonomies influence Scientific Attitude, Scientific Creativity and Metacognitive Awareness of secondary school students. The study opens new avenues for researchers to investigate into the science related behaviours of young children. The scope of the study is enormous in which curriculum planners, science teachers, teacher educators and persons involved in education can use the findings of the study to improve the performance of the students in schools as well outside schools. The study will help educators to plan and test objectives or learning outcomes more effectively. This helps the whole educational system function successfully. The study also opens the area of metacognition, which is a much researched variable recently, helpful in increasing the achievement of secondary school students.

The present study has certain limitations also. In spite of exerting maximum efforts to make the study most objective and fruitful the investigator could not get rid of the following limitations.

1. Owing to practical reason, the study was confined to schools of Kottayam District.
2. Even though the investigator reviewed the literature and various studies based on the variables, researcher could have included a preliminary survey phase in order to find the present status of teaching and learning phase.
3. The investigator collected possible reviews but there were only few studies on taxonomies carried out in Indian context. So it is an attempt from the part of the investigator.
4. Since the study is intended to compare the effectiveness of instruction based on three different taxonomies on science learning outcomes control group is not included.
5. The study was confined to three independent variables only, Scientific attitude, Scientific Creativity and Metacognitive Awareness.
6. In order to reduce the length of the topic instead of revised Bloom's taxonomy, investigator used Bloom's taxonomy and clarified it in the operational definition part of first chapter.
7. The sample of the study was confined to a small sample of six intact classes of VIII standard as this is considered as the representative sample of secondary school students.

Chapter II

REVIEW OF RELATED LITERATURE

- **Theoretical Framework of the Variables**
- **Studies Related to Revised Bloom's Taxonomy**
- **Studies Related to SOLO Taxonomy**
- **Studies Related to Mc Cormack and Yager's Taxonomy**
- **Studies Related to Scientific Attitude**
- **Studies Related to Scientific Creativity**
- **Studies Related to Metacognition**

In research process, making an extensive review of related studies is a vital component. In this chapter, the investigator reviews the related views of other established researchers in the field in which the current study is undertaken. In the present study, the investigator has gone through various books, theses, reports, journals and research reviews related to the topic. This helped the investigator in determining what has already been done in the thrust area of study. The process of reviewing avoids unintentional duplication, provides necessary insights into the logical framework of topic under study and facilitates the interpretation of results. It also points out research strategies, specific procedures and measuring instruments that have and not have been found to be productive in investigating the problem (Gay, 1996).

In this chapter, the researcher attempted to explore the theoretical aspect of SOLO Taxonomy, Revised Bloom's Taxonomy, Mc Cormack and Yager's Taxonomy, Scientific Attitude, Scientific Creativity and Metacognitive Awareness. The researcher scrutinized various studies conducted in the educational settings and related these variables in the present educational area. Hence, this chapter comprised of two sections, the theoretical background of the variable and studies done by other researchers in this area.

Theoretical Framework of the Variables

The theoretical aspect of SOLO taxonomy, Revised Bloom's Taxonomy, Mc Cormack and Yager's taxonomy, Scientific Attitude, Scientific Creativity, and Metacognitive Awareness are presented in this section.

SOLO Taxonomy

"SOLO Taxonomy provides a simple and robust way of describing how learning outcomes grow in complexity from surface to deep understanding" (Biggs & Collis, 1982). The Structure of Observed Learning Outcomes (SOLO) taxonomy explains the increasing complexity of students' learning process. It was developed in 1986 by two Australian academics John Biggs and Kevin Collis. SOLO Taxonomy was created by careful analysis of student responses to evaluation tasks. While developing it, Biggs and Collis considered many factors of learners which affect their learning like, previous knowledge, misconceptions, motives, intensions regarding education, learning strategies etc. So it has been gone through qualitative and quantitative dimensions and validated for use in a wide range of disciplines (Hattie & Brown, 2003).

SOLO is a structured framework used by learners to measure progress of thinking and learning outcome. SOLO clarifies learning outcome of an activity, a unit, a project etc. This model works with outcomes related to both descriptive and functional areas of learning. SOLO is useful to teachers in various ways, planning the level of learning, assessment of students learning etc.

In SOLO, a student understands leads from simple to complex connections as they passes from ignorance to expertise. Each level of understanding is a continuation of the previous level. Thus SOLO displays student's outcome at five levels. Learners progress through these five stages; which are relevant to all subjects and all disciplines. The five levels are Pre structural, Uni structural, Multi structural, Relational and Extended abstract levels. All these five levels can be classified into three groups. These three groups are considered as three levels of knowledge, surface knowledge, deep knowledge conceptual knowledge.

The first Pre structural level of SOLO is a stage of ignorance and it is not included in the three levels of knowledge mentioned earlier. The next two stages namely Uni structural and Multi structural are included in surface knowledge. The last two levels Relational and Extended Abstract levels are included in deep knowledge. By using this taxonomy one can identify the level in which a student is recently operating.

SOLO taxonomy category definition

SOLO Taxonomy has five main stages.

1. Pre structural: In this level student's understanding, or existing knowledge is limited or nonexistent, or the task is approached from a different angle.
2. Uni structural: In this level students might know one key piece of knowledge but they are unable to connect it to anything else in this level.
   Indicative verbs- identify, name, follow simple procedure etc.
3. Multistructural: At this level, students can show an understanding of several piece of knowledge but they don't know how to connect them together.
   Indicative verbs: combine, describe, enumerate, perform serial skills, list etc.
4. Relational: At this level student's understanding of the several elements is strong and they can make connections between them.
   Indicative verbs: analyze, apply argue, compare/contrast, criticize, explain causes, relate, justify etc.
5. Extended Abstract: Now students can apply their learning in new contexts and can visualize it as part of a greater whole.

Indicative verbs: create, formulate, generate, hypothesize, reflect, theorize etc.

Psychological Bases of the four levels

Biggs and Collis (1982) made their model on the basis that "in any learning episode, both qualitative and quantitative learning outcomes are determined by a complex interaction between teaching procedures and student characteristics". By considering student's previous knowledge, motivation, learning strategies, intentions about learning they arranged the levels based on various characteristics ie, from concrete to abstract, increasing number of organizing dimensions , increasing consistency and increasing use of organizing principles. The four ways in which complexity increases are capacity, relationship, consistency and closure, and structure (Hattie & Bown, 2003).

Capacity: Working memory and attention span increases at each level of SOLO. At surface level students only encode or recall the given information. At deep level in depth thinking and establishing relationships between facts is needed.

Relationship**:** At uni structural level, children know only one aspect and no relationship is possible. In multi structural they consider many aspects but they don't have the ability to relate it. At relational level students establishes relationships between many aspects and in extended abstract level, students apply this relationships to new situation.

Consistency and closure: At uni structural level, students give an answer with immediate recall of information (closure) but in extended abstract level student moves to the possibility of inconsistency across contexts.

Structure: In uni-structural responses a learner need only a single relevant information but in multi structural, several bits of information has to be linked. At relational level an underlying conceptual structure is needed. While in extended abstract a generalised structure is needed for application in new contents.

By SOLO students can observe learning progress due to their efforts rather than luck or fixed abilities. In this way, SOLO supports students, in developing metacognition, self regulation, self efficacy, engagement and resilience (Brown 2003). SOLO helps a teacher in evaluating achievement, engaging in curriculum analysis, judging the specific learning out comes, setting quality of learning, instigating appropriate remedial measures etc. SOLO helps for defining quality of learning and standards for teachers and students to set goals for different tasks. Each SOLO level is a metric of the complexity of the material, so it is easy for a teacher to select a task, which is relevant to student performances (Hattie, 2003).

SOLO taxonomy helps teachers and students as an alternative tool for selecting items for a test. According to Biggs and Collis(1982), "SOLO levels arise form an understanding of the process of student learning, and a concern to develop qualitative criteria of learning that have formative as well as summative value".

Bloom's Taxonomy

Bloom's Taxonomy of educational objectives was published in 1956 by a committee of educational psychologists under the leadership of Dr. Benjamin S Bloom. The aim of the committee was to develop a system of, categories of learning to assist in designing and assessment of educational programmes. It identifies three domains of learning, each of which is organized as a series of levels as pre requisites. It is suggested that one cannot effectively address higher levels until those below them have been covered. It provides a basic sequential model for dealing with topics in the curriculum, and also suggests a way of categorizing levels of learning, in terms of expected outcome of a programme (Artherton, 2013). Each of these categories requires learner to use different sets of mental processing to achieve stated outcomes within learning environment.

It is a set of three models used to classify learning objectives on the basis of level of complexity and specificity (Bloom, 1956). These objectives or behavioural outcomes of individuals resulting from instruction are classified into three domains.

1. Cognitive domain: Includes those objectives which deal with recall and recognition of knowledge and development of intellectual abilities. The objectives coming under this domain are knowledge, comprehension, application, analysis, synthesis and evaluation.
2. Affective domain: This domain deals with interests, attitudes, opinions, appreciations, values and emotional sets. Objectives coming under this category are, perception, set, guided response, mechanism, complex overt response, adaptation and organization.
3. Psychomotor domain: Includes physical and motor skills. Objectives of this domain are receiving, responding, valuing, organization and characterization.

Goal of Blooms Taxonomy is to motivate educators to focus on all the three domains creating a more holistic form of education. The cognitive domain objectives are the primary focus of all traditional education and it is commonly used to structure curriculum, learning objectives, learning experiences and assessment.

Bloom's Revised Taxonomy

In 1990's, Lorin Anderson, a former student of Benjamin S. Bloom revised the original Bloom's Taxonomy and named it Revised Bloom's Taxonomy. In the new version of Bloom's Taxonomy, the names of the six categories were changed from noun to verb forms, because thinking is an active process (Anderson & Krathwohl 2001). There was a change in terminology also i.e. knowledge changed into remembering, comprehension become understanding and synthesis into creating. Anderson rearranged the six categories with higher objective as creating. The knowledge level of the original taxonomy is divided into four levels; factual, conceptual, procedural, and metacognitive. Objectives of Revised Bloom's taxonomy are remembering, understanding, applying, analysing, evaluating and creating.

Terminology changes

The six major categories were changed from noun to verb forms. The lowest level of original taxonomy, knowledge is renamed as remembering. Comprehension and synthesis are retitled as understanding and creating.

Definitions of new terms are as follows

- **Remembering:** Retrieving, recognizing and recalling relevant knowledge from long term memory.
- **Understanding:** constructing meaning from oral, written and graphic messages through interpreting, exemplifying, classifying, summarising, inferring, comparing and explaining.
- **Applying:** carrying out or using a procedure through executing or implementing.

- **Analyzing:** Breaking material into constituent parts, determining how the parts relate to one another, and to an overall structure or purpose, through differentiating, organizing and attributing.
- **Evaluating:** Making judgments based on criteria and standards through checking and critiquing.
- **Creating**: Putting elements together to form a coherent or functional whole. Recognizing elements into a new pattern or structure through generating planning or producing **(**Anderson & Krathwohl, 2001).

Structural changes

In the structure of original Bloom's taxonomy certain logical changes has been made. Original taxonomy was in one dimensional form while the new taxonomy taken the form of a two dimensional table. The two dimensions considered here are, knowledge dimension the cognitive process dimension.

Table 1

The revised taxonomy table

	Cognitive Process dimension					
The Knowledge Dimensions	Remember	Under-stand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual						
Procedural						
Metacognitive						

Knowledge Dimension of Revised Bloom's Taxonomy

Factual knowledge: This dimension contains knowledge which is basic to specific disciplines. It includes all the details that a student must know, to understand a particular discipline like facts, terms, details of elements etc.

Conceptual knowledge: Includes classifications generalizations, theories, models and structures pertinent to a particular disciplinary area.

Procedural knowledge: This comes under the doing aspect of knowledge. This area of knowledge includes methods of inquiry, specific skills, algorithms techniques and, particular methodologies.

Metacognitive knowledge: This is the knowledge of one's own cognitive process and cognition. It includes self knowledge about cognitive process as, solving problems, processing information etc. It is a higher order thinking skill involving active control on cognitive process.

A teacher can use of all these knowledge dimensions plotted in a Taxonomy table for ensuring necessary objectives of a unit and for a better and effective transaction. For a particular unit teacher can make sure that pupil are getting knowledge related to factual areas, conceptual areas, procedural areas and lastly the metacognitive procedures involved in learning. Teachers can make use of new taxonomy dimension for the formulation of objectives, refinement of existing objectives and for better assessment methods. In all areas of instructional procedure a teacher can make use of the set up standards of Revised Bloom's Taxonomy.

Mc Cormack and Yager's Taxonomy

Science learning becomes fruitful when a student learns how to use scientific knowledge and scientific ways of thinking to live a better life and to make rational and social decisions. Mc Cormack and Yager opined that science education is giving importance to knowing and understanding of factual information only. They viewed that for the development of a scientifically literate person who can meet the needs of the society, mere presentation of factual information is not enough. Thus they proposed a new taxonomy of science education containing six domains related to science learning.

Six domains of Taxonomy of science education

1. Concepts (knowing and understanding): scientific information- facts, concepts, laws, hypotheses and theories accepted by the scientific community.
2. Processes (exploring and discovering): processes of science, how scientists work and think.
3. Applications (using and applying): Applications of what is learned, to do science, connection to everyday life, informed decision making.
4. Attitudes (feeling and valuing): Attitudes, sensitivity , societal issues and impacts
5. Creativity (imaging and creating): Idea generation, designing, problem solving.
6. Nature of science (the scientific endeavors): History and philosophy of science, how science progress and, science knowledge and understanding develop.

1. Conceptual Domain

Milller (1989) noted that without an understanding of science concepts it would be impossible for the student to follow much of the public discussion of scientific results or public policy issues related to science and technology. Students should have concrete experience with concepts before moving to abstractions. Only then they can use those concepts in real life situations. Facts, laws, principles and the internalized knowledge held by students, all fall under the umbrella of concept domain (Mc Cormack and Yager 1989). Science learning should promote conceptual linkages instead of concepts in isolation approaches

2. Process domain

Science process skills are certain inquiry skills related to exploring and investigating activities in science. These skills are essential for everyday life, to understand nature, and to yield important insight of science education (Aikenhead, 1979). For programme, Science: A Process Approach (SAPA) American Association for the Advancement in science (AAAS) in 1968 identified 13 process skills. These are the process used by scientists in accomplishing their work. The ability to use these process skills in a combined manner should be the target of science education.

Process skills used in science

- Observing
- Using space and time relationships
- Classifying, grouping and organizing
- Using numbers and quantifying
- Measuring
- Communicating

- Inferring
- Predicting
- Identifying and controlling variables
- Interpreting data
- Formulating hypotheses
- Defining operationally
- Experimenting

3. Application Domain

A key element in the application domain is the determination of the extent to which the students can transfer and effectively use what they have learned to a new situation especially in their daily life (Grunloud, 1981). Application domain is an important domain of Mc Cormack and Yager's taxonomy, because children use learned concepts and process not only in familiar contexts but also in solving new problems also. In school, children apply this knowledge in problem solving and learning new material, while in their daily life, they choose these concepts and skills for dealing with novel contexts. Beginning science learning based on students concerns in the real world may be the way to diminish the gap between the world of school science experiences and their personal, societal and technological experiences (Mc Cormack and Yager 1989). Children should be able to integrate science, technology and knowledge to solve current social and technological issues. This gives training in integration of knowledge and skills.

Characteristics of application domain

- Critical thinking
- Open ended question
- Use of scientific process

- Making intra disciplinary connection
- Making inter disciplinary connection
- Decision making based on scientific knowledge
- Understanding and evaluation of scientific development
- Application of science concepts and skills to solve technological problems
- Understanding scientific and technological principles involved in technological devices.

4. Attitude Domain

Felker (1974) found that when students were induced to make positive statement about them, they attained more positive attitudes about themselves. In science education attitude is very important in various contexts. Two categories of attitudes in science are; attitude towards science (interest in science, attitude towards scientists, and attitude towards social responsibility in science) and scientific attitude (open mindedness, honesty, scepticism) (Gardner, 1975). Science teachers should retain the interest of their students by changing instruction and assessment practices and by being more students centred. Students should be able to solve problems with greater independence without parent or teacher involvement (Mc Cormack and Yager, 1986)

Characteristics of attitude domains

- Exploration of human emotion
- Expression of personal feelings in a constructive way
- Decision making about personal values
- Decision making about social and environmental issues
- Positive student attitude towards science
- Positive attitude towards oneself
- Development of sensitivity to respect others feelings

5. Creativity domain

Creativity is integral to science and scientific process. It is used in generating problems and hypotheses for designing plan of action (Hodsons & Reid , 1988). According to Torrence (1969) “creativity is a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements and disharmonies”. He included identification of difficulties, search for solution, making guesses or formulating hypothesis about deficiencies as attributes of creativity. It is an important part of many process of science. Creativity is difficult to assess. To nurture and enhance creativity of a student in the class room, teacher should be student centred. Openness in classroom, acceptance of ideas, thinking outside the box, trying new things, and a ‘go with the flow’ approach are signs of a student’s creativity. Scientists and students work in the laboratory by manipulating natural phenomena for a better understanding, to find the cause behind it and to experiment something new. An imaginative and inventive mind is necessary for creativity which is lacking in traditional class room.

Characteristics of creativity

- Visualization – production of mental images
- Generation of metaphors
- Divergent thinking
- Imagination
- Novelty-combining objects and ideas in new ways.
- Open ended question
- Solving problems and puzzles
- Consideration of alternative view points
- Designing devices and machines
- Generation of unusual ideas
- Multiple modes of communicating results
- Representation in various ways and modes

6. Nature of science domain

According to NRC (1996) "science is a human endeavour that relies on reasoning, insight, energy, skill and creativity". Science teachers must concentrate on an instruction which helps in the understanding of scientific nature of science. In the course of human history, people have developed many interconnected and subsequently validated ideas about the physical, biological, psychological and social worlds (AAAS, 1990). Through generations these ideas helped to achieve a reliable understanding of nature and man through observation, experimentation and validation. Nature of science deals with how scientific knowledge has developed and the role of scientists in it. Science is tentative in nature. Instruction should reflect this nature of science (Lederman 1992).Children should be sensitized with the world of scientists and their works, through Nature of Science Domain. In the attempt to reflect the nature of science, group work, reporting findings, discussions and reaching consensus are all parameters involved in the nature of science domain.

Characteristics of Nature of Science Domain

- Framing questions for scientific research
- Competitive side of scientific research
- Methodologies used in scientific research
- Interactions among other disciplines
- Team spirit in scientific research
- History of scientific ideas
- Ways in which science build understanding of the natural world.

SCIENTIFIC ATTITUDE

Education should function as a tool for social change and scientific change. Throughout in the history of India, various commissions and committees placed science at an important position in the field of education. For the all round development of the personality of children, science education should aim at development of scientific attitude in them.

Scientific attitude is the mental readiness to do certain science related activities. It is an important outcome of science teaching. Many educationists consider scientific attitude as the product of teaching science but majority consider it as equally important as knowledge (Rao, 2003). Science teaching should aim at developing scientific attitude common to scientists than following a particular method. Some of the characteristics of scientific attitude are, removal of false belief with logical method, curiosity, open mindedness, tolerance, rational outlook suspended judgement, etc. According to Vaidya (1971) “Scientific attitude is a set of emotionally toned ideas about science and scientific methods, and is directly or indirectly related to a course of action”. According to John Dewey (1933) “scientific attitude is linked with curiosity, fertile imagination and tone of experimental inquiry” Ausekar (1995) stated that “scientific attitude is open mindedness, a desire for accurate knowledge, confidence in procedures for seeking knowledge and the expectation, that the solution of the problem will come through the use of verified knowledge”:

Having scientific attitude consists in being willing to accept only carefully and objectively verified facts and to hold a single fact above the authority. To develop scientific attitude in learners, teacher should motivate questioning attitude, spirit of enquiry, respect for evidence etc. in the class. While children practice and observe science, they feel and develop different components of scientific attitude. Students who have positive attitude towards science shows increased attention to classroom instruction and participate more in science related activities (Germann, 1988, Jarvis & Pell, 2005).

Dimensions of attitude

An attitude has four dimensions namely intensity, extensity, duration and direction. All these four aspects are important in influencing the behaviour of a person.

Intensity

Intensity of an attitude is evidenced by the extent to which it motivates an individual's behaviour. An intense attitude will break all its obstacles to find its expression in the behaviour of a person.

Extensity

It is a measure of attitude, which has broad and pervading influence on the behaviour of a person.

Duration

It is the function of education to modify existing negative attitude and create new, positive and enduring attitude.

Direction

It gives us the evidence on which part of a person's behaviour is modified.

Factors influencing the development of Attitudes

There are many factors, which influence the development of attitude in a person. Some of them are listed below.

Maturation

With maturity a person's attitude become more positive and the person will be able to solve the problems.

Physical factors

Physical factors like malnutrition, disease and accidents can affect the attitude of a person.

Home influence

Home environment, attitude of members in the home, economic stability moral stability etc can affect the attitude of person.

Social environment

Stereotype society, orthodox people, prejudices and biases etc existing in a society causes a person's attitude to be negative.

Cognitive factors: Cognitive factors like intelligence, creativity and achievement effects the attitude.

Components of scientific attitude

Components of scientific attitude approved by majority of educational psychologists are as follows.

- Critical mindedness (looks for consistency and challenges the validity of statements)
- Suspended judgment (recognizes the restricted nature of evidence and concept)
- Honesty (reports all evidences and acknowledges the work of others)
- Objectivity (considers pros and cons and all of the evidence available unbiased)

- Willingness to change (alters hypotheses, assumptions, technologies and methods)
- Open mindedness (considers several possible alternatives when investigating)
- Questioning attitude (asks many questions: how, what, who, where, when and why)
- Tolerance to uncertainty (rejection of certainty)

Other components of scientific attitudes

Curiosity

Looking to be creative

Appreciation for beauty

Appreciation for complexity

Appreciation of unity

Perseverance

Some major components given by Srivastava (1980) are as follows

Commitment to the value of rationality

Tendency to test traditional beliefs

Seeking natural course of events and identification

Science teachers should inculcate these components of scientific attitude among their students through special instructional strategies.

Science teaching objectives and scientific attitude

Rao (1990) in his report of school science teaching, stated certain objectives for science teaching and scientific attitude.

They are as follows,

- To arouse curiosity of a learner, towards the nature surrounding him and to understand natural phenomena.
- To give training in systematic observation
- To develop scientific attitude
- To give an idea about scientist's works.

  All India seminar held in 1992 put forward certain aims and objectives to science teaching, important among them are given below.

- To familiarize pupil with the world in which he lives and make to understand the impact of science, so as to enable him to adjust.
- To acquaint him with the scientific method and enable him to develop scientific attitude.
- To give pupil a historical perspective, so that he may understand the evolution of scientific development.
- Science strengthens commitments of man to free enquiry and search for truth as its highest beauty and obligation (Cilenti, 1988). Therefore the study of science imparts training in scientific method and developing scientific attitude among learners. This quality ensures sustainable development of an individual as well as nation which is becoming more and more scientific gradually (Rao, 1990)

SCIENTIFIC CREATIVITY

Scientists use creativity in every stage of scientific research. (Abd-el Khalik , Bell & Lederman, 1998). Creativity plays a significant role in every scientific activity. Creativity is used especially while introducing a problem, formulation of hypotheses and for designing and conducting experiments. So it touches every step of life (Saxena, 1994). For the development of fundamental understanding of scientific principles, and for finding a useful and new solution for life related problems, one needs creativity. All individuals who learn to think creatively while dealing with the scientific work can also apply these skills in other areas (Meador, 2003). Although creativity is accepted as a problem solving skill in research literature, it requires creative performance, recognition of the problem, thinking differently and finding solutions. Recognition of the problem plays an extremely important role in the creative process

Creativity

Creativity is influenced by many factors, so it is difficult to explain creativity by a single definition. There are a lot of definitions in creativity. According to Havinghurst and Dehaan (1961) "creativity is the quality which leads to the production of something new and desirable. The new product may be new to society or new to the individual who creates it." By the analysis of a large number of definitions on creativity, Rhodes (1961) said that there are four strands of creativity or 4 P's namely: person, process, press and product. The definitions in the light of 4 P's are given below.

Creativity and Person

According to Simpson (1922) "creative ability is the initiative which one manifests by his power of thought into an altogether different pattern of thought concerning the problem of identification. It is the mental quality for searching, combining and synthesizing". Thurston (1938) states that, "an act is creative if the thinker reaches a solution in a sudden closure which necessarily implies some novelty to him". Guilford (1956) analysed additional factors that were put forth in the scheme of classification of human abilities. He extracted four fluency factors, namely associational, expressional, word and identical and two flexibility factors namely, spontaneous and adaptive. Torrence (1969) sorted out 84 important characteristics from various studies. According to K.N Sharma (1971) "The creative person must be highly sensitive, has high aesthetic sense, independence of judgment initiative and preference for perceptual novelty and complexity."

Stein (1953) views that "A process is creative when it results in a novel work that is accepted as a point in time". Mackinnon (1962) states that "creativity is a process which has a time dimension and which involves originality, adaptiveness and realization". Yamamoto (1964) defined creativity as, the process of forming new ideas or hypotheses, testing these ideas and communicating the results.

Creativity and Press

Press in the term denoting interaction between human beings and their environment. Maslow is considered as the expert in defining creativity based on press. According to Maslow (1963), "creativity involved a fundamental change in personality structure and that this change occurs in the dissection of fulfilment". Vinacke (1951) believed creativity as "an integrated harmony between external world of reality and individual's internalized needs.

Creativity and product

Measurement of creativity was a serious problem faced by psychologists. Some psychologists opined that it is the product which the creative individual makes and value of creative product is based on its greatness and novelty.

Guilford is considered as the exponent in the field of measurement of creativity. He measured creativity on the basis of fluency, flexibility and originality components. Sharp (2001) defined "creativity as the product of distinctive drives and unconscious wishes that aspire to become immortal". Wertheimer defined creativity as 'productive thinking'. Taylor (1964) defined creativity as "the measure of creative product be the extent to which it restructures our universe of understanding".

Creativity and Process

John Dewey (1933) was first to think creativity as a process. He gave the following model of five steps in typical problem solving process.

Difficulty is felt →Difficulty located and defined →Possible Solution → Consequences are considered →A solution in accepted

The Wallas model comprised of the following four steps

Preparation → Incubation → Illumination →Verification

Scientific creativity

According to Mackinnon there are three types of creativity, Type I, Type II and Type III. They are described below.

Type I: This type of creativity is also known as Artistic creativity. Here the creator expresses his creativity through the product of creation like works of sculptors, poets, composers painters, play writers, novelists etc.

Type II: This type of creativity is also known as Scientific creativity which is exhibited mainly by scientists, biologists, engineers and chemists. There the creator interacts with the environment and a novel and an appropriate product is produced with his effort.

Type III: This category of creativity comprises the qualities of both the above mentioned creativities. Here creativity can be seen as the presentation of the creator and the product, linked with a novel and an appropriate product. Modellers, designers, musical arrangers, musical performers, representational painters and architects are the representatives of this creativity.

The present study deals with scientific creativity or Type II creativity. According to Torrance (1995), “creativity is recognizing gaps in the problem or information, creating ideas or hypotheses and transmitting the data”. This definition proves that creativity is an inevitable part of science. Scientific creativity can be considered as a helping hand in achieving new and original steps in performing the targets of science (Aktamis and Ergin, 2008).

Important Theories of creativity

There are many theories about creativity. Only few of them are discussed here.

Process theory

Process theory of creativity was proposed by Wallas (1926). He presented a theoretical oriented model of creative process namely preparation, incubation, illumination and verification. These steps explain the route of creative thinking. Followed by Wallas, Dewey gave five stepped model and Rossman gave seven stepped model to explain creativity.

Intellect Theory

Guilford (1956) viewed creativity as divergent thinking and proposed that it is an aggregate of mental abilities involving divergent thinking slab of SI model. Intellect theory states that “creativity can be drawn from the divergent production of process put first, then four contents and lastly the six products in symbols as under.

Table 2

Intellect Theory

Process	Contents	Products
Divergent (D)	Figural (f)	Units (U)
Production (P)	Symbolic (S)	Relations (R)
	Semantic (S)	Systems (S)
	Behavioral (B)	Implication (I)

Guilford said that other process like cognition (C), memory (M), convergent production (N) and evaluation could not promote divergent thinking abilities but it influence creativity. Non verbal creativity is exhibited by figural contents produced by divergent production process, verbal creativity is developed when symbolic and semantic contents are used and lastly behavioural contents gives behavioural creativity.

Cognitive theory

This theory implies creativity is coming from cognitive styles which effectively lead to novel information. Gardner points out that "accuracy of perception is based on the ability to decant attention".

Components of creativity

According to Guilford creativity is mostly associated with divergent products. He related divergent thinking to certain well known abilities as follows.

Fluency- ability to produce a number of valid responses

Flexibility – ability to produce wide variety of responses

Originality - ability to generate rare and uncommon responses

Elaboration - ability to construct complex object on the basis of simple construct.

Later Guilford (1967) added two other abilities; redefinition and resistivity to problem; which are related to convergent production and evaluation category of intellectual operations.

Idea of Guilford on creativity influenced many. Different components considered by different researchers related to creativity are as follows.

1. Majundar (1975) Singh (1980) – guess consequences, alternate uses problem sensitivity, remote association, apparatus improvement, finding conceptual correlates etc.
2. Misra (1986): redefinition, elaboration, product improvement, guess, causes, guess consequences.
3. Sharma and Shukla (2005): guess consequences; predict unusual uses, finding new relationships, finding out causes etc.
4. Hu &Adey (2002) made scientific structure creativity model (SSCM) having 3 dimensions namely, scientific process (scientific thinking and scientific imagination), personality trait (fluency, flexibility and originality) and scientific product (technical product, scientific knowledge, scientific phenomenon scientific problem).

   Mc. Cormack and Yager (1989) in their taxonomy, included a domain ; imagine and creative which include student abilities related to creativity like visualizing or producing mental image, combining objects and ideas in new ways producing alternate and unusual uses of objects, solving problems and puzzles, pretending, dreaming etc.

METACOGNITIVE AWARENESS

Metacognition is a new concept in the field of educational psychology. Metacognition is a word denoting awareness of one's own thoughts. It enables a student to become a successful learner and is associated with intelligence. Metacognition is a higher order thinking skill involving active control on cognitive process while learning occurs. It is the "thinking about thinking" helping learners in learning how to learn". More precisely it is the mental activities used to plan, monitor and assess ones understanding and performance. It also includes awareness about ones thinking and learning and oneself as a thinker and learner.

Metacognitive practices enhance student abilities to apply their learning in new contexts (Brown 1987). Pintrich (2005) argues that students who know about different kinds of strategies for learning, thinking and problem solving will be more likely to use them, not just practice them". Metacognition helps students to recognize their strength and weakness in every field of their life. This knowledge will help them to expand the extent of their ability. According to Bransford (2000) "those who know, strength and weakness in their areas will be more likely to actively monitor learning strategies and resources and assess their readiness for particular tasks and performances".

Definitions of Metacognition

According to Schraw and Dennison (1994) "Metacognition refers to the ability to reflect upon, understand and control one's own learning" Flavell (1976) defined metacognition as "individual's awareness of how he learns and what he does".

Tylor (1999) defines metacognition as “an appreciation of what one already knows, together with a correct apprehension of the learning task and what knowledge and skills it requires, combined with the ability to make correct, inferences about how to apply one’s strategic knowledge to a particular situation, and to do so efficiently and reliably.”

Conceptions of Metacognition

Mental processing of information is known as cognition, it is the function of human mind which allows perceptions to grow into conceptions. Control over our own cognition is known as metacognition. It involves both monitoring and regulations of one’s own thinking process. It is a conscious verification of one’s own cognition to expand knowledge. A metacognitive skill acts as predictors of academic achievement. It is related to all areas of learning like, communication, reading, comprehension, language acquisition, social cognition, attention, self control, memory, self instruction, problem solving and personality development (Cooper , 1993).

Dewey asserted that learning is an action process involving assimilation from within. He concentrated on the inductive process of learning through observation. He gave a scientific outlook of metacognition. According to him metacognition of reflective thinking occurs by two processes, first a conscious recognition of doubt and feeling a state of restlessness, second involving in an active process of induction by searching and inquiring to solve the difficulty or doubt. Dewey gave an early conceptual frame work of metacognition by describing it as self monitoring and self regulation process.

Piaget (1972) coined the term “consciousness of cognizance” for metacognition. He studied metacognitive activities of young children and noted that, they are doing mental activities in the direction of metacognition but are unaware of that. But as the children reaches adolescence they start recognizing the step by step activities of mental activities. Vygotsky (1962) added language and communication as the expression of one's cognition. According to Vygotsky a person use his "inner voice" to think by which he reinforce his own concrete experiences and link these experiences with others. This process is described by Vygotskian metacognitive theory which is related to Cognitive Psychology of executive control.

Term Metacognition was introduced by Flavell (1976). He was a cognitive researcher and a professor of Psychology. He referred metacognition as "cognition about cognition or knowing about knowing" and recognized certain strategies of metacognition like, remembering, categorizing and recalling. According to Flavell, "Metacognition refers to one's knowledge concerning one's own cognitive process or anything related to them, like learning relevant properties of information or data".

Components of Meta cognition

Metacognition is classified into three components, metacognitive knowledge or metacognitive awareness, metacognitive regulation and metacognitive experiences.

Metacognitive knowledge or metacognitive awareness

Metacognitive knowledge is what individuals know about themselves and others as cognitive processors. It is divided in to three categories; knowledge of person variables, task variables and strategy variables. Flavell stated that all these variables overlap and combine when an individual works. Result of that work is due to the interactions of the various variables and metacognitive knowledge available at that particular time.

1. Person variables: It refers to the knowledge about one's own learning processes as well as other people's learning processes.
2. Task variables: It includes knowledge about the nature and characteristics of a task and how to manage the task. This helps the individual in successful completion of the task.
3. Strategy variables:This includes the knowledge and identification of metacognitive strategies and using it appropriately and effectively.

Metacognitive awareness is of three types.

Declarative knowledge

It is also known as world knowledge. It is the knowledge about the factors which can influence one's own learning or performance. This is the actual knowledge which are known as written or spoken.

Procedural knowledge: It is the knowledge about how to do something. One who possesses a clear procedural knowledge can perform the tasks automatically. This is done by effective use of various strategies. This involves abilities like identifying the task, checking the progress of task, evaluating, predicting the outcome, allocating of one's own resources for the task , determination of order or sequences of activities for the completion of task etc.

Conditional knowledge:

It is the knowledge about when and why to use declarative and procedural knowledge. This knowledge helps the students to use strategies more effectively. This allows maximum utilization of their resources for learning.

Metacognitive regulation

This is the second component of metacognition. It refers to the monitoring and control of one's cognitive process during learning (Nelson & Narens, 1994). Through this one can regulate one's own cognition and experiences related to learning through prescribed activities. This includes activities like; oversee learning, planning and monitoring activities related to cognition, monitoring the outcomes etc. The sub components coming under metacognitive regulation is planning, information management strategies, comprehension, monitoring, de bugging strategies and evaluation.

Planning: This involves cognitive activities done prior to learning like, planning, goal setting, collecting resources etc.

Information management strategies: This involves effective sequencing and processing of information, which is a key element of metacognition. Some activities are organising, elaborating, summarising and selective focussing.

Comprehension Monitoring: It is self evaluation or assessment of one's own learning or use of a particular strategy.

Debugging Strategies: This is the diagnosis and remediation of one's own strategy use. This is used to correct comprehension and performance errors.

Evaluation: This is the evaluation of performance and strategy use after a learning episode.

Metacognitive experiences

These are experiences which help current ongoing cognitive work. These experiences always occur after a cognitive activity. Metacognitive experience involves the use of metacognitive strategies or metacognitive regulation (Brown, 1987). Metacognitive strategies are essential processes that a person uses to control cognitive activities and to make sure that a cognitive goal has been achieved. Metacognitive experience helps a person to process information, memories or other earlier experiences, to recall and use them as resources in processing or solving a current cognitive problem. It is also affected by certain affective responses like success or failure, frustration or satisfaction, and many other responses that effect a person's willingness or interest to do similar tasks in future.

STUDIES RELATED TO SOLO TAXONOMY

Purti & Mardiana (2017) in their study named 'How to analyse the student's thinking levels based on SOLO taxonomy found out that, students with high self esteem can achieve uni structural to relational thinking level, students with medium self esteem can reach to the level of uni structural to multi structural level and students with low self esteem able to reach uni structural to pre structural level. Investigators concluded that by paying attention to self esteem especially in higher order objectives students can achieve optimal learning; extended abstract level in SOLO taxonomy. Sample selected for the study was 32, VIII grade students and used qualitative research with descriptive research approach. Tools used for the study are Self-esteem questionnaire, problem solving test and interview.

Keskin et al. (2016) conducted a study to examine the compatibility of the questions used by the social studies teachers in 6^{th} and 7^{th} level examination. Research tools included; case study, observation and document analysis. Sample of the study included four teachers at the sixth grade and three teachers at the seventh grade. Investigators found out that even though teachers asked questions in the uni structural and multi structural levels, most of the relevant achievements corresponded to the relational structure level according to SOLO taxonomy. The results showed that SOLO Taxonomy can be used effectively both in teaching and learning process.

Canfield & Krockenberger (2016) made a study to describe and evaluate an Interactive Student Centred Teaching Strategy of learning to analyse laboratory data in clinical pathology. Learning outcomes and assessment components are designed for deeper learning with the help of SOLO Taxonomy. Study found out that, the strategy enhanced interpersonal skills and encouraged deep approach of learning.

Sophie (2015) conducted a study on deep level learning with SOLO Taxonomy. Investigator found that SOLO Taxonomy provides a common language of learning for students, to communicate with their teachers and peers. The SOLO framework gives teachers and students an opportunity to know where they are, define their success and the way for achieving it. The five levels, Pre-structural, Uni-structural, Multi-structural, Relational and Extended abstract assist teachers in planning and assessing deep level learning. SOLO allows students to engage in active and collaborative dialogue within five different levels of thinking.

Brown et al. (2013) studied that students vary in learning approaches in different contexts. Some learners apply surface approach while some apply deep approach of learning. Surface approach leads to poor quality learning outcomes, while deep approach leads to better understanding, retention and achievement. Study revealed that SOLO Taxonomy helps to increase deeper understanding, of a concept and to design goals and levels of achievement which help in evaluation processes.

Bhattacharya et al. (2013) investigated the level of learning attainment in Qualitative Outcome Learning (QOL) through SOLO Taxonomy. Computer assisted content, based on SOLO levels were given to children of 14 years age to test their understanding. They used QOL to assess the learning. The study found out that SOLO Taxonomy stimulates deep learning.

Stephen (2013) stated that SOLO describes the levels of increasing complexity of students understanding. It helps teachers to get an understanding of the learning process by observing the learning outcomes of students. By SOLO Taxonomy, a teacher can react to student's response differently, relating to, whether they know to make connection between facts, they have surface or deep knowledge etc. A teacher gets a clear conceptual understanding of subject.

Guico & Dolor (2013) conducted a study on the level of awareness and possible concerns of the marine faculty members on outcome based education. The investigator examined SOLO Taxonomy and viewed that it provides a systematic way of describing a student's knowledge, which grows in complexity when mastering a concept. It is also helpful to teachers in formulating outcomes which is useful to students to decide the way for achieving their goal.

Evan (2012) studied that the ability to calculate progress is important for creativity. It gives signs that you have to go back and get some more insights. SOLO Taxonomy gives the awareness about where you are, in the learning process. Researcher viewed that even though SOLO is an assessment tool used by teachers, it is more powerful when the learner use it as a self assessment tool.

Didan (2011) described SOLO Taxonomy as a tool to design learning experiences for the acquisition and application of knowledge. Because SOLO helps to classify learning outcomes based on its complexity. The researcher found out that, SOLO Taxonomy helps to map student's levels of understanding and to assess how much they apply knowledge.

Kiani (2011) conducted a study to evaluate the examination system at grade five in Punjab, based on SOLO Taxonomy. Administers, Head, teachers and students of all the primary schools were included in the study populations. Two types of questionnaires for both teachers and administers, and a self developed achievement test were used to collect data. Study findings showed that majority of the administrative staff and teachers are satisfied with the new examination system based on SOLO Taxonomy. It increased the authenticity of class V examination, increased students learning, creative thinking and, reading and writing ability among students.

Lucander et al. (2010) investigated to find out whether SOLO Taxonomy will be useful in developing deep learning approach, through the assessment of learning by summative evaluation techniques. 32 secondary school students were selected as experimental group who got SOLO Taxonomy treatment and the other 35 students received traditional method of teaching. Effects of the two treatments were analyzed by summative assessment through SOLO Taxonomy. Study found out that SOLO Taxonomy as a model for improving learning and as a tool to develop and promote deeper approach of learning in students.

Smith &Colby (2010) examined student's level of learning and teacher's effort to foster deep learning. Study sample consisted of 64 teachers from different areas. Collection of data was done by examining the teaching practices and student's learning outcomes using SOLO Taxonomy. It has been found out that most of the class room learning was characterized by reproduction; categorizing information and replication of simple procedures. Through this study they gave many implications for fostering deep learning.

Bei (2009) made an enquiry in to student's, concept understanding level using SOLO Taxonomy. Investigator found out that SOLO Taxonomy gave deep quality level to education and explored student's learning. Study results showed that SOLO Taxonomy appraised student's learning and increased conceptual understanding level.

Minogue & Jones (2009) conducted a study on, using SOLO Taxonomy for the evaluation of student learning in studying cell membrane transport through Computerized Learning Environment. Two groups of 80 students were selected randomly and two types of feedback were given. One group received visual feedback and the other group received visual and haptic feedback. Pre test- post test comparisons were made and found out that the scores obtained showed significant difference. The findings revealed that the group receiving haptic augmentation of computer based science instruction lead to deeper level of understanding.

Burnette (2007) conducted a study on 35 clients, appeared for counselling. Participants were asked to write a letter on what they have learned from counselling. The written responses were analyzed to different levels using SOLO Taxonomy. Study suggested that SOLO offers an excellent method to assess the outcomes of counselling in an instructional frame work.

Gillian & Levis (2006) explored the use of SOLO Taxonomy for development and assessment of higher order thinking in higher education. The study revealed that SOLO Taxonomy is a good tool to find out metacognition and entering knowledge in a discipline. The study also found out that, through SOLO students can organize their knowledge in a discipline and present models of desired learning outcomes level and its assessment.

Chan et al. (2002) investigated the application of three different taxonomies in assessing student's cognitive learning outcomes. The three taxonomies studied are SOLO Taxonomy, Bloom's Taxonomy and Reflective Thinking Measurement model. Through experimental study, by analyzing scripts of long essay papers and short classroom discussion responses investigators found that SOLO is the most suitable Taxonomy for assessing learning outcomes.

Ditchfield (1996) investigated structural organization conceptions, and knowledge of their own learning possessed by 40 teachers of 23-53 years age studying an in service course on adult learning. Teachers were asked to give a written statement about learning at the beginning of first semester. Project statements were categorized and analyzed on the basis of SOLO Taxonomy. 80% of responses were at multi structural level while other responses varied between different SOLO levels. Result showed that teachers also need to learn about SOLO based learning to become independent learners.

Courtney (1986) studied significance of SOLO Taxonomy for teaching and learning Geography. Researcher found out that the five level hierarchies of SOLO Taxonomy helped teachers to evaluate the quality of student's thinking. Study also found out that SOLO Taxonomy in good for framing questions, and scoring responses. SOLO has broad curriculum applicability and can improve teaching and learning activities.

STUDIES ON REVISED BLOOM'S TAXONOMY

Juneau (2016) made a study on sixth grade students to find out the effect of Bloom's Taxonomy in fostering critical thinking .She found out that after laying out goals in each category of objectives under cognitive domain of Bloom's Taxonomy, students moves forward mastering each level, takes control of information and knowledge presented. Adopting a systematic way of teaching, through the taxonomy, gaining and utilizing student's knowledge at each level, students can easily reach to their maximum level of learning.

Akinde (2015) made a pilot study on learning outcomes based on Didactic and Socratic instructional methods. The study lasted for 7 weeks. Two groups were selected, one group got Didactic method while the other group got Socratic Method and lastly a test was conducted based on five levels of Blooms Taxonomy. Findings showed that there was no significant difference between the two groups of students.

Ugur et al. (2015) examined the integration of Self Development Theory and Bloom's Taxonomy to promote self development of students in educational settings. The core components of SDT were incorporated into Bloom's Taxonomy for a value integrated personal growth. Both teachers and students were participated in the study and findings showed that the process of self development can be enhanced by internalization of cognitive learning and supported by favourable developmental outcomes of students.

Wisvanathan & Murthy (2015) conducted a study on how to develop student's higher level cognitive skills. They developed questions in higher cognitive levels based on Revised Bloom's Taxonomy and examined whether the students can solve the higher order questions. Two schools of Mumbai were selected and took class 3^{rd} and 4^{th} students as samples. The investigators observed that students answered higher order thinking questions.

Ayesha & David (2011) conducted a study on student – content interaction in online courses. The role of question prompts is facilitating higher level engagement with course content. Based on Bloom's Taxonomy, various cognitive level questions were given and analysed its relationship with subsequent responses in online forum. Results indicated that higher levels promoted higher level student responses and questions related to comprehension, application and synthesis invited highest average number of student responses.

Mc Bain (2011) made a study to examine how students can understand up to higher order thinking skills while handling critical thinking questions with the help of Bloom's Taxonomy. Two classes of high school students were taken and questions were given based on gradation levels of Bloom's Taxonomy. The investigator found that there is no significant difference between students while answering lower order objective questions of Bloom's Taxonomy, but when they reach higher order objectives there is significant difference in answers.

Neil & Rita (2011) studied outcome based programme evaluation using Bloom's, taxonomy. Outcome based programme evaluation is a method used to assess outcomes based on certain indicators. Investigators checked the acquisition of outcomes of learner activities using Bloom's Taxonomy. The study indicated that Bloom's Taxonomy is helpful in identifying, classifying and clearly communicating outcome indicators by which a teacher can evaluate their programme.

Rupani and Bhuto (2011), through a survey study evaluated the existing teaching with the aid of three domains of Bloom's Taxonomy. The study found out that existing teaching was teacher centred, and gives emphasis to rote learning. The study also indicated that affective and psychomotor domains are untouched in present method.

Sultana (2010) study was to improve method of teaching by effective use of taxonomy. Researcher used Revised Bloom's Taxonomy for the study. Study involved 123 teachers in four sections of undergraduate course, on classroom assessment. Two groups received same instructional information but with different practice activities. Results showed that there was no significant difference between two groups.

Kristeal (2010) examined the effect of Bloom's taxonomy based lesson plans. Two groups of students were selected for the study. One group taught using Bloom's taxonomy based lesson plans and other group was taught by text book based instruction. Two groups were parallely taught by two mathematics teachers. By analyzing post test scores it was observed that the group received Bloom's taxonomy based classes score high than other group.

Savickiene (2010) published an article on a problematic issue regarding ineffective use of teaching outcomes of affective domains of Bloom's Taxonomy. The article examines the present validity criteria of learning outcomes in affective domain and suggests certain solutions for learning and teaching affective domain.

Carolyn & Frank (2009) reviewed that communication of educational objectives is essential for teaching learning process. Bloom's taxonomy provided an easy way of communication of educational objectives for cognitive learning. Six hierarchical levels of Bloom's Taxonomy ensure different applications and adaptations of student learning.

Guruprasad (2009) studied application of Bloom's Taxonomy to questioning techniques in the classroom. The researcher viewed that in many countries Bloom's Taxonomy is used for curriculum development, classroom interaction and learning assessment which are the core areas of education. The study observed that with the help of Bloom's taxonomy, it is easy to frame higher order thinking questions and it increased questioning skills.

Halawi et al. (2009) examined the effectiveness of e learning. Through an exploratory study investigator evaluated e learning through web CT on the basis of Bloom's Taxonomy. A questionnaire was made to test whether individual and instructional factors play any important role in learning while using web CT. 75 participants were involved in the study. Results indicated that individual and instructional factors do not play a major role in learning process.

Crowe et al. (2008) developed a Blooming Biology Tool (BBT) based on Bloom's Taxonomy to assess student's cognitive skills. BBT consist about 600 science questions from college life science exams and standardized tests. Researchers administered it on three different higher secondary school settings. It was found that, it helped in adjusting teaching, attaining mastery in learning the content and in assisting students for college level exams.

Rodney (2007) found out that in organic chemistry classes most students try to memorise data than understanding it. He suggested that by implementing Bloom's Taxonomy we can increase the level of comprehension in organic chemistry classes.

Renumol and Jayaprakash (2006) analysed the difficulties of students in programming education. Sample selected was a group of undergraduate engineering students. Analysis was made on the basis of Bloom's Taxonomy. It was observed that in all domains students exhibited problems. Results of the study showed that six levels of cognitive domains of Bloom's taxonomy are very important in programming process, and that is why students faces difficulty in learning.

In a study conducted by **Airasian & Miranda (2002),** Revised Blooms Taxonomy and its role in learning and assessment was examined .Researcher found out that it presents a new and reliable way to assess complex cognitive and metacognitive knowledge.

Krathwohl (2002) revised original Bloom's Taxonomy of educational objectives. It described a new way for classifying educational objectives which were different form original Bloom's, Taxonomy. The paper gives importance to knowledge dimension and cognitive process of cognitive domain.

Gokhale (1995) compared the effectiveness of Individual Learning and Collaborative learning to enhance drill and practice skills and critical thinking skills. Sample consist of 48 undergraduate Industrial Technology students. Non equivalent control group design was selected for the study. 24 students got Individual learning and the other 24 got Collaborative learning. A test was prepared by the researcher on the basis of Blooms taxonomy, and administered on both the categories as pre test and post test. Pre test scores were same for both groups but in post test, the group which got collaborative learning showed high scores in critical thinking.

STUDIES RELATED TO Mc CORMACK AND YAGER'S TAXONOMY

Faheen & Yager (2016) viewed that for achieving an effective student learning we need to consider all the six Science Domains. They found out that process skills indicated student success, Concept and Process Domains are part of traditional learning , Creativity and Attitude are enabling domains, Application Domain helps to apply these of concepts in new contexts and lastly Nature of Science Domain includes philosophy, history and sociology of scientific process. Investigators suggested that a science teacher should focus on all the six domains while teaching.

Rajasree (2014) conducted a study to analyze the effectiveness of Mc Cormack and Yager's Taxonomy in teaching physics at secondary level. A sample of 340 students of tenth standard were selected. 170 students were given, teaching based on Mc. Cormack and Yager's Taxonomy and the other 170 students who were the control group received teaching, based on Bloom's Taxonomy. Tools used for the study are Achievement test in physics, Physics Interest Inventory, Scientific Attitude Scale, Scientific Creativity Test, Science Process skill test and Metacognitive Inventory. Findings revealed that achievement of experimental group was better than control group. Experimental group gained more scores which are significantly different from control group with respect to interest in Physics, Scientific Attitude, Scientific Creativity, Science Process skills, Metacognitive Awareness and Achievement in physics.

Cherif and Verma (2010) made a study to assess student's performance and understanding. The investigator concentrated on the effective understanding of human body organs for deep learning. Student achievement was assessed based on Mc Cormack and Yager's Taxonomy. They found out that this Taxonomy is useful to teachers for evaluating the level of cognitive involvement during learning activities.

A comparative study of Text Book Based Instruction and STS (science, technology and society) based instruction was done by **Ackay and Yager (2010)** in fourth, fifth and sixth grade students. Effect of the two processes was evaluated using Mc. Cormack and Yager's Taxonomy. They found out that there was no difference in the concept Domain but found significant differences in other five domains.

Miranda (2008) conducted a study on Pedagogic Content Knowledge and Technology Teacher education. Researchers found out that Mc Cormack and Yager's Taxonomy was found to be helpful in guiding the field of engineering and technology. Taxonomy of science education put fourth five domains which are arranged hierarchically as, Knowledge, Process, Creativity Attitude and Application. Mc Cormack and Yager's Taxonomy was found to be a good tool for Pedagogical Content Knowledge treatment of engineering curriculum.

According to **Yager (2007),** STS or Science, Technology and society is considered to be an important part of the curriculum. But it is transmitted in a traditional way. Investigator found that when STS is effectively implemented, a science student can obtain all the key concepts of science and technology. The six domains of Mc Cormack and Yager's Taxonomy indicate varying goals of science education. These domains present a hierarchy of science ingredients which can reform science education.

Yager (2007) found out that Mc Cormack and Yager's Taxonomy is useful for STS and it broadened the vision "Science for all". Mc Cormack and Yager defined and explained all the six domains which are important to science. According to them these domains functions as,basis for defining goals, curriculum standards, instruction and assessment.

Veal (1999) made pedagogic content knowledge Taxonomies in which Mc Cormack and Yager's Taxonomy is included. Pedagogic Content Knowledge Taxonomy is a new trend in educational reforms for expertise teaching. It serves as a model for guiding science teacher development.

Melear (1995) investigated creativity and inventiveness in science. In that study the investigator referred Mc. Cormack and Yager's Taxonomy which is comprised of imaging and creating as one among the six domains. This domain is of great help to teachers and students to be creative in teaching and learning process. The study also mentioned the importance of creativity in a classroom with STS focus.

STUDIES RELATED TO SCIENTIFIC ATTITUDE

Ahuja (2017) conducted a study on scientific attitude and science achievement among secondary school students. Descriptive survey method was adopted on 208 secondary school students. Study results showed a positive correlation between scientific attitude and science achievement. Researcher opined that science-teaching strategies developing scientific attitude worked as a determinant of academic performance among students.

Singh & Singh (2017) investigated correlation between Scientific Attitude and scientific interest among IX standard students. Method adopted was normative survey and sample consisted 320 students of Government and Private schools. Study revealed that there is a high positive correlation between scientific attitude and scientific interest.

Kaur et al. (2015) studied achievement in science of secondary school students in relation to gender, locality and scientific attitude. Survey technique was used for the study. 200 twelve standard students were taken by random sampling method from rural and urban areas. Three way analysis of variance was used to analyse the data collected by Scientific Attitude Scale and Science Achievement test. Results showed that there is no significant different in male/ female and rural / urban students in scientific achievement. Achievement in science of students with low, average and high scientific attitude was significant. Three way interaction effects among sex, habitation, and scientific attitude on achievement of science was not significant.

Pradhan (2015) conducted a study on comparing scientific attitude of English medium and Odia medium students. He took 120 tenth standard students, 60 from English and 60 from Odia medium school of Khurda district of Odisha. 't' test and descriptive statistics methods were used to analyse the data. Findings revealed that girls and boys of Odia medium school differ in their scientific Attitude. Girls of Odia medium school have high scientific attitude than boys. There was no significant difference in scientific attitude of boys and girls of English medium schools. And finally, there was no significant difference in the scientific attitude of Odia and English medium students.

Gupta (2015) analysed the influence of area, gender and stream of study on scientific attitude of higher secondary school students. Tools used were scientific Attitude scale and Attitude towards science scale. Findings showed that gender has no effect on scientific attitude and attitude towards science, but stream of study plays an important role in developing scientific attitude and attitude towards science.

Chandrasekharan (2014) made a study to develop scientific Attitude, Critical Thinking and Critical Intelligence of higher secondary school biology student by applying Synetics technique. Eleventh standard students were taken as sample. Control and experimental group were selected randomly from the total sample. Pre test and post test were carried out and the data was analysed by't' test. The study results showed that by synetics model, scientific attitude of the students were developed and enhanced compared to traditional way of teaching.

Nambikkai (2014) conducted a study to find out differences in scientific attitude of secondary school students with respect to gender, locality, religion, educational qualifications and annual income of father. Results showed that (1) There is no significant difference between male and female students in their scientific attitude, (2) There in no significant difference between rural and urban secondary school students in their scientific Attitude. (3) There in no significant relationship between father's educational qualification and their scientific Attitude. (4) There is no significant relationship between father's income and their scientific Attitude. (5)There is no significant relationship between religion and scientific attitude.

Safdar & Shah (2014) undertook a work to construct and validate an instrument to measure scientific attitude of secondary school students. Another objective of the study was to compare the attitude gained through Meaningful Learning Model of Ausabel and traditional method of learning physics. The study extended for 35 weeks. Findings revealed that there is a gain in scientific Attitude, for students taught using Meaningful learning Model than traditional teaching method.

Srivatava (2014) investigated whether achievement in science can predict scientific Attitude in students. 480 Ninth standard students were taken as samples; among them 240 were girls and 240 were boys. Scientific Attitude Questionnaire and Scientific Achievement test were used as tools. Findings of the study showed that knowledge, comprehension and application in science do not contribute to scientific attitude among male students. But female students with comprehension and knowledge in science showed scientific attitude.

Relationship between scientific Attitude and Environmental Awareness among secondary school students was explored by **Srivastava (2013)**. Investigator took IX standard students as sample. Findings of the study showed that scientific attitude of boys was not related to their Environmental awareness. But in case of girls there is a significant relationship between scientific Attitude and Environmental awareness.

Lekshmi & Anjuli (2010) studied the extent to which scientific attitude and scientific aptitude help in improving environmentally sensitive behaviour. They took 480 secondary school students for study. The study revealed that scientific attitude influences environmental practices of children, but scientific aptitude does not influence it. Through curiosity and open mindedness components of scientific Attitude children developed conservation of nature, control of noise pollution and limited use of poly products.

Jancirani, Devakrishnan & Devi (2012) investigated scientific attitude of adolescence students with respect to gender, locality, method of instruction and type of management. By random sampling 300 adolescent students were selected for the study. Scientific Attitude Questionnaire was used to collect data. Analysis was done by mean, standard deviation and 't' test. The study revealed that there is significant difference in the scientific Attitude of adolescent children with respect to gender, locality, medium of instruction and type of management. Scientific attitude of self-financing schools were better than Government and Aided school students.

Pillai (2012) analysed scientific Attitude of higher secondary school students in Virudhanagar district of Tamilnadu. The investigator found out that male and female students significantly differ in their scientific attitude. The study also showed that Government/Private school, Rural/urban school students differ significantly in their scientific Attitude.

Khan et al. (2012) studied the development of scientific Attitude by biology teaching based on Inquiry method. Research design used in the study was pre test-post test experimental control group design. 120 secondary school students learning biology were selected as sample. Control group received, traditional method of teaching and experimental group received, Inquiry method based teaching. Comparison of data was done by t test. Finding showed that enquiry method is more effective for biology teaching for developing scientific Attitude than traditional method.

Pattil (2011) made a comparative study of scientific attitude among secondary level students. 120 students were taken as samples for the study. Mean, standard deviation and ‘t’ test were used to analyze the data. Findings showed that there is significant difference between male and female student of secondary level and higher secondary level is their scientific attitude. Scientific attitude of male students of secondary level and higher secondary level is more than female students of secondary and higher secondary level.

Durga Rani (2007) Identified educational Aspirations and Scientific Attitude of urban students of secondary and higher secondary levels. Findings revealed that higher secondary students show realistic aspirations which are dominant in girls. While students of secondary school showed idealistic educational aspirations, higher secondary school students possess long range aspirations and secondary school students possess short range aspirations. It is also found that scientific attitude has a direct influence on educational aspirations.

Rao (2003) found out that scientific attitude of pupils studying in private schools, rural schools, English medium schools and residential schools was higher than government, urban and Telungu medium school students. Irrespective of their sex, all the pupils hold an average scientific attitude. The study also revealed that school facilities and teaching and learning environment enhances development of scientific attitude in children.

Moore et al. (1997) revised his scientific attitude inventory which was constructed about 25 years ago. He improved readability and gender biased language elements. Number of items was reduced to 40 which were to 60 in older version. Reliability and validity was also established.

Bourn and Ghiselli (1955) examined two persons, one having scientific Attitude and another not having scientific Attitude. After the comparison of those two persons, the investigator found out that one characteristic of scientific Attitude is flexibility. The person having scientific Attitude always tried to improve his beliefs rather to defend it.

John Dewey (1933) explained some important characteristic of scientific attitude as curiosity, fertile imagination and love to experimental enquiry.

STUDIES RELATED TO SCIENTIFIC CREATIVITY

Sri Astutic (2017) studied the effect of scientific creativity test to train secondary student's learning outcome. Investigators made a scientific creativity test to develop scientific creativity skills in students. Effectiveness of the test was measured by achievement test and self assessment. Indicators used in achievement test included, unusual use, technical production, hypothesizing, science imagination, problem solving, creative experiment, science product and scientific creativity. Sample included 140 students and results showed that the test was effective to develop scientific creativity skills.

Kumar & Chahar (2016) conducted a study on the relationship between creativity in science and certain demographic variables of secondary school students. The study found out that there is a significant relationship between each of the components of creativity in science and total creativity in science based on demographic variables like sex, locale and socio economics status.

Grace et al. (2016) conducted a study on secondary school biology teacher's perception of scientific creativity. Research design selected was cross sectional survey. 205 secondary school biology teachers were selected by random sampling method. Data was collected using questionnaire and analysed by descriptive statistics. Result of the study showed that a high percentage of biology teachers have clear perception of general creativity but only a small percentage have correct perception of scientific creativity. Study implication pointed out that teacher education programme should give emphasis on increasing creativity, and curriculum materials and methods should include activities to enhance scientific creativity.

Birgili (2015) made a study on creative and critical thinking skills in problem based learning environment. Researcher analysed, philosophy and characteristics of problem based learning, role of teachers and students, and its advantages and disadvantages. The researcher found out that PBL grounded instructional strategy is a useful approach to inculcate creativity and creative thinking skills.

Hu &Wu (2013) developed an intervention programme named "Learn to think" (LTT) to increase the thinking abilities of secondary and primary students. This article studied the influence and delayed effects of LTT on scientific creativity of secondary school students. Among 107 students 54 participated in LTT and the rest had not. The study lasted for two years. Pre test and delayed post test was conducted. Result showed that LTT promotes development of scientific creativity in secondary school students and effects of scientific creativity are not necessarily immediate but long lasting.

Munakata & Vaidya (2013) studied the philosophy of creativity and its enhancement through an undergraduate research experience. They offer some suggestions for infusing maths and science undergraduate curriculum with research experiences as a way of enhancing creativity in student. Creativity increases a student's scientific thinking, motivation, passion, adaptability, skills and responsibilities. Study findings revealed that the research experiences at the undergraduate level instil a deep sense of learning and make university experiences pleasurable and long lasting.

Meyer (2012) conducted a study on teaching for creativity. He viewed that science teachers often neglect scientific creativity in science classroom. Creativity is put apart for arts and humanities. Some science teachers rarely consider this for gifted students. Teaching for creativity can help students to improve critical thinking skills, motivation and they start to understand the role of creativity in developing new scientific knowledge. The study gives implications on how to modify lessons and labs to promote creativity in class room.

Khan & Khan (2011) conducted a study to find out differences between boys and girls in terms of different aspects of creativity. Sample consisted, 50 boys and 50 girls taken through random selection. The investigator administered Torrence test of creative thinking. ‘t’ test, and standard deviation show that boys do not differ significantly in all the variables of verbal creativity except in the measure of originality from the girls.

Aktamis& Ergin (2008) made a study to test the effectiveness of scientific process skill education to promote scientific creativity, attitudes towards science and achievement in science. Sample consisted of about 40 students of secondary school. Achievement test, Scientific Attitude scale and Scientific Creativity test were employed to collect data. The result of the study showed that scientific process skill education increased student achievement, scientific attitude and scientific creativity when compared with teacher centered method.

Kind (2007) investigated the role of creativity in science education. He viewed that creativity is not fully established as a mainstream topic in psychology and education research. He believed that each school subject should emphasize creativity within the agenda reflecting the characteristics of education. In this study the researcher reviewed common approaches of creativity in science education and summarises by giving certain suggestions for making science education a contributor to develop student's creativity.

Sharma & Shukla (2005) developed a scientific creativity scale and administered it on urban, rural and refuge students of the middle schools in India. The test consisted items related to fluency, flexibility and originality which are the components of scientific creativity. The results showed that lowest scores came from urban pupils and rural pupils scored higher in fluency component than refugees.

Lin et al. (2003) analysed the effect of Cognitive Acceleration through Science Education (CASE) programme on secondary school student's scientific creativity. Scientific creativity test was used to collect data from students. Findings of the study indicated that CASE programme promoted the overall development of scientific creativity but effects on different scientific creativity aspects varied.

Simonton & Kaith (2003) studied creativity as an integration of person, product and process perspectives. According to Simonton, psychologists investigate scientific creativity from two perspectives; correlational studies of a creative person and experimental studies of creative process. A third and new perspective is creative products that emerged from scientific careers and communities of creative scientists. Key findings from both correlational and experimental work strengthens study conclusion. Researcher remarked that for a unified view of scientific creativity, process and product perspectives should be integrated.

Sansanwal and Deepika (2003) conducted a study to found out the relationship between scientific creativity and intelligence. The study inferred that male and female students do not differ significantly in scientific creativity. Interaction of sex and standard do not affect scientific creativity. The study also found that of students belonging to high and low levels of intelligence do not differ significantly, in their creativity.

Hu & Adey (2002) developed a scientific creativity test for secondary school students. Construction of the test was based on the analysis of various aspects of scientific creativity. Findings of the research showed that scientific creativity of secondary school students increases with age and scientific ability is a necessary but not sufficient condition for scientific creativity.

Haneeshia (2001) conducted a comparative study for scientific creativity of students in DPEP and non DPEP schools in the state of Kerala. The study found out that DPEP and non DPEP students differ significantly with components like fluency, flexibility, originality and total creativity.

Unsworth (2001) wrote in his article that most researchers assume that creativity is a unitary concept, without understanding the phenomenon. He argued against this homogeneity of creativity and developed a matrix of four creative types, responsive, expected, contributory and proactive. He explained processes, predictors and new methodologies for the four creative types.

Asmali (1994) investigated the relationship between achievement in science, science interest, scientific attitudes, process outcomes in science and scientific creativity of secondary school students. The correlation coefficient of achievement in science and scientific creativity was found to be significant at 0.01 level.

Misra (1986) investigated the effect of home and school environment on scientific creativity. The results showed that boys and girls do not differ significantly in inquisitiveness, an aspect of scientific creativity. All the significant relations among the variables seemed to vary with respect to intelligence and socio economic status.

Yawalkar (1985) conducted a study on the development of scientific creativity. The main objective of the study was to test the efficiency of two creative teaching techniques namely “Oionics” and Morphological Correlates Analyses. Personality correlates of scientific creativity considered in the study was self reliance, dominance, emotional stability and venturesome. Findings showed that overall scientific creativity tend to dominate in Oionics than Morphological Correlates Analysis.

STUDIES RELATED TO METACOGNITION

Cecilia (2016) explored influence of metacognition training on the academic performance of middle school students. Study was conducted through experimental method on a sample of 180 students of sixth and eighth grades. Intervention sessions were designed and implemented to develop metacognitive skills among students. Researcher used pre and post –qualitative and quantitative assessments along with quarterly grades. Results showed that metacognition and motivation were positively correlated with academic performance. Research findings also showed that sixth grade students showed high levels of metacognition, self efficacy and engagement than eighth graders, with lower levels of anxiety.

Jaleel and Parameswaran (2016) studied Metacognitive Awareness of secondary school students. They administered standardised metacognitive Awareness Inventory on 180 secondary school students of various schools in Kottayam District. Using survey method the investigators found out that secondary school students are identically distributed according to their locale, gender and level of management of the school in Metacognitive Awareness.

Hidayat (2014) conducted a study to test the effect of Metacognitive Awareness and Learning Strategies on student success in distance learning class. Metacognitive Awareness Inventory and Learning strategy questionnaire were used as tools to collect data. Samples considered for the study are 126 under graduate students. Findings revealed that Metacognitive Awareness and Learning strategy has a significant effect on learner's academic success.

Goh & Hu (2014) investigated the relationship between Metacognitive Awareness and Listening Performance. Samples taken for the study are 113 students of higher secondary schools, who took English as their second language. Metacognitive Awareness Questionnaire and Listening Questionnaire were developed as tools for the study. Findings revealed that there is significant positive relationship between metacognitive awareness and listening skill. Study also showed that there is considerable difference in metacognitive awareness among different type of learners.

Sivakumar (2014) conducted a study on metacognitive awareness of, secondary teacher education students in relation to their attitude towards teaching. 300 student teachers were selected by random sampling method. Data was analysed with respect to gender, nativity and age of the students. Results indicated that there is significant difference between male and female students in Metacognitive Awareness and Attitude towards teaching.

Sony (2014) investigated the effect of Metacognitive Interaction for enhancing achievement in economics among secondary school students. Sixty tenth standard students of Government school were taken as sample for the study. Tools used are Metacognition Orientation Frame work and achievement test developed by the investigator. Findings revealed that self-regulative learning enhanced through metacognition increased student achievement in economics, and it helped them to become independent learners.

Wong (2012) analyzed self-regulation, use of Metacognitive skills and punctuality in learning. Metacognitive awareness, Procrastination and Academic performance were found out using questionnaires. Study was conducted on 314 students of two universities of Hong Kong. Findings showed that high Metacognitive Awareness and low Procrastination tendency are two positive elements for academic learning.

Alka (2011) developed a Metacognition Integrated Multimedia Science Package for students at secondary level. Secondary student's Metacognitive Awareness and Metacognitive teaching competency of teachers were found out. The study showed that metacognition integrated multimedia package was useful to secondary school students in enhancing achievement, metacognitive ability and social skills.

Dul (2011) investigated the effect of Metacognitive strategies in achievement and retention for developing writing skills. Study sample was 77students of English language. Experimental group received instruction based on metacognition and control group received traditional method of instruction. Both group were given writing assessment tests as pre test, post test and retention test. Findings revealed that metacognitive strategies contributed much to achievement and retention in writing.

Jayaprabha (2011) found out the effect of Metacognitive instruction in science classrooms. Quasi experimental design was used for the study. Experimental group received metacognitive instruction for

11 weeks. Achievement test was conducted to experimental and control group. Finding revealed that experimental group got more marks in achievement test than control group.

Rahman et al. (2010) made a study to test the impact of Metacognitive Awareness on student performance. A sample of 90 students of tenth standard was taken for the study. Metacognitive Awareness Inventory and Chemistry achievement test were used as tools for the study. Findings showed the existence of correlation between metacognitive awareness and academic performance of students. The study also showed that male and female students do not differ significantly in their metacognitive awareness.

Zohar & David (2010) undertook a study on the contribution of Metacognitive strategies in Scientific Enquiry Learning. The result showed that teaching of metacognitive strategies had a stronger effect for low achieving students than for high achieving students through scientific enquiry learning practices.

Choube (2009) studied the influence of constructivist approach on problem solving and metacognitive skills of science students at secondary level. Using reflective skills and metacognitive skills students define, plan and self monitor their thinking during problem solving. Findings showed that constructivist approach enhanced the metacognitive skills of students in science through problem solving approaches.

Young and Fry (2008) made a study to use Metacognitive Awareness Inventory to measure how much it is related to academic achievement of the college students. It was a correlation study between end of course grades, cumulative GPA and MAI. They found that there was a significant difference between graduate and undergraduate students on the regulation of cognition but not on knowledge of cognition.

Nair, (2014) made a study on the impact of various learning styles and metacognition upon the methods of teaching especially in secondary school students. Tools used were a questionnaire related to teaching and learning styles. Study took a sample of 5000 students of all type of schools. Findings showed that thought promoting learning styles and metacognition, influenced students positively.

Shabaya (2005) conducted a study on the role of service teachers in developing metacognitive Awareness strategies in language and arts writing .It was a qualitative study to assess development of metacognitive awareness strategies among high school. Student samples taken are pre service teachers and high school students. Study revealed the following results. (1) Student's self perceptions changes as writers (2) Development of metacognitive awareness (3) Development of metacognitive awareness is different in different students. (4) Four different writing approaches yield effective writing instruction.

Conclusion

Since the inception of educational taxonomies, various researchers have attempted to gain a better understanding of the educational objectives and how it can best contribute to teacher preparation. The value of using educational taxonomies in the development of science related learning outcomes among secondary school students represents a tool for planning, implementing and assessing instruction. Educational taxonomy provides educators with a common frame of reference that classifies various types of learning outcomes. As the studies conducted under Revised Bloom's Taxonomy and Mc Cormack and Yager's taxonomy are very few the investigator could not include much reviews in that area. The realizations that emerged from thorough analysis of the research reviews set the stage for framing the present study of its kind and for developing strategies for promoting attainment of science related learning outcomes through the adoption of a proper educational taxonomy among secondary school students.

Chapter III

METHODOLOGY

- Design of the Study
- Variables of the Study
- Tools Used for Data Collection
- Sample Selected for the Study
- Data Collection Procedure
- Scoring and Consolidation of Data
- Statistical Techniques Used

Scientific method of collecting data and analysis of that data for getting the accurate results determine the quality of research. Research methodology contains systematic procedures through which a researcher leads from identification of the problem to the final conclusion. The role of methodology is to carry on the research work in a scientific and valid manner. This is a carefully planned quantitative research using experimental method.

The present study entitled 'Effectiveness of an instruction based on SOLO Taxonomy, Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on certain learning outcomes of secondary school students, attempts to study influence of three independent variable on three dependent variables, Scientific attitude, Scientific Creativity and Metacognitive Awareness of secondary school students. The methodology followed for the study is described under the following major headings.

Design of the study

Variables of the study

Tools used for data collection

Sample selected for the study

Data collection procedure

Scoring and consolidation of data

Statistical Techniques used

Design of the study

Research design is a conceptual framework within which research could be conducted. As the main purpose of the study is to compare the effectiveness of an instruction based on SOLO taxonomy, Bloom's Taxonomy and Mc Cormack and Yager's taxonomy on certain learning outcomes of secondary school students of Kerala , experimental method was adopted for the study.

Experimental method is used in settings where variables defining one or more causes can be manipulated in a systematic fashion in order to discern effects on other variables. “Experimental method is the description and the analysis of what will be or what will occur under carefully controlled conditions” (Best, 2009). It establishes a logical association between manipulated facts and observed effects.

For the present study, the researcher used a Quasi Experimental Research Design and in it, the Pre-test Post-test Non Equivalent Groups Design is chosen. This design is often used in classroom experiments; when experimental groups are such naturally arranged groups as intact classes. In this design, the investigator has three experimental groups; Experimental Group I taught through SOLO Taxonomy, Experimental Group II, taught through Revised Bloom’s Taxonomy, and Experimental Group III taught through Mc Cormack and Yager’s Taxonomy. After giving pre tests to all three groups, experimental treatment is administered to three groups and then followed by Post tests. The difference between pre test and post tests scores are compared with the help of appropriate statistical techniques to ascertain the effect of the independent variables.

Variables of the Study

The present study is designed to assess the effectiveness of instruction based on SOLO taxonomy, Revised Bloom’s taxonomy and Mc Cormack and Yager’s taxonomy on three learning outcomes, Scientific Attitude, Scientific creativity and Metacognitive Awareness of secondary school students. The independent variables and dependent variables selected for the study are the following:

Independent variables

Instructional procedure was taken as the independent variable, with the following levels of treatment.

a) SOLO taxonomy
b) Revised Bloom's Taxonomy
c) Mc Cormack and Yager's Taxonomy

Dependent Variables

1. Scientific attitude
2. Scientific creativity
3. Metacognitive Awareness

Control Variable

1. Previous achievement
2. General Intelligence

Tools used for data collection

Investigator used the following tools for collecting data for the study.

1. Raven's standard progressive matrices for testing the general intelligence of secondary school students.
2. Scientific Attitude Test for testing the scientific attitude of Secondary School Students (Meera and Revati,2016)
3. Scientific Creativity Test for testing the Scientific Creativity of Secondary School Students (Weiping Hu & Philip Adey, 2002)
4. Metacognitive Awareness Inventory for testing the Metacognitive Awareness of Secondary School Students (Meera and Revati,2016)
5. Lesson transcripts based on SOLO Taxonomy for teaching science lessons of VIII standard (Meera and Revati,2016)

6. Lesson transcripts based on Revised Bloom's Taxonomy for teaching science lessons of VIII standard (Meera and Revati,2016)
7. Lesson transcripts based on Mc Cormack and Yager's Taxonomy for teaching science lessons of VIII standard (Meera and Revati,2016)

Description of Tools

Selection of appropriate tools is very essential for any type of study. The tools used should be reliable and valid and then only the study will give accurate measurement of the variables under investigation. The details regarding the tools used for the study are given below

Raven's Standard Progressive Matrices

Raven's Standard Progressive Matrices is a widely used non verbal intelligence test. It measures a person's ability to form perceptual relations and to reason by analogy, independent language and formal schooling, and may be used with persons ranging in age from six years to adult. The Standard Progressive Matrices was designed to find out two complimentary components of general intelligence, the educative ability and reproduction ability. Educative ability is the ability to think clearly and make sense of complex data and reproductive ability is the ability to store and reproduce information.

Raven's Standard Progressive Matrices consists of non verbal multiple choice tests of abstract reasoning. It asses a person's capacity to observe meaningless figures, see the relation between them, imagine the nature of the figure completing each system of relations, thus developing a systematic method of reasoning. This non verbal test consists of 60 items arranged in five sets (A, B, C, D and E) of 12 items each. The person taking the test has to select the one that most logically fits the missing part from the six or eight options provided. Each set of figure is presented with a principle or theme, by which the child can obtain the missing piece. Within each set, items are arranged in the order of increasing difficulty. Maximum score is 60 and score of a person taking the test is the total number of item answered correctly. The total score obtained by a student is considered as the Non Verbal Intelligence Score.

According to Raven, validity estimated varied from .50 to .80 and the reliability coefficients of the test varied from .80 to .90. In the present study, internal consistency of the test was established by calculating Cronbach's alpha and the obtained alpha (N=100) for the total test is .81. The calculated alpha for the sub tests ABCD and E are .87,.85,.83,.82 and .76 respectively. It is a reliable and valid tool, well established to measure Non Verbal Intelligence.

Scientific Attitude Scale

According to Vaidya (1971) "Scientific attitude is a set of emotionally toned ideas about science and scientific methods, and is directly or indirectly related to a course of action". Scientific attitude scale is a tool aimed to assess the range of science correlated attitudes among students. Science teaching should aim at developing scientific attitude common to scientists than following a particular method. While children practice and observe science they feel and develop different components of scientific attitude. Students who have positive attitude towards science, show increased attention to classroom instruction and participate more in science related activities (Germann, 1988, Jarvis & Pell, 2004). Comte (1830) had identified scientific attitude as the highest level of intellectual insight. To measure scientific Attitude of secondary school students, investigator decided to administer a scientific attitude scale. For that, the investigator prepared a Scientific Attitude Scale .The scale was prepared by following Likert method and is a five point scale.

Preparation of the items

The first step followed in the tool preparation was the identification of the areas which can interpret the scientific attitude of secondary school students. A five point Likert type Scale on Scientific Attitude was prepared for obtaining data from secondary school students. As a preliminary step , the item for the draft attitude scale was prepared after a thorough review of relevant literature and also with the advice of experts in the field of science and research.. After discussion with the experts in the field of science education 70 statements of both negative and positive were prepared and it was given to another group of experts for criticism and suggestions. As per the suggestions received, some of the statements were deleted and others were modified. Thus the edited draft consists of 64 items. These 64 items are arranged randomly. Sufficient space is provided against statements for entering the response in the scale itself.

The first part consists of general information regarding the secondary school students, such as Name of the student, Name of the school, Class number and Standard with division. Necessary instructions were given to help the respondents in filling the scale.

The second part of the scale deals with statements to test the Scientific Attitude of secondary school students. This part includes Scientific Attitude of secondary school students towards various dimensions like, Rationality, Curiosity, Open-mindedness, Aversion to Superstition, Objectivity of Intellectual belief and Suspended judgement. Description of the data collected under these heads is detailed below.

Rationality

Children having Scientific Attitude is critical minded in their behaviour. They look for consistency and challenges the validity of statements and consults number of authorities before reaching a conclusion. A total of 7 statements are incorporated under this head. Among these 2 were negative and 5 were positive.

Example: It is often said that science can provide answers to anything we want to know.

Curiosity

Curiosity is one of the fundamental attitude that a science student should posses. Every individual has an urge to know and understand the natural world. This urge of a student to study how things in the natural world works, why and what factors affect it etc. are coming under this. Under this dimension 18 statements were prepared out of which, 15 are positive statements and 3 are negative statements.

Example: I would like to find clarifications wherever I feel doubts about scientific facts.

Open mindedness

This characteristic of scientific attitude considers several possible alternatives when investigating a problem and considers and evaluates ideas presented by others. An open minded person can modify and discard hypotheses if necessary. There are 9 statements under this head. Of these 4 are negative and five are positive

Examp: I always like to appreciate the hard work and dedication of scientists.

Aversion to superstition

An individual having Scientific attitude will always prefer experimental evidence and scientific explanation. He rejects superstition and accepts science paradigms out of an appreciation for the power of reality based knowledge. There are 13 statements under this dimension .Among them one is positive and all others are negative statements.

Example: I believe in superstitions which my parents follow.

Objectivity of intellectual beliefs

Displaying intellectual honesty in all works is one of the components of Scientific Attitude. A person who is engaged in scientific investigation reports all evidences even when it contradicts with the hypothesis formulated and acknowledges the work of others. There are 10 statements under this head, of which 4 are negative and six are positive.

Example: I will change my opinion about a scientific fact on the basis of sufficient evidence.

Suspended judgment

This is another component of scientific attitude which recognizes the restricted nature of evidence and concept. A person having this nature will never become hurry to form an opinion on a given issue until he had investigated in it, because it is very difficult to give up an opinion already formed. This strategy makes one to find more facts or evidence to support the opinions. Under this component of Scientific Attitude, 7 statements were included in the scale, where 2 among them are negative and five among them are positive.

Example: It is good to go for clarification before approving an idea.

Component wise distribution of the draft scale is presented below.

Table 1

Component wise distribution of the Items in the draft scale on Scientific Attitude of Secondary school students

Sl No.	Components	Item numbers
1	Rationality	1, 2, 29, 34, 36, 52, 64
2	Curiosity	5, 7, 10, 12, 14, 16, 21, 26, 30, 38, 41, 48, 49, 56, 59, 60, 61
3	Open mindedness	13, 24, 37, 43, 45, 47, 54, 55, 58
4	Aversion to Superstition	3,8,9,15,17,22,27,28,31,33,42,44
5	Objectivity of Intellectual beliefs	4,6,18,23,32,39,46,51,53,62
6	Suspended judgment	19, 20, 25, 35, 50, 57

Try out of the Tool

The draft scale of scientific Attitude was tried out on a sample of 150 secondary school students. The investigator contacted the Principals of two Secondary Schools for getting permission to collect data. After obtaining permission from the Principals, the Scientific Attitude Scale was administered to Secondary School Students.

Each of the statement in the Scientific Attitude Scale expresses a feeling which a particular people have towards science. Students have to express the extent of agreement between the feeling expressed in each statement and their own feeling on a five point scale. They have to put a tick mark (✓) against columns of each statement and your own feeling. A time of one hour was allotted for completing the test .The five points are strongly agree, agree, undecided, disagree, and strongly agree. The sheets were scored using the scoring scheme. For each positive item, a score of '5' was given to the response 'Strongly Agree', a score of '4' was given to the response 'Agree', a score of '3' was given to the response of 'Undecided', a score of '2' was given to the response 'Disagree' and a score of '1' was given to the response 'Strongly Disagree'. Reverse scoring procedure was adopted for negative items. The scores of individual items were summed to give total scores for the try out session.

Item Analysis

For the finalisation of the Scientific Attitude Scale, item analysis was done. The procedure suggested by Edwards (1957) was followed. The scored response sheets were arranged in the descending order on the basis of scores obtained. Then the subjects having the top 27% and low 27% scores were taken as high and low group respectively. Items were selected by finding out the 't' value of each statement.

Then the numerical values of mean responses to each item were calculated the critical ratio 't' using the formula (Edwards, 1957, p.153).

$$t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\frac{\Sigma(X_H - \bar{X}_H)^2 + \Sigma(X_L - \bar{X}_L)^2}{N(N-1)}}}$$

Where,

$\overline{X_H}$ = Mean score for the given students of higher group

$\overline{X_L}$ = Mean score for the given students of lower group

X_H = Score of an individual for a given statement in higher group

X_L = Score of an individual for a given statement in lower group

N = Number of students in criterion group

Table 2

The ‘t’ value of the data obtained from Item Analysis

Item No	t value	Item selected	Item No	t value	Item selected
3	3.261*	Accepted	35	1.656	Rejected
4	1.398	Rejected	36	4.655*	Accepted
5	4.382*	Accepted	37	3.307*	Accepted
6	.446	Rejected	38	2.74*	Accepted
7	4.560*	Accepted	39	.972	Rejected
8	5.799	Accepted	40	5.821*	Accepted
9	3.512*	Accepted	41	3.518*	Accepted
10	5.083*	Accepted	42	1.878	Rejected
11	.562	Rejected	43	1.581	Rejected
12	3.161*	Accepted	44	3.396*	Accepted
13	3.965*	Accepted	45	1.336	Rejected
14	4.321*	Accepted	46	3.039*	Accepted
15	3.185*	Accepted	47	2.672*	Accepted
16	4.132*	Accepted	48	2.763*	Accepted
17	1.518	Rejected	49	2.377*	Accepted
18	.851	Rejected	50	2.018*	Accepted
19	.182	Rejected	51	2.546*	Accepted
20	6.209*	Accepted	52	3.453*	Accepted
21	2.365*	Accepted	53	.596	Rejected
22	3.427*	Accepted	54	.838	Rejected
23	4.762*	Accepted	55	2.452*	Accepted
24	5.107*	Accepted	56	2.500*	Accepted
25	2.216*	Accepted	57	1.357	Rejected
26	3.166*	Accepted	58	2.500*	Accepted
27	1.482	Rejected	59	3.606*	Accepted
28	.406	Rejected	60	2.449*	Accepted
29	1.728	Rejected	61	2.691*	Accepted
30	5.091*	Accepted	62	1.077	Rejected
31	3.998*	Accepted	63	1.996*	Accepted
32	.238	Rejected	64	1.154	Rejected
33	4.344*	Accepted			
34	.952	Rejected			

*indicates items selected for the final scale.

There were 64 statements in the draft scale on Scientific Attitude. According to Edwards (1957) statements with 't' value equal to or greater than 1.96 at 0.05 level can be selected. So the investigator selected 41 statements in the final scale and rejected 23 statements. Thus the final scale on Scientific Attitude consisted of 41 statements. Positive statements include 1, 5, 10, 12, 14, 16, 25, 26, 30, 37, 38, 46, 47, 48, 49, 50, 51, 52, 55, 56, 58, 59, 60, 61, 63 and negative statements include 3, 7, 9, 13, 15, 20, 21, 22, 23, 24, 31, 33, 36, 40, 41, 44. The final copy of Malayalam and English versions of the Scientific Attitude scale was attached in the Appendix II A and II B.

Reliability

Reliability refers to the extent to which the responses or behaviour made by individuals are consistent across items, settings, raters or time. In the present study, the reliability was found using test retest method. For this purpose the Scientific Attitude was administered twice with a time interval of 15 days to a sample of 100 children. The reliability coefficient for Scientific Attitude was found to be 0.78.

Validity

For establishing content validity, the investigator, defined the construct, then identified the domains of the construct, and developed a pool of items. The content validity shows the adequacy of the content of the test. This form of validity is estimated by evaluating the relevance of the test item individually and as a whole. The items in the scales are based on the review of related literature and the tools already available, also the logical examination of statements . The items of this tool are based on the Scientific Attitude under 6 major components. After careful examination of the items, some statements were modified, and are subjected to expert item analysis. Their suggestions have been taken into account to enhance the content and quality of items. In view of the changes made in the language, content coverage and format of the items, it can be said that, the scale used for the study has content validity.

Face validity is the term used to characterise test materials that appear to measure what the test desires to measure and appears to those it is meant, to experts, examiners, educationists and the like ie, the test items should be related to the variable that is being measured. It is clear that, all the items in the respective tool measure the specific variable under study ie, Scientific Attitude. The investigator established construct validity by correlating the scores obtained by 100 students in Scientific Attitude Scale prepared by the investigator with another standardised Scientific Attitude scale having the same test content. Then the coefficient of correlation between two scores was found out to be 0.79 which indicated that the scientific attitude scale made by the investigator has construct validity.

Scientific Creativity Test

Scientific Creativity is an intellectual trait or ability for producing a product or an idea which is original and has personal or social value, designed with a purpose in mind, using given information. In the present study for measuring the Scientific Creativity of secondary school students, the investigator adopted Scientific Creativity Test developed by Weiping Hu and Philip Adey (2002). There are many Tests available for testing Scientific Creativity, but majority of the tests demand awareness about a vast area of scientific knowledge, so they cannot be used for testing among secondary school students whose knowledge is limited. Scientific creativity Test by Weiping Hu and Philip Adey was proved to be one of the best tests available for testing Scientific Creativity of all secondary school students at different age in different cultures.

Description of the test

The test is meant for group administration. There are seven items to which students have to give their responses. Time allotted for the test is one hour. At the first part of the test there is instruction for the pupil on how to approach the seven tasks. The investigator gives necessary directions to students that there are seven different tasks based on science to which each student has to explore their creativity for solving those tasks. Pupils were asked to write their Name, School, and Class on the answer sheets before beginning the test. For items 1 to 4 one example is given for helping the students for understanding what type of answer is expected from them. Seven items and descriptions are given below.

Item 1

Write down as many as possible uses as you can for a piece of glass.

For example, make a test tube.

This task is about unusual uses; and tests fluency, flexibility and originality and thinking components of Scientific Creativity.

Item 2

If you can take a space ship to travel in the outer space and go to a planet, what scientific questions do you want to research? List as many as you can.

For example, are there any living things on the planet?

This task tests the degree of imagination a science student should have for making advancements in science. It measures sensitivity towards science problems. Scores were given to flexibility, fluency and originality.

Item 3

Think up as many possible improvements as you can to a bicycle, making it more interesting, more useful and more beautiful.

For example, make the tyres reflective so that they can be seen in dark.

This task is to measure a student's ability to improve a technical product. Investigator used bicycle here because of its familiarity with secondary school students. This item also scored for fluency, flexibility and originality.

Item 4

Suppose there is no gravity, describe what the world would be like?

For example, human beings would be floating.

This task measure a student's scientific imagination, This also measures fluency, flexibility and originality.

Item 5

Use as many possible methods as you can to divide a square into four equal pieces of same shape. Draw it on the answer sheet.

This task measures creative science problem solving ability of a student. It measures flexibility, originality, thinking and imagination.

Item 6

There are two different kinds of cloths. How can you test which is better?

Write down as many possible methods as you can and the instruments, principles and procedures.

Creative experimental ability is measured by this task. Pupil becomes engaged in creative scientific activity. It scores flexibility, originality and thinking.

Item 7

Design an apple picking machine. Draw a picture and point out the name and function of the parts.

This task measures a student's ability to design a creative science product. Scores were given to flexibility, originality, thinking and imagination.

Scoring Procedure

According to Weiping and Adey (2002) scoring procedure of items 1 to 4 is the sum of the fluency, flexibility and originality score. Flexibility is the approaches or areas used in the answer, fluency is the separate responses given, and originality is the frequency of the responses. If the probability of the response is smaller than 5%; 2 points, if between 5 to 10 % 1 point, and if it is greater than 10% ,0 point. For task 5 the investigator tabulates all the answers and tests its originality value. If the probability is less than 5% it gets 3 points, if it is from 5 to 10;2 points, and if it is more than 10% 1 point. Item six scores both flexibility and originality. Flexibility scores maximum 9 points; 3 points each for instruments, principle and procedure. For scoring originality; if the occurrence of the method is less than 5%;4 points ,if it is between 5 to 10% it gets 2 points and if the probability is greater than 10 % ;0 point. For scoring task seven, each machine function gets 3 points, and for originality, a score of 1 to 5 based on the overall impression of the script.

Validity and reliability of the Tool

The test manual provides evidence of the validity by conducting tests for two aspects of validity, construct validity and face validity. According to Guiford (1956), first step of validating Creativity test should be finding out factorial validity, a form of construct validity. Factorial validity is determined by factor analysis of test scores. The results showed that the test has good construct related validity considering one factor Scientific Creativity. For determining face validity, tool was given to experts and researchers in the field of education .The results showed a high degree of face validity.

According to the test manual, reliability of the test was investigated by two methods. Pearson's Product Moment correlation was calculated between each item and between each item and total score. Calculations showed that, correlations between items vary from moderate .345 to high, 729. Correlations between items and total score vary from .654 to .829, which is high, and these coefficients are significant at 0.01 level. Another method to test reliability is to calculate Cronbach Alpha Coefficient of internal consistency. The alpha value got from scores of 160 secondary school students is .893 which is very satisfactory for a test with only seven items.

The investigator established the reliability of the test for the present study by using test retest method and obtained a reliability coefficient 0.731. The test has been revalidated against B. Mehdi's Verbal Test of Scientific Creative thinking, prepared by Dr. U.P. Sharma and Dr. J. P. Shukla (2005) as an external criterion on a sample of 50 students of VIII standard. There are seven different tasks in the test which have to be answered in 60 minutes. One model of answers was provided after each question to clarify the mode of responses expected from the students and are asked to raise their hands for clearing doubts. Students should write their class, name, and sex in the answer sheets. The obtained correlation coefficient was 0.47. Since the test has proved to possess sufficient validity and reliability, it is suitable for assessing Scientific Creativity of Secondary school students. Scientific Creativity Test in English and Malayalam versions are presented as appendix III A and III B

Metacognitive Awareness Inventory

For measuring the metacognitive awareness of secondary school students, a metacognitive awareness inventory was constructed and standardised by the investigator. Metacognition is a word denoting awareness of one's own thoughts. It enables a student to become a successful learner and is associated with intelligence. Metacognition is a higher order thinking skill involving active control on cognitive process while learning occurs. It is the "thinking about thinking" helping learners in learning how to learn. Metacognitive practices enhance student abilities to apply their learning in new contexts (Brown 1987). Metacognition helps students to recognize their strength and weakness in every field of their life. This knowledge will help them to expand the extent of their ability. According to Bransford (2000) “those who know, strength and weakness in their areas will be more likely to actively monitor their learning strategies and resources and assess their readiness for particular tasks and performances”.

Components of Metacognition

Metacognition is classified into three components, metacognitive knowledge or metacognitive awareness, metacognitive regulation and metacognitive experiences. Description of each component and example of items included under each component are given below.

Metacognitive knowledge or metacognitive awareness

Metacognitive knowledge is what individuals know about themselves and others as cognitive processors. It is divided in to three categories; knowledge of person variables, task variables and strategy variables. Flavell stated that all these variables overlap and combine when an individual works. Result of that work is due to the interactions of the various variables and metacognitive knowledge available at that particular time. Metacognitive awareness is of three types.

Declarative knowledge

It is also known as world knowledge or factual knowledge. It is the knowledge about the factors which can influence one’s own learning or performance. This category includes knowledge about one’s skills, intellectual resources and abilities as a learner. Pupil acquires knowledge through presentations, demonstrations and discussions. Under this component, there are 9 statements.

Example: I know which information should get more importance during the learning process

Procedural knowledge

It is the knowledge about how to do something. One who possesses a clear procedural knowledge can perform the tasks automatically. This is done by effective use of various strategies. This involves abilities like identifying the task, checking the progress of task, evaluating, predicting the outcome, allocating of one's own resources for the task , determination of order or sequences of activities for the completion of task etc. This head includes 7 statements in the inventory.

Example: According to the nature of the content, I use different learning methods

Conditional knowledge:

It is the knowledge about when and why to use declarative and procedural knowledge. This knowledge helps the students to use strategies more effectively. This allows maximum utilization of their resources for learning. There are 8 statements in the scale under this sub component.

Example: I learn best when I have familiarity with the topic

Metacognitive regulation

This is the second component of metacognition. It refers to the monitoring and control of one's cognitive process during learning (Nelson & Narens, 1994). Through this one can regulate one's own cognition and experiences related to learning through prescribed activities. This includes activities like; oversee learning, planning and monitoring activities related to cognition, monitoring the outcomes etc. The sub components coming under metacognitive regulation is planning, information management strategies, comprehension monitoring, de bugging strategies and evaluation.

Planning

This involves cognitive activities done prior to learning like, planning, goal setting, collecting resources etc. There are 9 statements under this sub component.

Example: I always internalise an idea of what I have to learn before I start my learning

Information management strategies

This involves effective sequencing and processing of information, which is a key element of metacognition. Some activities are organising, elaborating, summarising and selective focussing. 14 statements are included under this category of subcomponent.

Example: I know which information should get more importance during the learning process.

Comprehension Monitoring

It is self evaluation or assessment of one's own learning or use of a particular strategy. 7 statements are included in the inventory under this subcomponent.

Example: I periodically review important topics for better understanding.

Debugging Strategies

This is the diagnosis and remediation of one's own strategy use. This is used to correct comprehension and performance errors. 7 items were incorporated under this subcomponent

Example: I often use certain memory tricks to remember points which are difficult to memorise

Evaluation:

This is the evaluation of performance and strategy used, after a learning episode. 8 items are included in the inventory under this sub component.

Example: I always try to find out the reason behind my failures, so that I can improve next time by rectifying it.

Table 4.3

Component wise distribution of the Items in the draft inventory on Metacognitive Awareness of Secondary school students

Components of Metacognition	Sub Components	Item Numbers
Metacognitive Knowledge	Procedural Knowledge	2,4,9,18,19,20,25,31,40
	Declarative Knowledge	3.16.46.48.54.55.60
	Conditional Knowledge	17,26,27,28,41,47,53,69
Metacognitive Regulation	Planning	5,8,10,12,22,42,57,61,67
	Information Management Strategies	1,13,14,15,29,30,33,35,37, 52,56,62,63,68
	Comprehension Monitoring	6,21,34,38,43,49,59
	Debugging Strategies	24,36,44,45,50,65,66

Try out of the Tool

The draft inventory of Metacognitive Awareness was tried out on a sample of 150 secondary school students. The investigator contacted the Principals of two Secondary Schools for getting permission to collect data. After obtaining permission from the Principals, Metacognitive Awareness Inventory was administered to Secondary School Students.

Each statement in the inventory expresses student's awareness about their learning process. Students have to express the extent of agreement between the feeling expressed in the inventory and their own feeling by putting a tick mark on a five point scale. The five points are, always, very often , sometimes, rarely and never. 60 minutes was allotted to students for completing the test. The sheets were scored using the scoring scheme 5 for always, 4 for very often , 3 for sometimes, 2 for rarely, 1 for never. Reverse scoring procedure was adopted for negative items. The scores of individual items were summed up to give total scores for the try out session.

Finalisation of the Tool

For the finalisation of the Metacognitive Awareness Inventory, item analysis was done. The procedure suggested by Edwards (1957) was followed. The scored response sheets were arranged in the descending order on the basis of scores obtained. Then the subjects having the top 27% and low 27% scores were taken as high and low group respectively. Items were selected by finding out the't' value of each statement.

Then the numerical values of mean responses to each item were calculated the critical ratio 't' using the formula (Edwards, 1957, p.153).

$$t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\frac{\Sigma(X_H - \bar{X}_H)^2 + \Sigma(X_L - \bar{X}_L)^2}{N(N-1)}}}$$

Where,

$\overline{X_H}$ = Mean score for the given students of higher group

$\overline{X_L}$ = Mean score for the given students of lower group

X_H = Score of an individual for a given statement in higher group

X_L = Score of an individual for a given statement in lower group

N = Number of students in criterion group

Table 4.4

The t value of the data obtained from Item Analysis

Sl .No	t Value		Sl .No	t Value	
1	*3.649	Accepted	36	*3.889	Accepted
2	*4.228	Accepted	37	*3.606	Accepted
3	.679	Rejected	38	*4.508	Accepted
4	*2.848	Accepted	39	*6.629	Accepted
5	*4.271	Accepted	40	*5.209	Accepted
6	*2.003	Accepted	41	*4.526	Accepted
7	*4.837	Accepted	42	*2.656	Accepted
8	*3.723	Accepted	43	*4.075	Accepted
9	*3.049	Accepted	44	*5.380	Accepted
10	*4.122	Accepted	45	*5.330	Accepted
11	*2.563	Accepted	46	*4.438	Accepted
12	*4.460	Accepted	47	*4.997	Accepted
13	*3.889	Accepted	48	*3.812	Accepted
14	*4.253	Accepted	49	*3.349	Accepted
15	*4.270	Accepted	50	*4.687	Accepted
16	*5.498	Accepted	51	*5.589	Accepted
17	*3.530	Accepted	52	*3.937	Accepted
18	*4.347	Accepted	53	*5.021	Accepted
19	*4.544	Accepted	54	*4.963	Accepted
20	*2.206	Accepted	55	*3.965	Accepted
21	*5.370	Accepted	56	*4.352	Accepted
22	*3.889	Accepted	57	*2.714	Accepted
23	*4.191	Accepted	58	*5.586	Accepted
24	*2.050	Accepted	59	*3.268	Accepted
25	.242	Rejected	60	*7.182	Accepted
26	*5.035	Accepted	61	*4.293	Accepted
27	*3.519	Accepted	62	*3.507	Accepted
28	*4.350	Accepted	63	*6.862	Accepted
29	*3.623	Accepted	64	1.339	Rejected
30	*4.960	Accepted	65	*4.326	Accepted
31	*4.737	Accepted	66	*3.674	Accepted
32	*5.353	Accepted	67	*2.598	Accepted
33	*5.455	Accepted	68	*3.709	Accepted
34	*5.089	Accepted	69	*4.721	Accepted
35	*6.099	Accepted			

*indicates items selected for the final scale.

There were 69 statements in the draft scale on Metacognitive Awareness. According to Edwards (1957) statements with‘t’ value equal to or greater than 1.96 at 0.05 level can be selected. So the investigator selected 66 statements in the final scale and rejected 3 statements. Thus the final inventory on Metacognitive Awareness consisted of 66 statements. All the statements were positive. The final copy of the Malayalam and English versions of Metacognitive Awareness Inventory was attached in the Appendix V A and V B respectively.

Reliability

Reliability refers to the extent to which the responses or behaviour made by individuals are consistent across items, settings, raters or time. In the present study, the reliability was found using test-retest method. For this purpose, the Metacognitive Awareness Inventory was administered twice with a time interval of 15 days to a sample of 100 children. The reliability coefficient for metacognitive awareness was found to be 0.76.

Validity

For establishing content validity, the investigator, defined the construct, then identified the domains of the construct, and developed a pool of items. The content validity shows the adequacy of the content of the test. This form of validity is estimated by evaluating the relevance of the test item individually and as a whole. The items in the inventory were based on the review of related literature and the tools already available, also the logical examination of statements . The items of this tool were based on the Metacognitive Awareness under two major components, and eight sub components..After careful examination of the items, some statements were modified, and are subjected to expert item analysis. Their suggestions have been taken into account to enhance the content and quality of items. In view of the changes made in the language, content coverage and format of the items, it can be said that, the inventory used for the study has content validity.

Face validity is the term used to characterise test materials that appear to measure what the test desires to measure and appears to those it is meant, to experts, examiners educationists and the like ie, the test items should be related to the variable that is being measured. It is clear that, all the items in the respective tool measure the specific variable under study ie, Metacognitive Awareness. The investigator established construct validity by correlating the scores obtained by 100 students in Metacognitive Awareness Inventory prepared by the investigator with another standardised Metacognitive Awareness Inventory having the same test content. Then the coefficient of correlation between two scores were found out to be 0.77 which indicated that the Metacognitive Awareness Inventory made by the investigator has construct validity.

Lesson transcripts based on SOLO Taxonomy

Lesson transcripts based on SOLO Taxonomy was prepared by the investigator in consultation with the subject experts from various Universities of Kerala, DIET and SCERT. The topics were selected from the VIII Standard Science Text book following Kerala Syllabus. The units selected for preparing the lesson transcripts were, 'Let's regain our fields' and 'Why classification'.

From the unit 'Let's Regain Our Fields' seventeen lesson transcripts were prepared based on the topics-Food safety and Crises in Agriculture, Crises in Agricultural Sector, Fertile soil the basis of food security, Microbes that provide fertilizers, Pest control, Integrated pest management, Waste management and sustainable agriculture, Livestock management, poultry farming and sericulture, Pisciculture, floriculture and apiculture, Cuniculture, mushroom culture and horticulture, Medicinal plant cultivation ,Polyhouse farming and precision farming, Cultivation without soil, Native varieties for tomorrow, Supporting organisations ,Possibilities to overcome crises in agriculture.

From the unit ‘Why classification’, seven lesson plans were prepared based on the topics – Criteria for classifying organisms, Taxonomy and taxonomic keys, Contributions of scientists in the history of taxonomy, Taxonomic hierarchy, Binomial Nomenclature, Five Kingdom classification, Modern trends in taxonomy.

Thus overall twenty four lesson transcripts based on three units were prepared based on the five levels of SOLO Taxonomy. The format of the lesson transcripts based on SOLO Taxonomy is given below.

1. General Information
2. Content overview
3. Content Analysis
4. Learning outcome levels of SOLO Taxonomy
5. Learning strategies
6. Pre requisites
7. Learning Materials
8. Class room procedures
9. Follow up activities.

1. General Information

General information includes, Name of the teacher, Name of the school, Standard, Subject, Unit, Name of the lesson etc.

2. Content overview

Content overview explains the topics and subtopics in the lesson.

3. Content Analysis

Content Analysis covers terms, facts and concepts in the lesson.

4. Learning outcome levels of SOLO Taxonomy

Pre structural

In this level students understanding, or existing knowledge is limited or nonexistent, or the task is approached from a different angle. Students before beginning to learn a particular concept may not have an idea of the concept. Sometimes they have a vague or wrong idea of the learning material. When teacher introduces the lesson, tests pre requisites needed to learn the lesson .Thus during the introduction teacher makes students aware about the idea they have, about the concept and parts of knowledge they should acquire to make the concept clear. This strategy helps them to become internally motivated to learn the particular lesson themselves.

Uni-structural

In this level students might know one key piece of knowledge but they are unable to connect it to anything else in this level. This is also a beginning stage of learning where a student knows single fact related to the concept. He is not aware or clear about other facts of the concept.

Multi-structural

At this level, students can show an understanding of several piece of knowledge, but they don't know how to connect them together. They gain knowledge associated to the concept by several activities but don't know how to organise these related concepts. During this stage the bits of knowledge commonly considered as facts of a concept are collected by the students.

Relational

At this level, student's understanding of the several elements is strong and they can make connections between them. Students attain more understanding of the concept. They become aware of the relationship between several pieces of knowledge and become able to connect those elements in a logical sequence. At this stage they can skilfully explain the concept.

Extended Abstract

Now students can apply their learning in new contexts and can visualize it as part of a greater whole. At this stage after dedicated hard work students master abstract concepts and relationships to formulate more generalised principles and to apply these understanding to new situations. This level is considered as the highest level of learning.

An example showing how to plan a lesson based on SOLO taxonomy is given below. Topic selected is ‘Food safety and crises in Agriculture’.

The investigator introduces the lesson by sensitizing the condition of agriculture near their home. Through teacher pupil interactive sessions teacher stresses the need to cherish agriculture and moves to the topic Food safety and Agriculture. At the pre structural level students are unaware of food security and solutions to solve food scarcity related problems. At uni structural level teacher shows some pictures related to severity of food scarcity. At multi structural level teacher shows a paper cutting describing food security bill passed by Loksabha. At relational level students forms a definition for food security and at extended abstract level children suggests certain ways for ensuring food security in our country.

As mentioned above students passes from known to unknown through the different stages of SOLO Taxonomy in developing knowledge about the relationship between area of cultivation, production of rice and population growth in different years. For that, the investigator displays a chart showing relationship between area available for cultivation, production of rice and population rate in Kerala in different years. From that chart, students develops knowledge which is at uni structural level; from that students moves from uni structural to multi structural by making inferences from the chart. In the relational stage children discusses the ill effects of food scarcity in groups and reports it in the class. At the extended abstract level students suggests some ways to regain fields.

5. Learning Strategies

This section explains various strategies used in the lesson

6. Pre requisites

Pre requisites means the previous knowledge of the pupil based on a particular topic

7. Learning Materials

This section explains the learning materials used for the particular lesson, which includes charts, pictures and paper cuttings.

8. Class room transaction

This includes a two column table, in which the first column contains the process or activity and the second column contains response or evaluation.

9. Follow up activity

Follow up activity includes the projects and assignments given to the pupils after the successful completion of the particular topic.

The classes based on SOLO Taxonomy were in such way as to enhance Scientific attitude, Scientific creativity and Metacognitive Awareness among children. Through various activities and class room interactions students passes from pre structural to the extended abstract level of SOLO taxonomy. The learning is self-directed and the investigator provides only necessary guidance to students. This ensures the development of Scientific Attitude, Scientific Creativity and Metacognitive awareness among the students.

Validation

The sample lesson transcripts based on SOLO Taxonomy was prepared by the investigator and was given to experts in SCERT, DIET and experienced teachers at secondary school. The draft lesson plans were modified by the investigator based on the feedback and comments received from the experts. First five lesson transcripts were given for tryout by the investigator to a class of VIII th standard from NSS Boys High School Perunna. Then the lesson transcripts were modified and restructured based on the actual feedback the investigator experienced. Thus twenty four lesson transcripts were prepared based on the SOLO Taxonomy. Sample lesson transcripts are given as appendices VII A and VII B.

Lesson Transcripts Based on Revised Bloom's taxonomy

For teaching Experimental Group II also, twenty four lesson transcripts on the same topics as it is in the SOLO taxonomy were prepared based on Revised Bloom's Taxonomy. Lesson transcripts were prepared by the investigator in consultation with the subject experts from various schools, DIET and SCERT. The format of the lesson transcripts based on Revised Bloom's Taxonomy is given below.

1. General Information

General information include, Name of the teacher, Name of the school, Standard, Subject, Unit, Name of the lesson etc.

2. Content overview

Content overview explains the topics and subtopics in the lesson.

3. Content Analysis

Content Analysis covers terms, facts and concepts in the lesson.

4. Learning Domains/Objectives

Remembering

Remembering is recalling and recognizing knowledge or previously learned material from memory. It happens when memory is used to produce or recollect definitions, facts, or lists, or to recite previously learned information.

Understanding

Understanding or comprehension is creating meaning from different types of written or graphic messages. It also includes constructing meaning from, activities like interpreting, exemplifying, classifying, summarizing, inferring, comparing or explaining. It is the ability of students to grasp or construct meaning from material.

Applying

Applying is the capability of a student to utilize learned material in new and concrete situations. It occurs through executing and implementing learned knowledge through products like models, presentations, interviews or simulations. Develop, operate, interpret, demonstrate, illustrate, practice, exhibit, dramatise are some verbs related to this objective.

Analysing

It is the ability of breaking down the parts of a material into its components, for understanding its organizational structure. Through this process pupil keenly observes how different parts of a concept related to one another, how they are interrelated, and how they join to form an overall structure. Analysis includes mental functions like differentiating, organizing, attributing, categorizing, investigating, experimenting, scrutinizing etc. Process of analysis can illustrated through creation of spread sheets, surveys, charts, diagrams, and graphic representations.

Evaluating

Evaluating is making of judgements through checking or critiquing based on certain criteria and standards for a given purpose. To demonstrate the process of evaluation some products like, critiques, recommendations, and reports can be used. It is the precursor of creating, the next objective of Revised Bloom’s taxonomy, because one need to evaluate thoroughly before creating something. Judge, assess, compare, evaluate, validate, measure etc are some of the actions in evaluating.

Creating

Creating is the higher objective of Revised Bloom’s Taxonomy. Creating means, putting elements together to form a functional whole, reorganizing elements to a new pattern through generating, planning, or producing. Creating requires students to join different parts in a new way and synthesizing a new form or product. Creating is considered as the most difficult function of the revised taxonomy.

Execution of lesson plan

Investigator gives an introduction to the topic ‘Crises in the agricultural sector’ by showing pictures of agricultural lands with various varieties of crops which are ready for harvest. Then shows, pictures of barren agricultural lands. Investigator directs students to note down the differences between those pictures and discuss present situation of agriculture in Kerala.

In the next step after recollecting past and present situation of agriculture in Kerala, the investigator shows a chart displaying different factors affecting agriculture. Investigator explains each factor in detail with the involvement of students. Lastly she directs the students to express their ideas to solve the problems. Here students moves from remembering to understanding and then leads to applying levels of instructional objectives of Revised Bloom's Taxonomy.

Investigator explains what is meant by essential elements and examples of essential elements necessary for plant growth .After that she shows a leguminous root to identify the presence of microorganisms in it and its effects on soil fertility. Here students understand effects of essential elements on plant growth and analyses parts of leguminous root.

For teaching pH of the soil, researcher explains what is meant by pH value and its significance in plant growth. Researcher shows some pH papers and colours representing pH values. Students understand what is meant by pH value and by analysis and synthesis they reaches to a conclusion on the method of testing pH.

5. Previous knowledge

Pupil need to possess certain previous knowledge before learning this topic like present state of agricultural land, soil fertility, factors causing soil fertility etc.

6. Teaching aids

This section explains learning materials used for teaching this lesson, which includes chart, leguminous root and pH papers.

7. Body of the lesson

For preparing a lesson plan based on Revised Bloom's Taxonomy investigator prepared a four column lesson plan consisting content column, objectives/specification column, learning experience column and evaluation column. At the end of the lesson plan, review questions and assignments were given.

Validation

The sample lesson transcripts based on Revised Bloom's Taxonomy was prepared by the investigator and was given to experts in SCERT, DIET and experienced teachers at secondary school. Draft lesson plans were modified by the investigator based on the feedback and comments received from the experts. First five lesson transcripts were given for tryout by the investigator to a class VIII students of NSS Boys high School, Perunna. Then the lesson transcripts were modified and restructured based on the actual feedback the investigator experienced. Thus twenty four lesson transcripts were prepared based on the Revised Bloom's Taxonomy. Sample lesson transcripts are given as appendices IX A and IX B.

Lesson Transcripts based on Mc Cormack and Yager's Taxonomy

For teaching Experimental Group III also, twenty four lesson transcripts on the same topics as it is in the Revised Bloom's taxonomy were prepared based on Mc Cormack and Yager's Taxonomy. Lesson transcripts were prepared by the investigator in consultation with the subject experts from various schools, DIET and SCERT. The format of the lesson transcripts based on Mc Cormack and Yager's Taxonomy is given below.

1. **General Information**

   General information include, Name of the teacher, Name of the school, Standard, Subject, Unit, Name of the lesson etc.

2. **Content overview**

   Content overview explains the topics and subtopics in the lesson.

3. **Content Analysis**

   Content Analysis covers terms, facts and concepts in the lesson.

4. **Learning Domains/Objectives**

There are mainly five domains in this taxonomy generally known as Taxonomy of Science Education. The learning domains are Knowledge Domain, Process Domain,, Application Domain, Attitudinal Domain and Creativity Domain,

Knowledge Domain

In this domain students acquire knowledge and understanding about terms, facts and concepts. At the beginning of the lesson teacher gives an appropriate introduction to the lesson through stories, poems, simple activities etc. In this session teacher establishes connection between what they already know, and what they are going to learn in the class by testing previous knowledge. Children recalls and recognises terms, facts and concepts themselves and with the help of teacher, through different types of activities.

Process Domain

One of the important aims of science education is the development of process skills in children. Science can only be learned through doing science. Investigator plans and designs various activities; both in individual as well as in groups; through which children gets training in scientific method and process skills. Students develop observation, classification, communication, prediction, inference, interpretation, experimentation etc. through scientifically planned activities in the class.

Application Domain

Pupil applies acquired knowledge and skills in new and unfamiliar situations. Through the objectives listed in this domain pupil develops competencies such as identifying applications of scientific concepts in everyday life, applying the learned scientific concepts and skills in solving day to day problems etc. This level of objective is considered to be one of the higher level of objective. Students reach to this higher objective only after having the required understanding of the topic.

Attitudinal Domain

Pupil develops scientific attitudes and values by learning science topics. After proper learning, understanding and application of scientific knowledge it becomes a part of their character. Science teacher formulates certain activities in the class and gives assignments and follow up activities after the completion of each lesson for the development of Scientific attitude and values in them. While preparing the lesson transcripts teacher plans strategies to develop, positive attitude towards science, school, teachers and towards oneself, respecting other's feelings and opinions, expression of one's own feelings in a constructive way etc.

An example for a lesson plan based on Mc Cormack and Yager's Taxonomy is given below.

Execution of lesson plan

The topic selected for teaching based on Mc Cormack and Yager's Taxonomy is Live stock management, Poultry farming and

Sericulture. The investigator introduces the lesson by giving a simple activity. Students were asked to write the names of various varieties of animals reared in houses for economical purposes. Students have to write animal’s names and how they are useful to humans. Students write their observations in the note book. The investigator and students discusses various animals reared in houses and their economical uses.

In the second step teacher shows a power point presentation about live stock management and plays a video showing an interview with the farmer. Power point presentation shows pictures of various varieties of cows, goats and buffaloes and method of rearing them scientifically for getting economically useful products. In the video a farmer describes how to look after cattle for a better production and what economical benefit he is getting from it. After showing this video, investigator directs children to note different varieties of cows, goats and buffaloes. Investigator consolidates the activity by discussing the inferences made by the students.

In the next step the investigator displays a chart showing labelled pictures of chicken, duck and quill varieties and supplies an activity card explaining the importance of each variety shown in the chart. Investigator gives instructions to children to observe each variety and compare with its economical importance. Investigator consolidates the activity by asking children to read their observations .

In the next topic of the lesson, the investigator displays a model showing the life cycle of silk worm and asks students to draw a flow chart, showing different stages of its life cycle. Students after completing the flow chart, watches a video showing different stages of natural silk production. Investigator directs students to note each stage in their science diary. Finally investigator consolidates the activity by giving names of different varieties of silk worm used for natural silk production.

In the last step teacher asks children to collect news about artificial milk and egg production and to make an album showing picture of various varieties mentioned above and its products.

5. Learning Strategies

Learning strategies used in this lesson includes observation, analysis, discussions etc.

6. Pre requisites

It is the previous knowledge of pupil about the topic. Here they know about certain varieties of animals and birds grown for economy, life cycle of silk worm etc.

7. Learning Materials

Learning materials used are, power point presentations, videos, charts, models and activity cards.

8. Classroom Transaction

Classroom transaction is shown in a two column format; where first column shows classroom activities and second column shows evaluation or response part of the activities.

9. Follow up activity

Follow up activity includes all the assignments and projects given to students after completion of the lesson. Here the investigator gives assignments which can awaken a student's application, attitude and creativity domain.

Since Mc Cormack and Yager's Taxonomy is a taxonomy for science education; investigator designed the lesson plan in such a way to fulfil the objectives of the taxonomy. Classroom interactions and activities are learner centred and classroom environment was also friendly and helpful for the free expression of the child. special care was taken to develop basic concepts related to each topic and acquisition of higher objectives as well. Investigator provided all the necessary guidance, help and clarified all doubts. Review questions after the lesson assessed attainment of objectives.

Validation

The sample lesson transcripts based on Mc Cormack and Yager's Taxonomy was prepared by the investigator and was given to experts in SCERT, DIET and Experienced teachers at secondary school. The draft lesson plans were modified by the investigator based on the feedback and comments received from the experts. First five lesson transcripts were given for tryout by the investigator to class VIII students of NSS Boys High School Perunna. Then the lesson transcripts were modified and restructured based on the actual feedback the investigator experienced. Thus twenty four lesson transcripts were prepared based on the Mc Cormack and Yager's Taxonomy. Sample lesson transcripts are given as appendices XI A, XI B.

Sample Selected for the study

Random sampling method was adopted for sample selection. Population for the present study consists of students studying in Standard VIII in the secondary schools of Kerala.

Sample is a part of the population which represents the characteristics of population and suits with the researcher's purpose. The investigator decided to adopt random sampling keeping in view of the experimental nature of the study. The sample of the study consisted of VIII standard students from three schools of Kottayam District of Kerala. The schools selected include three Govt. Aided Schools, .NSS Boy's High School, Perunna, NSS Girl's High School, Perunna, and

NSS Higher Secondary School, Kidangoor. Since the presented study is a comparative study, there was no control group and all the three groups were considered as experimental group. Investigator selected two divisions of VIII standard students from each school. After removing the absentees in pre test and post test the total number of students included in the study was 210; a group of 70 students each for three experimental groups.

Table 4. 5

Breakup of the sample for the study

No	Name of the school	Boys/Girls/ Co education	Type of School	No of students in Experimental group
1	NSS Boy's High School , Perunna	Boys	Aided	70
2	NSS Girl's High School ,Perunna	Girls	Aided	70
3	NSS HSS Kidangoor	Co-education	Aided	70
	Total			210

Experimental Study

The experiment was conducted to study the effectiveness of an instruction based on SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on certain learning outcomes at secondary level students. The design selected for the study was Pre test post test non equivalent group design. Since it is a comparative study, three of the groups taught through three types of taxonomies were considered as experimental groups. Procedure adopted in the experiment is given below.

- Administration of Pre tests for the three experimental groups
- Teaching the Experimental Group I based on SOLO Taxonomy and Experimental Group II based on Revised Bloom's Taxonomy and Experimental Group III based on Mc Cormack and Yager's Taxonomy
- Administration of the Post test for the three experimental groups

Administration of the Pre test

Before starting the experiment, investigator conducted pre tests for the three experimental groups. Scientific Attitude Scale, Scientific Creativity Test and Metacognitive Awareness Inventory were used as pre tests among secondary school students. Pre tests were conducted by the investigator herself for the three groups. The scores obtained from the students of the three experimental groups has been collected and subjected to statistical analysis.

Treatment for the groups

The students were taught based on three different taxonomies; SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy. Three different methods of teaching was adopted by the investigator to three experimental groups. Based on the different objectives of the three taxonomies, investigator prepared three different types of lesson transcripts and taught accordingly.

Post test

After completing the teaching of the experimental group based on the SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy the same scale on Scientific Attitude, Scientific Creativity Test and Metacognitive Awareness Inventory was administered to all the three groups. The scores obtained by the students were used for statistical analysis.

Data collection Procedure

Experimental study was conducted to study the effectiveness of an instruction based on SOLO Taxonomy, Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on certain learning outcomes such as, Scientific Attitude, Scientific Creativity and Metacognitive Awareness on secondary school students. The investigator developed and standardised necessary tools for the collection of data. Since it was very difficult to get three equivalent groups in the experimental design, the investigator selected two intact class rooms from each school for the experimentation and collection of data. The number of students in a class is around 50 so the investigator selected two classes for the study for getting a total of 70 students for the experimental study from each school. The three schools ; NSS Boy's High School, Perunna, NSS Girl's High School, Perunna, and NSS Higher Secondary School, Kidangoor were situated at the semi urban areas of Kottayam District. After finalising the sample and the tools to be used, the investigator visited the selected schools and contacted the heads of the institution and the respective subject teachers to get permission for experimentation and collection of data.

Before starting the treatment, the investigator compared the previous achievement in Biology of the three experimental groups. The researcher met the students to establish a rapport with them and explained the purpose of the study briefly. At first, Raven's Progressive Matrices test was administered to compare the general mental ability of the students. After that, the investigator administered pre tests for

Scientific Attitude, Scientific Creativity and Metacognitive awareness. The rules and procedures for each type of the test was strictly followed. The response sheets were collected back after the allotted time from the experimental groups and was scored and subjected to statistical analysis.

Three experimental groups were taught using three different Taxonomies with different objectives. The investigator prepared 24 lesson transcripts for each taxonomies and taught considering the aim of each taxonomies. For that, she adopted different strategies in her teaching. Same content is used to teach in three different ways.

After completing the teaching, the three experimental groups; Scientific Attitude scale, Scientific Creativity Test and Metacognitive Awareness Inventory were again administered as post tests to all the groups. The scores obtained from the three experimental groups were used for statistical analysis.

Scoring and Consolidation of data

Response sheets were scored based on the scoring procedure of each tool . Scores were consolidated to facilitate computer analysis of the data using SPSS Software version 22.

Statistical techniques used

Computer facilities using the software programme SPSS was made use of for the statistical analysis of the data collected.

The researcher used the following statistical techniques to analyse the data and to draw the conclusions.

- Independent Sample ‘t’ test is used for testing the significant difference between two means. In the present study, the investigator compared the pre test mean score and the post test mean score of each experimental group.

- Paired Sample ‘t’ test is used for the comparing mean scores of pre test and post test in the Experimental group I (taught through SOLO Taxonomy), Experimental group II (taught using Revised Bloom’s Taxonomy), and Experimental Group III (taught using Mc Cormack and Yager’s Taxonomy) .
- Gain score comparison - The difference between post test and pre test score is termed as the gain score. Gain score comparison is used for comparing the gained performance of secondary school students in the Scientific Attitude, Scientific Creativity and Metacognitive Awareness.
- One way ANOVA is used for comparing the variance of pre test in the three Experimental Groups. It is an effective way to determine whether the means of more than two samples are different to attribute to the sampling error.
- Scheffe’s Test of Multiple Comparison- It is a conservative method of testing the significance of one or more comparisons of mean values arising in analysis of variance.
- Analysis of covariance (ANCOVA) – Single factor analysis of covariance with one co-variate is used in the present study. It was employed to remove statistically the effects of extraneous variable and to provide an unbiased comparison .In the present study, ANCOVA (Uni-variate Analysis) is used for the testing of effectiveness of each independent variable on the dependent variable. Pre test scores of each group is taken as a covariate with the help of SPSS version 22.

Chapter IV

ANALYSIS AND INTERPRETATION OF DATA

- **Analysis of Data for Equating the Groups**
- **Comparison of Scientific Attitude**
- **Comparison of Scientific Creativity**
- **Comparison of Metacognitive Awareness**

"Analysis is a process which enters into research in one form or another, from the very beginning, it may be fair to say that research consists; in general of two larger steps, the gathering of data and the analysis of these data; but no amount of analysis can validly extracted from the data factors which are not present" (Good, Barr & Scats, 1996). This chapter displays the statistical analysis of the data and the interpretation of the results. After the data has been collected, it is processed using Microsoft Excel-2013 Software.

The data may be adequate, valid, and reliable to any extent; it does not serve any worthwhile purpose unless it is carefully edited, systematically classified and tabulated, scientifically analyzed, intelligently interpreted and rationally concluded. The present attempt is intended to study the effectiveness of an instruction based on SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on certain learning outcomes of secondary school students.

The data collected for the study were analyzed using relevant statistical techniques. The analysis and interpretation of the results have been presented under the following sections.

Analysis of data for equating the groups

Comparison of Scientific Attitude

Comparison of Scientific Creativity

Comparison of Metacognitive Awareness

Analysis of Data for Equating the Groups

To make the study effective it is better to select equated groups. The equality of the two groups selected for the study was ensured before the experiment, with regard to the control variables; Previous achievement in science and Intelligence score of the students.

The data collected were subjected to Test of Significance of Difference among the students from three experimental groups, using one way ANOVA. The detailed description of analysis is presented under the following heads.

Comparison among Experimental Group I (SOLO Taxonomy), Experimental Group II (Revised Bloom's Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy) with regard to Previous Achievement in Science

The investigator collected the scores of students of the three experimental groups for previous achievement in science. The obtained data were analyzed by computing Analysis of Variance and subjected to 'F' test. The details of the analysis are summarized in the tables below.

Table 1

Data and results of one way ANOVA for testing the significant difference among the three experimental groups for previous achievement in science

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	146.410	2	73.205	2.213	p>0.05
Within Groups	6846.371	207	33.074		
Total	6992.781	209			

The above table shows that the obtained 'F' value, 2.21(p>0.05) is not significant at 0.05 level. This shows that the three groups do not differ significantly in their previous achievement in science. Therefore, it can be inferred that all the groups selected for the experiment are more or less equal in their previous achievement in science.

Comparison among Experimental Group I (SOLO Taxonomy), Experimental Group II (Revised Bloom's Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy) with regard to Intelligence Test Scores

Raven's Standard Progressive Matrices was administered to students in the experimental groups before conducting the experiment, to get an idea about their level of intelligence. The data thus obtained were analysed by computing Analysis of Variance and subjected to 'F' test. Details of the analysis are summarized in the table below.

Table 2

Data and results of One Way ANOVA for testing the significant difference among the three experimental groups for General Intelligence

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	87.971	2	43.986	1.17	p>0.05
Within Groups	7747.843	207	37.429		
Total	7835.814	209			

It is evident from the table that the obtained 'F' value 1.17 is not significant at 0.05 levels. This shows that the three groups do not differ significantly with regard to their intelligence. Therefore it can be inferred that all the groups selected for the experiment are more or less equal in their intelligence, and do not differ significantly in their intelligence.

Comparison of Scientific Attitude of Secondary School Students in the Experimental Group I (SOLO Taxonomy), Experimental Group II (Revised Bloom's Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy)

After equating the group, the investigator administered pre test in Scientific Attitude, Scientific Creativity, and Metacognitive Awareness among the three experimental groups. Then administered intervention strategy in each experimental group like, Experimental Group I (SOLO Taxonomy), Experimental Group II (Revised Bloom's Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy). After the intervention investigator administered same test as post test in the three groups. Then tabulated the scores in the pre test and post test and condensed it in to the descriptive statistics of pre test and post test for analyzing preliminary features of the data. Following tables show the descriptive statistics of the pre test and post test scores of each group with regard to the learning outcome, Scientific Attitude.

Descriptive statistics of pre test scores of Scientific Attitude of the Secondary school students in the Experimental Group I (SOLO Taxonomy), Experimental Group II (Revised Bloom's Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy)

a) Before the experiment

Before starting the experiment, Scientific Attitude test was administered by the investigator as pre test to all the groups. Each group consisting a total number of 70 students. The pre test scores obtained by the students in the three groups were condensed into Arithmetic Mean, Median, Mode, Standard Deviation, and Skewness. This was to get a general picture of the performance of students in the three Experimental groups before the experiment.

Table 3

Descriptive statistics of Scientific Attitude among secondary school students before the experiment

Statistics	SOLO Taxonomy	Revised Bloom's Taxonomy	Mc Cormack and Yager's Taxonomy
Mean	158.66	152.96	155.79
Median	157.00	156.00	156.00
Mode	141	156	161
Std. Deviation	19.476	19.52	20.549
Skewness	.014	-.171	-.010
Kurtosis	-.924	-.374	-.367

The maximum score being 210 for Scientific Attitude, the obtained mean score of SOLO Taxonomy is 158.66, Revised Bloom's Taxonomy group is 152.96, and that of Mc Cormack and Yager's Taxonomy group is 155.79. All these values indicate that, the average Scientific Attitude of the students in each group is more or less the same.

The median scores are 157, 156, and 156 for, SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy group students respectively, which indicate the middle score of the Scientific Attitude in the group. The median value represent that 50% of the students are above and below the value. The mode value obtained for SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy group are 141, 156, and 161 respectively. These are the most repeating scores in the Scientific Attitude test. The standard deviation of the SOLO Taxonomy group is 19.476, Revised Bloom's Taxonomy group is 19.52 and Mc Cormack and Yager's Taxonomy group is 20.54. These values show the variations of scores in each group before the intervention.

The Skewness obtained for Revised Bloom's, Mc Cormack, and Yager's Taxonomy are negative, and for SOLO Taxonomy, it is positive. Kurtosis value of all the group are negative that means the distribution is platykurtic. Graphical representation of Measures of central tendency is shown below.

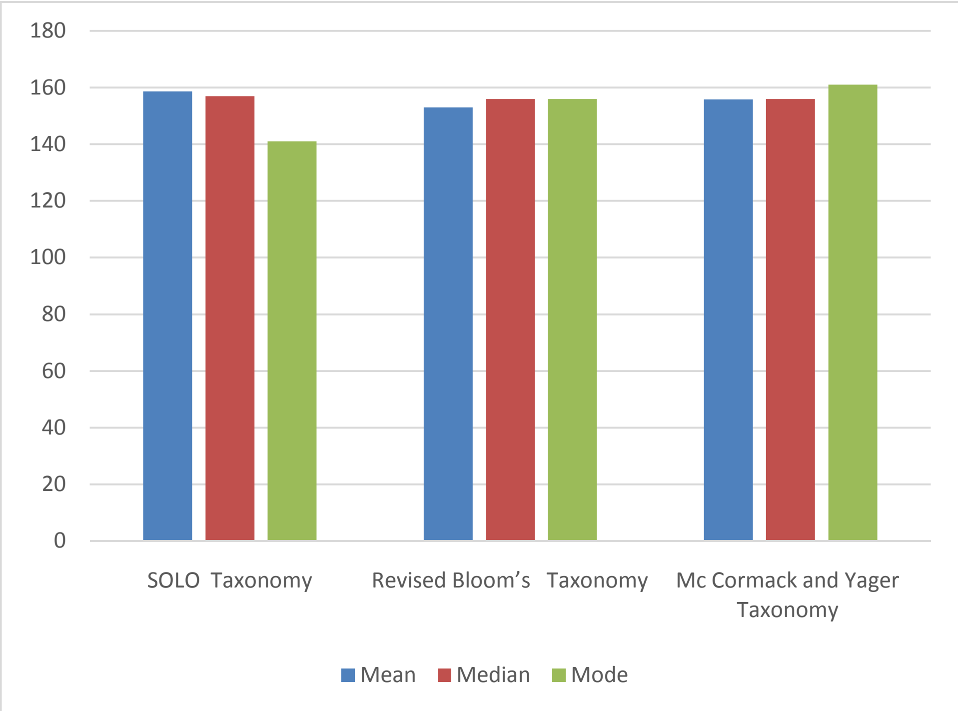


Figure 1: *Graphical Representation of Measures of Central Tendency of Pre test Scores of the secondary school students in the three experimental groups*

b) After the Experiment

The same Scientific Attitude test was administered by the investigator as post test to all the groups. Each group consisting a total number of 70 students. The post test scores obtained by the students in three groups were condensed into Arithmetic Mean, Median, Mode, Standard Deviation, and Skewness. This was done to get a general picture of the distribution.

Table 4

Descriptive statistics of Scientific Attitude among secondary school students after the experiment

Statistics	SOLO Taxonomy	Revised Bloom's Taxonomy	Mc Cormack and Yager's Taxonomy
Mean	181.03	167.47	195.67
Median	179.00	171.50	200.00
Mode	210	173	200
Std. Deviation	20.157	17.62	17.591
Skewness	.494	-.660	-1.418
Kurtosis	1.128	.080	.888

The maximum score being 210 for the Scientific Attitude, the obtained mean score of SOLO Taxonomy group is 181.03, Revised Bloom's Taxonomy group is 167.47, and Mc Cormack and Yager's Taxonomy group is 195.67. All these values indicated that the students from each group have different levels of Scientific Attitude after the experiment.

The Median scores obtained are 179, 171.50 and 200 for SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy group students respectively, which indicated the middle score of the Scientific Attitude in each group. The median value represents that 50% of the students lies above and below the value.

The mode value obtained for SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy group are 210,173 and 200 respectively. Mode value signifies most repeating scores in the attitude test. The Standard Deviation of the SOLO Taxonomy Group is 20.15, Revised Bloom's Taxonomy group is 17.62, and Mc Cormack and Yager's Taxonomy group is 17.59. These values show that there is variation of scores in each group after the intervention.

The Skewness obtained for Revised Bloom's and Mc Cormack and Yager's Taxonomy were negative but for SOLO Taxonomy, it is positive. And the Kurtosis value of all the groups is positive. It means that the distribution is leptokurtic. Graphical representation of Measures of central tendency is shown below.

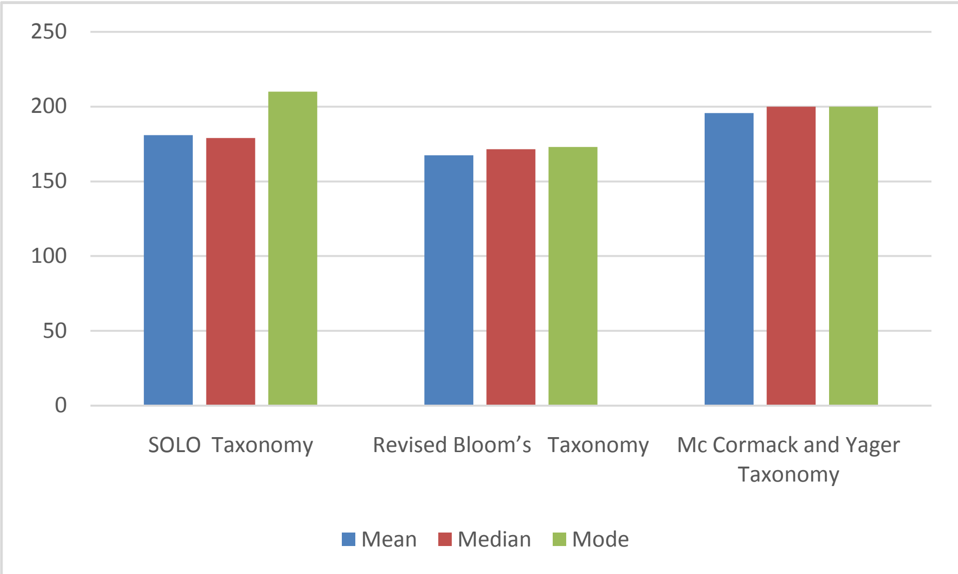


Figure 2: *Graphical Representation showing Measures of Central Tendency of Post test Scores of Secondary School Students in the three Experimental Groups*

Comparison of Scientific Attitude

Effectiveness of Instructions based on, SOLO Taxonomy, Revised Bloom's Taxonomy, and Mc Cormack and Yager's Taxonomy on Scientific Attitude of Secondary School Students

One of the purposes of this study is to compare the effectiveness of instruction based on the SOLO, Revised Bloom's and Mc Cormack and Yager's Taxonomy on Scientific Attitude of secondary school students. For this, the investigator developed following hypothesis, and tested these hypotheses using ‘t’ test ‘F’ test, such as ANOVA and ANCOVA followed by adjusted post test.

1. There will be no significant difference between the mean pre test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom’s Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager’s Taxonomy) for Scientific Attitude of Secondary School students.
2. There will be no significant difference between the mean post test scores of Experimental group I, Experimental group II and Experimental group III for Scientific Attitude of secondary school students.
3. There will be no significant difference between the mean pre test and post test scores of Scientific Attitude of Experimental group I.
4. There will be no significant difference between the mean pre test and post test scores of Scientific Attitude of Experimental group II.
5. There will be no significant difference between the mean pre test and post test scores of Scientific Attitude of Experimental group III.
6. There will be no significant difference between the mean gain scores of Scientific Attitude of Experimental group I and Experimental Group II.
7. There will be no significant difference between the mean gain scores of Scientific Attitude of Experimental group I and Experimental Group III.
8. There will be no significant difference between the mean gain scores of Scientific Attitude of Experimental group II and Experimental Group III.

Comparison of pre test scores of Scientific Attitude among Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom's Taxonomy), and Experimental group III (Group receiving instruction based on Mc Cormack and Yager's Taxonomy)

For this, the investigator compared all the pre test scores of each experimental groups using One Way analysis of Variance. The data and results of the test of significance were given in the table below.

Table 5

Data and result of pre test scores of Scientific Attitude in each Experimental Group

Source of variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1137.171	2	568.586	1.44	p>0.05
Within Groups	81614.429	207	394.273		
Total	82751.600	209			

The obtained 'F' value is 1.44 which is not significant at 0.05 level of significance (p>0.05). This shows that there is no significant differences in the pre test mean scores among the students in each experimental group. Therefore all the three experimental groups do not differ significantly in their Scientific Attitude. So it is inferred that, before the intervention, three groups were more or less same in Scientific Attitude.

Comparison of post test scores of Scientific Attitude among Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom's Taxonomy), Experimental group III (Group receiving instruction based on Mc Cormack and Yager's Taxonomy)

For this, the investigator compared all the post test scores in the each experimental groups using One Way Analysis of Variance. The data and results of the test of significance were given in the table below.

Table 6

Data and result of post test scores of Scientific Attitude in the each experimental group

Source of variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	27847.152	2	13923.576	40.69	P<0.01
Within Groups	70822.829	207	342.139		
Total	98669.981	209			

The obtained 'F' value is 40.69 which is significant at 0.01 level of significance (p<0.01). This shows that there is significant difference in the post test means scores of the Scientific Attitude in each experimental group. Therefore the all the three experiment groups differ significantly in their Scientific Attitude after the intervention. So it is inferred that after the intervention three groups differ in Scientific Attitude. In order to find out the initial difference among the three groups the investigator used Scheffe post hoc test.

Table 7

Data and Results of Scheffe post hoc test in scientific attitude among the three groups

Group	N	Subset for alpha = 0.05		
		1	2	3
Revised Bloom's Taxonomy	70	167.47		
SOLO taxonomy	70		181.03	
Mc Cormack and Yager's Taxonomy	70			195.67

The above table shows that the obtained mean scores of Mc Cormack and Yager's Taxonomy is 195.67, SOLO taxonomy 181.03 and Revised Bloom's Taxonomy 167.47. So it is clear that Mc Cormack and Yager's Taxonomy significantly differ from SOLO and Revised Bloom's Taxonomy for Scientific Attitude. It can be represented below through the mean plot.

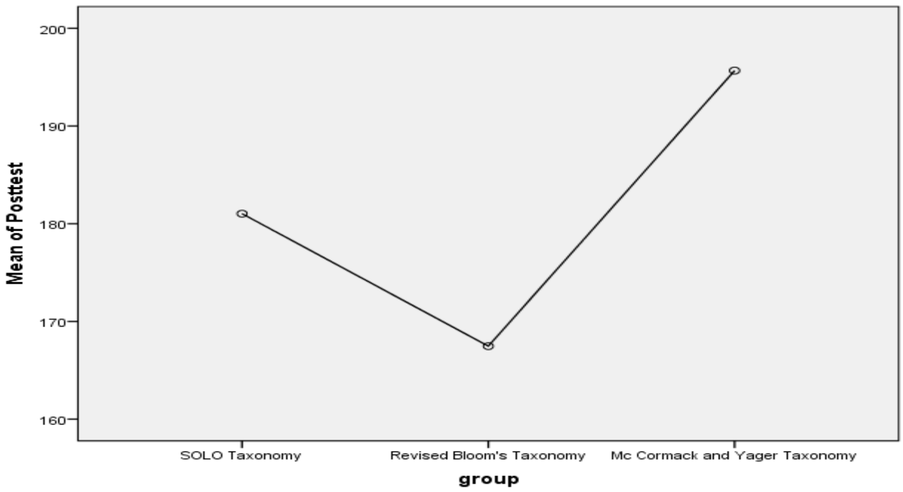


Figure 3: *Mean plot showing the difference in Scientific Attitude of students in the experimental groups receiving instruction based on three taxonomies*

Comparison between the mean Pre test and Post test scores of Scientific Attitude of Experimental Group I

The difference between the pre test and post test mean scores of the Experimental group I (SOLO Taxonomy) was tested for significance by finding the Critical Ratio using Paired Sample 't' test. The data and results for the test of significance were given in the table below.

Table 8

Data and result of Pre test and Post test scores of Scientific Attitude in Experimental Group I

Tests	Mean	N	Std. Deviation	R	t	Sig
Pre test	158.66	70	19.476	.041	6.82	$P<0.01$
Post test	181.03	70	20.157			

The obtained 't' value is 6.82, which is highly significant at 0.01 level of significance. That means there exist a significant difference between pre test and post test mean scores in SOLO Taxonomy group. Since the mean of post test, 181.03 is greater than that of the pre test mean 158.66; it is inferred that instruction based on the SOLO Taxonomy is effective in developing the Scientific Attitude.

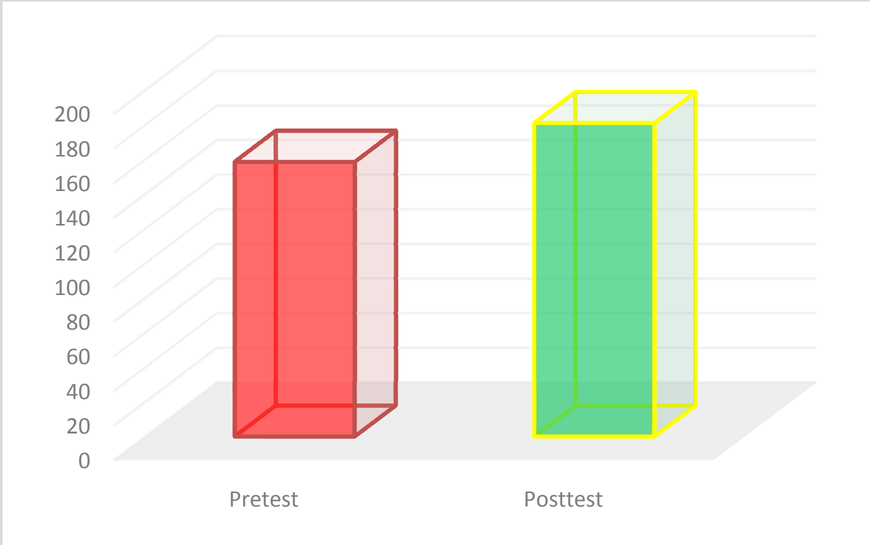


Figure 4: *Graphical Representation showing Pre test and Post test Mean scores of Scientific Attitude in Experimental Group I*

Comparison between the mean Pre test and Post test scores of Scientific Attitude of Experimental Group II

The difference between the pre test and post test mean scores of the Experimental group II (Revised Bloom's Taxonomy) were tested for significance by finding the Critical Ratio using paired sample 't' test. The data and results of the test of significance were given in the table below.

Table 9

Data and result of Pre test and Post test scores of Scientific Attitude in Experimental Group II

Tests	Mean	N	Std. Deviation	r	't'	Sig
Pre test	152.96	70	19.526	.80	10.45	P<0.01
Post test	167.47	70	17.626			

The obtained t value is 10.45, which is highly significant at 0.01 level of significance. That means there exists a significant difference between pre test and post test mean scores in the Revised Bloom's Taxonomy group. Since the mean of post test 167.47 is greater than that of pre test mean 152.96, it is inferred that instruction based on the Revised Bloom's Taxonomy is effective in developing Scientific Attitude.

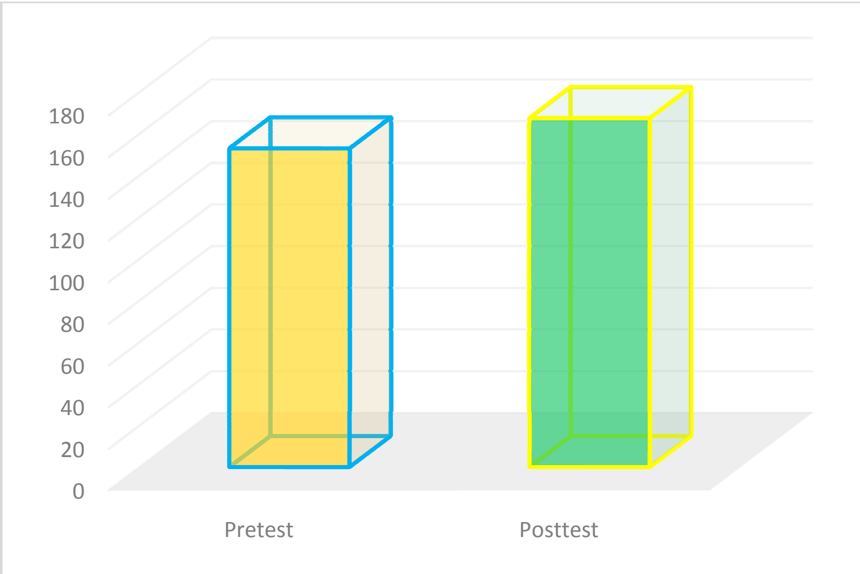


Figure 5: *Graphical Representation showing Pre test and Post test Mean scores of Scientific Attitude in Experimental Group II*

Comparison between the mean Pre test and Post test scores of Scientific Attitude of Experimental Group III.

The difference between the pre test and post test mean scores of the Experimental group III (Mc Cormack and Yager's Taxonomy) were tested for significance by finding the Critical Ratio, using Paired Sample 't' test. The data and results of the test of significance were given in the table below.

Table 10

Data and result of Pre test and Post test scores of Scientific Attitude in the Experimental Group III

Tests	Mean	N	Std. Deviation	r	t	Sig
Pre test	155.79	70	20.549	.542	18.09	p<0.01
Post test	195.67	70	17.591			

The obtained‘t’ value is 18.09, which is highly significant at 0.01 level of significance which means, there exists a significant difference between pre test and post test mean scores in the Mc Cormack and Yager’s Taxonomy group. Since the mean of post test 195.67 is greater than that of the pre test mean 155.79, it is inferred that instruction based on the SOLO Taxonomy is effective in developing Scientific Attitude.

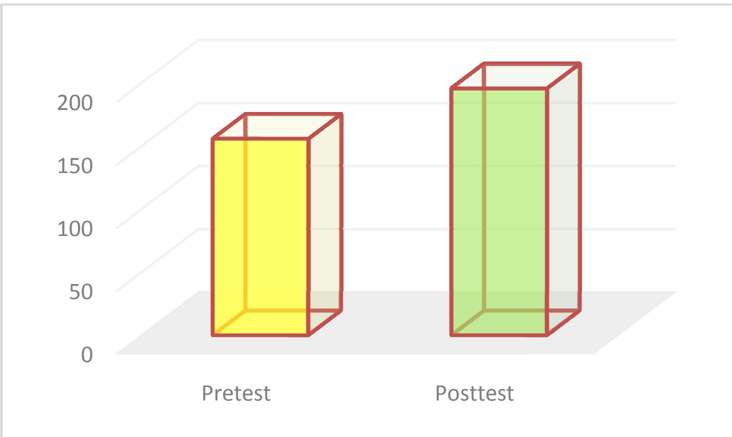


Figure 6 : *Graphical Representation showing Pre test and Post test Mean scores of Scientific Attitude in Experimental Group III*

Comparison between the Mean Gain Scores of Scientific Attitude between Experimental group I and Experimental Group II

The difference between the Mean Gain Scores of the Experimental group I (SOLO Taxonomy) and Experimental Group II (Revised Bloom's Taxonomy) were tested for significance by finding the critical ratio, using Independent Sample 't' test. The data and results of the test of significance are given in the table below.

Table 11

Data and result of Pre test and Post test Gain scores of Scientific Attitude of Experimental group I (SOLO) and Experimental Group II (Revised Bloom's)

Tests	Mean	N	Std. Deviation	t	Sig
Revised Bloom's Taxonomy Based Instruction	14.51	70	11.61	2.34	$P<0.05$
SOLO Taxonomy based Instruction	22.81	70	27.27		

The obtained't' value is 2.34, which is highly significant at 0.05 level of significance. It means that, there exists a significant difference between mean gain scores of Revised Bloom's Taxonomy group and SOLO Taxonomy group. Since the mean gain of SOLO Taxonomy group 22.81, is greater than that of the mean gain of Revised Bloom's 14.51; it is inferred that students from SOLO Taxonomy group have high gain in their Scientific Attitude.

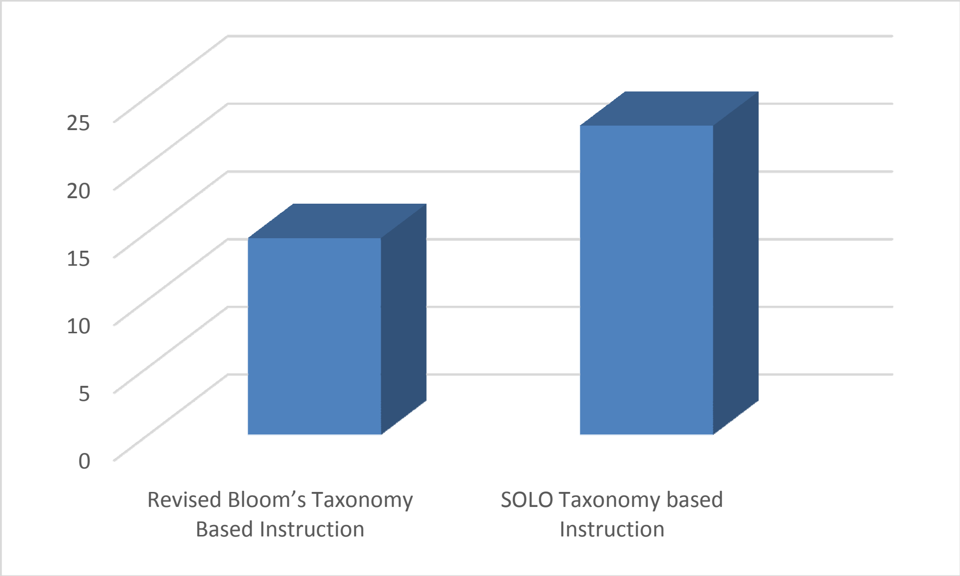


Figure 7: *Graphical Representation showing Pre test and Post test Gain scores of Scientific Attitude among Experimental group I (SOLO) and Experimental Group II (Revised Bloom's)*

Comparison between the Mean Gain Scores of Scientific Attitude among Experimental group II and Experimental Group III

The difference between the mean gain scores of the Experimental group II (Revised Bloom's Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy) were tested for significance by finding the Critical Ratio, using Independent Sample 't' test. The data and results of the test of significance were given in the table below.

Table 12

Data and result of Pre test and Post test Gain scores of Scientific Attitude among Experimental group II and Experimental Group III

Tests	Mean	N	Std. Deviation	t	Sig
Revised Bloom's	14.51	70	11.61	9.74	P<0.01
Mc Cormack and Yager's	39.88	70	18.44		

The obtained't' value is 9.74, which is highly significant at 0.01 level of significance. It means that, there exists a significant difference between mean gain scores among the Revised Bloom's and Mc Cormack and Yager's Taxonomy group. Since the mean gain of Mc Cormack and Yager's Taxonomy group, 39.88 is greater than that of the mean gain of Revised Bloom's 14.51, it is inferred that students from Mc Cormack and Yager's Taxonomy group have high gain in their Scientific Attitude score.

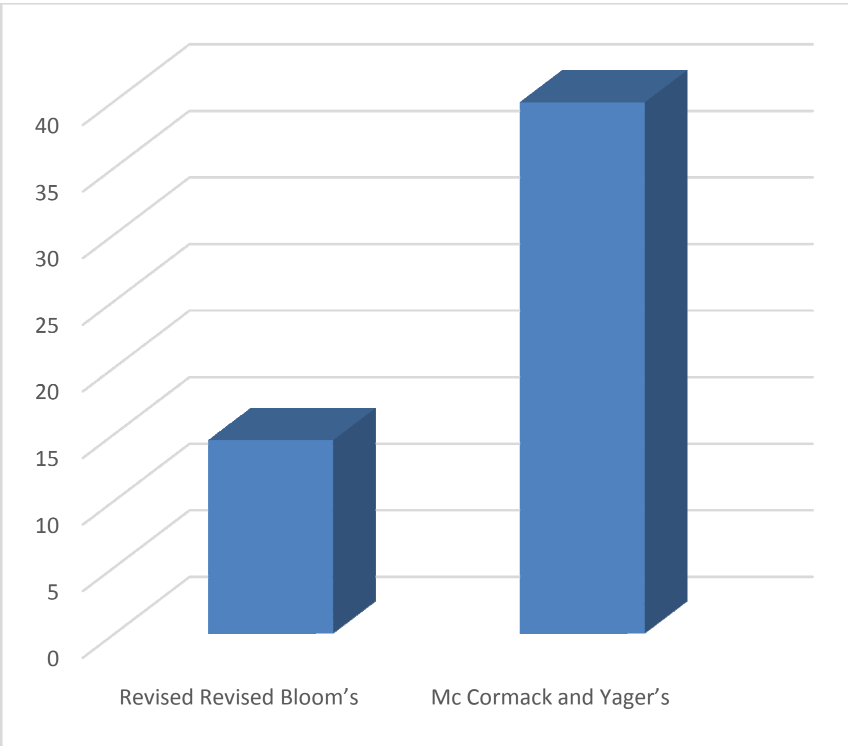


Figure 8: *Graphical Representation showing Pre test and Post test Gain scores of Scientific Attitude among Experimental Group II and Experimental Group III*

Comparison between the Mean Gain Scores of Scientific Attitude of Experimental group I and Experimental Group III

The difference between the mean gain scores of the Experimental group I (SOLO Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy) were tested for significance by finding the

Critical Ratio, using independent sample 't' test. The data and results of the test of significance were given in the table below.

Table 13

Data and result of Pre test and Post test Gain scores of Scientific Attitude among Experimental group I and Experimental Group III

Tests	Mean	N	Std. Deviation	t	Sig
SOLO Taxonomy Group	22.81	70	27.27	4.33	P<0.01
Mc Cormack and Yager's Taxonomy Group	39.88	70	18.44		

The obtained't' value is 4.33, which is highly significant at 0.01 level of significance. It means that there exists a significant difference between mean gain scores in the SOLO and Mc Cormack and Yager's Taxonomy group. Since the mean gain of Mc Cormack and Yager's Taxonomy group 39.88, is greater than that of the mean gain of SOLO 22.81, it is inferred that students from Mc Cormack and Yager's Taxonomy group have high gain in their Scientific Attitude score.

Comparison of Effectiveness of Instructions based on Revised Bloom's Taxonomy SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy on Scientific Attitude of secondary school students

In this section investigator compared the post test score of Scientific Attitude among secondary school students in the three groups using Univariate Analysis. Here the investigator took pre test as co variate. Following tables show the results.

Table 14

Data and Results of the Univariate analysis, for testing the Effectiveness of Instructions based on Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy on Scientific Attitude of secondary school students

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Pre test Scientific Attitude	14040.43	1	14040.432	50.937	P<0.01
Group	25757.83	2	12878.91	46.723	P<0.01
Error	56782.39	206	275.643		
Total	7008196.	210			

Above table shows the obtained 'F' for the error is 46.723 which is highly significant at 0.01 level of significance ($p<0.01$). It means that the instructions based on Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy were effective for developing Scientific Attitude among secondary school students.

The adjusted means of post test scores (x, y means) of students in each experimental groups were calculated. The difference between the adjusted y means was tested for significance. The data for adjusted means of post test scores of students in experimental groups were given in the following table.

Table 15

Data for adjusted means of post test scores for Scientific Attitude among secondary school students who received instructions based on Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy

Groups	N	Mx	My	M_{XY}		t
Revised Bloom's Taxonomy(A)	70	152.96	167.47	168.65	A-B	3.96*
SOLO Taxonomy(B)	70	158.66	181.03	179.84	B-C	5.63*
Mc Cormack and Yager's(C)	70	155.79	195.67	195.68	A-C	9.61*
Total	210	155.80	181.39			

*significant at 0.01 level

Above table shows, the adjusted post test mean scores in each group for the instructions based on Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy on Scientific Attitude of secondary school students. The adjusted mean score of Mc Cormack and Yager's is 195.68, which is greater than the adjusted mean score of SOLO Taxonomy 179.84 and Revised Bloom's Taxonomy 168.65. In order to find out the significant mean differences among the each taxonomy, investigator used pair wise comparison. Following table shows the pair wise comparison.

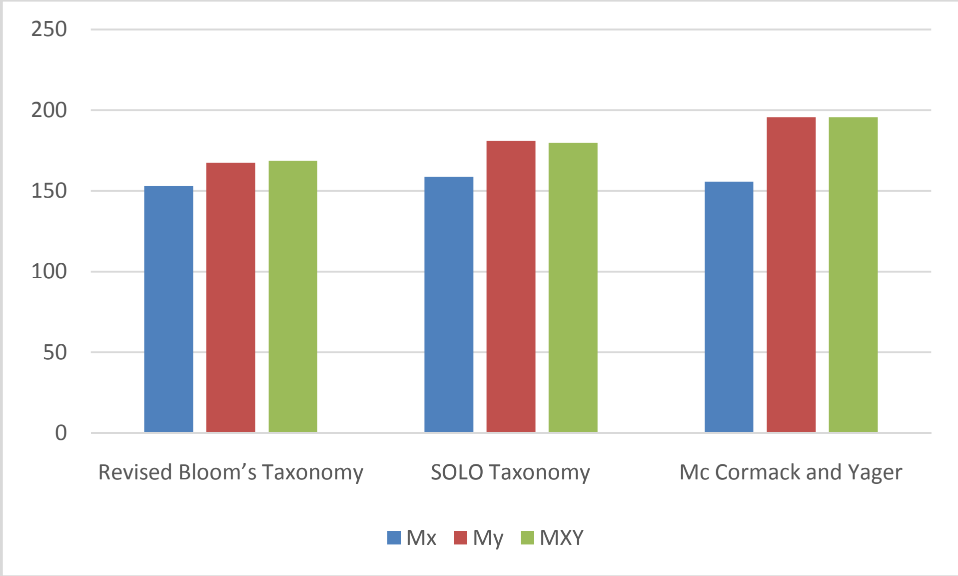


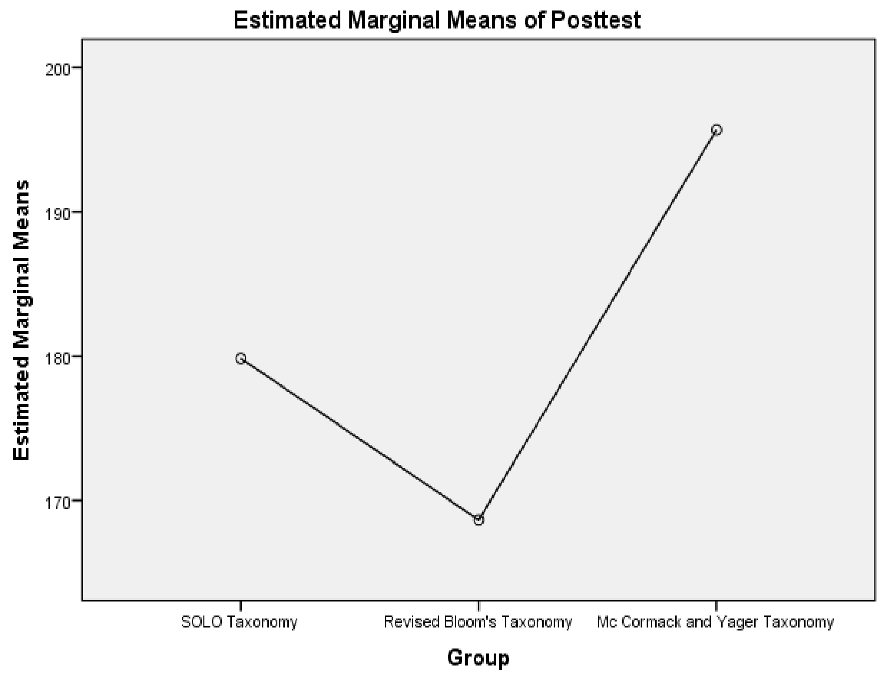
Figure 9: *Graphical Representation showing Pre test and Post test adjusted means of Scientific Attitude of Experimental Group I, Experimental Group II and Experimental Group III*

Table 16

Data and result of the significant mean differences among the Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy using Pair wise Comparisons

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
Revised Bloom's Taxonomy	SOLO Taxonomy	-11.193*	2.826	P<0.01
	Mc Cormack and Yager's Taxonomy	-27.027*	2.811	P<0.01
SOLO Taxonomy	Revised Bloom's Taxonomy	11.193*	2.826	P<0.01
	Mc Cormack and Yager's Taxonomy	-15.834*	2.811	P<0.01
Mc Cormack and Yager's Taxonomy	Revised Bloom's Taxonomy	27.027*	2.811	P<0.01
	SOLO Taxonomy	15.834*	2.811	P<0.01

Above table shows, that the obtained mean difference is significant between Revised Bloom's with SOLO Taxonomy is 11.193 and Revised Bloom's with Mc Cormack and Yager's Taxonomy is 27.027. Both differences are highly significant. In the case of SOLO with Mc Cormack and Yager's Taxonomy, also the mean difference (15.83) is highly significant. Among the mean differences Mc Cormack and Yager's Taxonomy have high difference compared to SOLO and Revised Bloom's. So it can be concluded that Mc Cormack and Yager's Taxonomy is highly effective to develop Scientific Attitude among secondary school students and then comes SOLO Taxonomy for developing Scientific Attitude. From the present study, it was found that Revised Bloom's Taxonomy comes below the other two taxonomies in developing Scientific Attitude among secondary school students. It can be represented below through estimated marginal mean plot.



Covariates appearing in the model are evaluated at the following values: Pretest ScientificAttitude = 155.80

Figure 10: *Graphical Representation showing Estimated Marginal Mean Plot of Scientific Attitude among Experimental Group I, Experimental Group II and Experimental Group III*

Comparison of Scientific Creativity

Comparison of Scientific Creativity of Secondary School Students in the Experimental Group I (SOLO Taxonomy), Experimental Group II (Revised Bloom's Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy)

After equating the group, the investigator administered pre test in Scientific Attitude, Scientific Creativity, and Metacognitive Awareness among the three experimental groups. Then administered intervention strategy in each experimental group like Experimental Group I (SOLO Taxonomy), Experimental Group II (Revised Bloom's Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy).After the intervention investigator administered same test as post test in all the three the groups. Then tabulated the scores in the pre test and post test and condensed it in to the descriptive statistics of pre test and post test for analyzing the preliminary features of the data. Following tables shows the descriptive statistics of the pre test and post test scores of the each group with regard to the learning outcome Scientific Creativity.

Descriptive statistics of pre test scores of Scientific Creativity among Secondary school students in the Experimental Group I (SOLO Taxonomy) Experimental Group II (Revised Bloom's Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy)

a) Before the experiment

Before starting the experiment, Scientific Creativity test was administered by the investigator as pre test to all the groups. Each group consisting a total number of 70 students. The pre test scores obtained by the students in three groups were condensed into arithmetic mean, median, mode, standard deviation, and skewness. This was to get a general picture of the performance of students in the three groups before the experiment.

Table 17

Descriptive statistics of Scientific Creativity among secondary school students before the experiment

Statistics	SOLO Taxonomy	Revised Bloom's Taxonomy	Mc Cormack and Yager's Taxonomy
Mean	18.56	19.17	20.89
Median	18.00	20.00	21.00
Mode	18	20	28
Std. Deviation	6.264	6.769	7.412
Skewness	-.051	-.125	-.174
Kurtosis	-.647	-.575	-.856

Obtained mean score for Scientific Creativity of Revised Bloom's Taxonomy group is 19.17, SOLO taxonomy group is 18.56, and that of Mc Cormack and Yager's Taxonomy group is 20.89. All these values indicated that, the average Scientific Creativity of the students in each group is more or less the same.

The median scores are 18, 20 and 21 for SOLO Taxonomy, Revised Bloom's Taxonomy, and Mc Cormack and Yager's Taxonomy group students respectively, which indicated the middle score of the Scientific Creativity in the group. The median value represent that 50% of the students are above and below the value.   .

The mode value obtained for Revised Bloom's Taxonomy, SOLO Taxonomy and Mc Cormack and Yager's Taxonomy group are 18, 20, and 28 respectively. These are the most repeating scores in the Scientific Creativity test. The standard deviation of the SOLO

Taxonomy group is 6.26, Revised Bloom's Taxonomy group is 6.76 and Mc Cormack and Yager's Taxonomy group is 7.41. These values show the variations of scores in each group before the intervention.

The skewness obtained for the Revised Bloom's, Mc Cormack and Yager's Taxonomy and SOLO Taxonomy are negative. And the kurtosis value of all the group are negative that means the distribution platykurtic. Graphical representation of Measures of central tendency is shown below. The values of the measures central tendency is approaching to normality.

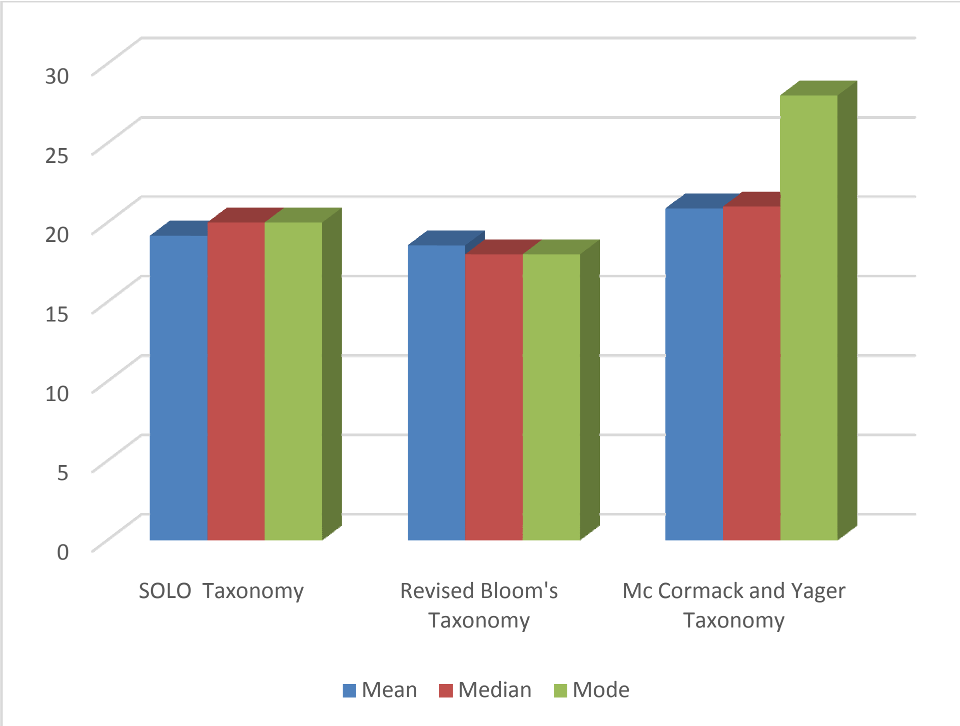


Figure 11: *Graphical Representation of Measures of Central Tendency of Pre test Scores of Scientific Creativity of the secondary school students among the three experimental groups*

b) After the Experiment

The same Scientific Creativity Test was administered by the investigator as post test to all the groups. Each group consisting a total number of 70 students. The post test scores obtained by the students in three groups were condensed into Arithmetic Mean, Median, Mode, Standard Deviation, and Skewness. This was done to get a general picture of the distribution.

Table 18

Descriptive statistics of Scientific Creativity among secondary school students after the experiment

Statistics	SOLO Taxonomy	Revised Bloom's Taxonomy	Mc Cormack and Yager's Taxonomy
Mean	27.71	28.61	35.37
Median	27.50	28.50	36.50
Mode	35	32	40
Std. Deviation	4.505	4.897	4.926
Skewness	.353	-.604	-.942
Kurtosis	-.931	-.327	-.267

The obtained mean score of Scientific Creativity for SOLO Taxonomy group is 27.71, Bloom's Taxonomy group is 28.61 and Mc Cormack and Yager's Taxonomy group is 35.37. All these values indicated that the students from each group have different levels of Scientific Creativity after the experiment.

The Median scores are 27.50, 28.50 and 36.50 for SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy group students respectively, which indicated the middle score of the Scientific Creativity in the each group. The median value represents that 50% of the students lies above and below the value.

The mode value obtained for the SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy group are 35, 32 and 40 respectively. Mode value signifies most repeating scores in the Scientific Creativity test. The Standard Deviation of the SOLO Taxonomy Group is 4.50, Revised Bloom’s Taxonomy group is 4.89, and Mc Cormack and Yager’s Taxonomy group is 4.92. These values show that there is variation of scores in each group after the intervention.

The Skewness obtained for Revised Bloom’s and Mc Cormack and Yager’s Taxonomy were negative but for, SOLO Taxonomy it is positive. And the Kurtosis value of all the groups is negative. It means that the distribution is platykurtic. Graphical representation of Measures of central tendency is shown below.

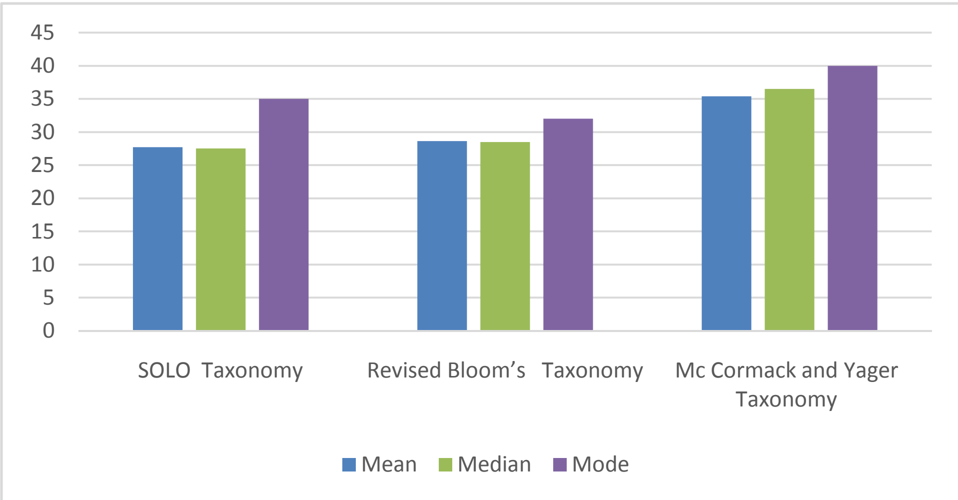


Figure 12: *Graphical Representation showing Measures of Central Tendency of Post test Scores of Secondary School Students in the three Experimental Groups*

Effectiveness of Instructions Based on, SOLO Taxonomy, Revised Bloom’s Taxonomy, and Mc Cormack and Yager’s Taxonomy on Scientific Creativity of Secondary School Students

One of the purposes of this study is to compare the effectiveness of instruction based on the SOLO, Revised Bloom’s and Mc Cormack and Yager’s Taxonomy on Scientific Creativity of secondary school students. For this the investigator developed following hypothesis, and tested these hypotheses using ‘t’ test , ‘F’ test, such as ANOVA and ANCOVA followed by adjusted post test.

1. There will be no significant difference between the mean pre test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Bloom’s Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager’s Taxonomy) for Scientific Creativity of secondary school students.
2. There will be no significant difference between the mean post test scores of Experimental group I, Experimental group II, and Experimental group III for Scientific Creativity of secondary school students.
3. There will be no significant difference between the mean pre test and post test scores of Scientific Creativity of Experimental group I.
4. There will be no significant difference between the mean pre test and post test scores of Scientific Creativity of Experimental group II.
5. There will be no significant difference between the mean pre test and post test scores of Scientific Creativity of Experimental group III.
6. There will be no significant difference between the mean gain scores of Scientific Creativity of Experimental group I and Experimental Group II.
7. There will be no significant difference between the mean gain scores of Scientific Creativity of Experimental group I and Experimental Group III.

8. There will be no significant difference between the mean gain scores of Scientific Creativity of Experimental group II and Experimental Group III.

Comparison of pre test scores of Scientific Creativity among Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom's Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager's Taxonomy)

For this, the investigator compared all the pre test scores of each experimental group using One Way Analysis of Variance. The data and results of the test of significance were given in the table below.

Table 19

Data and result of pre test scores of Scientific Creativity in each Experimental Group

Source of variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	203.895	2	101.948	2.18	p>0.05
Within Groups	9660.300	207	46.668		
Total	9864.195	209			

The obtained 'F' value is 2.18 which is not significant even at 0.05 level of significance (p>0.05). This shows that there is no significant differences in the pre test mean scores of students in each experimental group. Therefore all the three experimental groups do not differ significantly in their Scientific Creativity. So it is inferred that, before the intervention three groups were more or less same in Scientific Creativity.

Comparison of post test scores in Scientific Creativity among Experimental group I, Experimental group II and Experimental group III

For this, the investigator compared all the post test scores in the each experimental groups using One Way Analysis of Variance. The data and results of the test of significance were given in the table below.

Table 20

Data and result of post test scores of Scientific Creativity in the each experimental group

Source of variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2452.352	2	1226.176	53.67	P<0.01
Within Groups	4729.214	207	22.846		
Total	7181.567	209			

The obtained 'F' value is 53.67 which is significant at 0.01 level of significance (p<0.01). This shows that there is a significant difference in the post test means scores of the students in the each experimental group. Therefore the all three experiment groups differ significantly in their scientific Creativity after the intervention. So it is inferred that after the intervention three groups differ significantly in their Scientific Creativity. In order to find out the initial difference among the three groups investigator used Scheffe post hoc test.

Table 21

Data and results of the Scheffe post hoc test for the difference in scientific creativity

Group	N	Subset for alpha = 0.05	
		1	2
SOLO Taxonomy	70	27.71	
Revised Bloom's Taxonomy	70	28.61	
Mc Cormack and Yager's Taxonomy	70		35.37

Above table shows that the obtained mean scores of Mc Cormack and Yager's Taxonomy is 35.37, SOLO taxonomy 27.71 and Revised Bloom's Taxonomy is 28.61. So it is clear that Mc Cormack and Yager's Taxonomy significantly differ from SOLO and Revised Bloom's for Scientific Creativity. It can be represented below through mean plot.

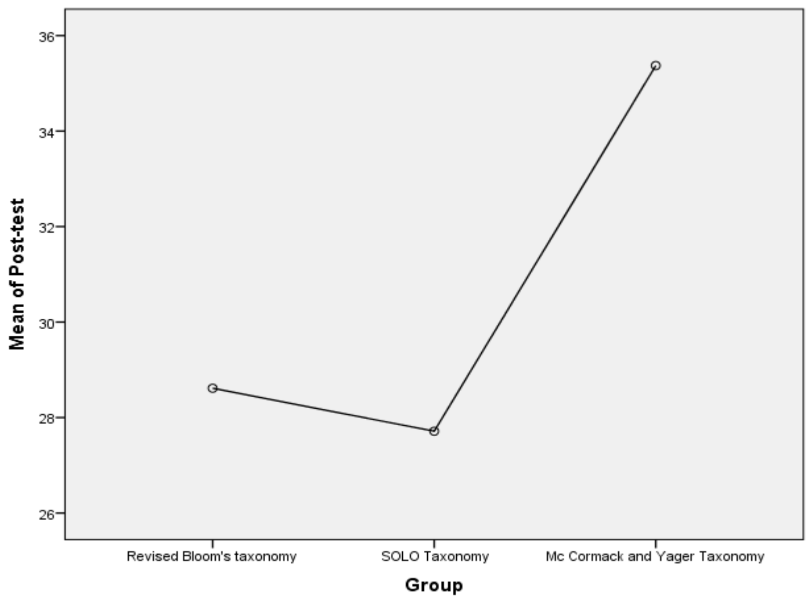


Figure 13: *Mean plot showing the difference in Scientific Creativity of students in the experimental groups receiving instruction based on three taxonomies*

Comparison between the mean Pre test and Post test scores of Scientific Creativity of Experimental Group I

The difference between the pre test and post test mean scores of the Experimental group I (SOLO Taxonomy) were tested for significance by finding the Critical Ratio using Paired Sample ‘t’ test. The data and results of the test of significance were given in the table below.

Table 22

Data and result of Pre test and Post test scores of Scientific Creativity in Experimental Group I

Tests	Mean	N	Std. Deviation	r	t	Sig
Pre test	18.56	70	6.264	.30	11.87	P<0.01
Post test	27.71	70	4.505			

The obtained ‘t’ value is 11.87, which is highly significant at 0.01 level of significance. It means that there exists a significant difference between pre test and post test mean scores in the SOLO Taxonomy group. Since the mean of post test 27.71 is greater than that of pre test mean 18.56, it is inferred that instruction based on the SOLO Taxonomy is effective in developing Scientific Creativity.

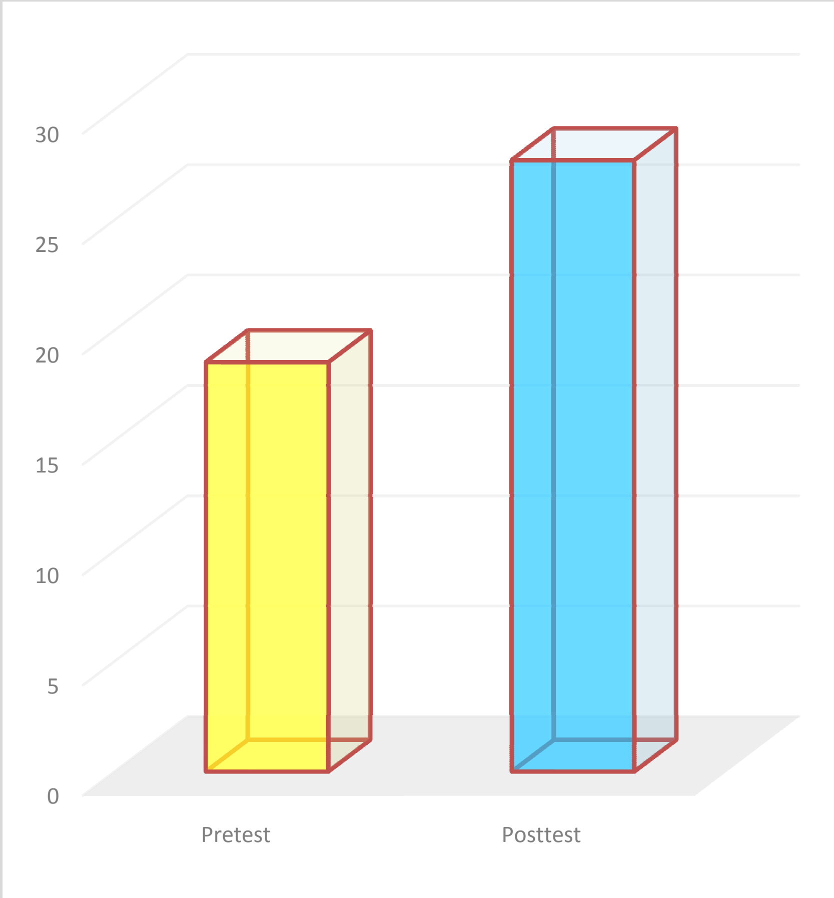


Figure 14: *Graphical Representation showing Pre test and Post test Mean scores of Scientific Creativity in Experimental Group I*

Comparison between the mean Pre test and Post test scores in Scientific Creativity of Experimental Group II.

The difference between the pre test and post test mean scores of the Experimental group II (Revised Bloom's Taxonomy) were tested for significance by finding the Critical Ratio using paired sample 't' test. The data and results of the test of significance were given in the table below.

Table 23

Data and result of Pre test and Post test scores of Scientific Creativity in Experimental Group II

Tests	Mean	N	Std. Deviation	r	t	Sig
Pre test	19.17	70	6.769	.413	12.12	P<0.01
Post test	28.61	70	4.897			

The obtained‘t’ value is 12.12, which is highly significant at 0.01 level of significance. That means there exist a significant difference between pre test and post test mean scores in the Revised Bloom’s Taxonomy group. Since the mean of post test 28.61 is greater than that of the pre test mean 19.17, it is inferred that instruction based on the Revised Bloom’s Taxonomy is effective in developing Scientific Creativity.

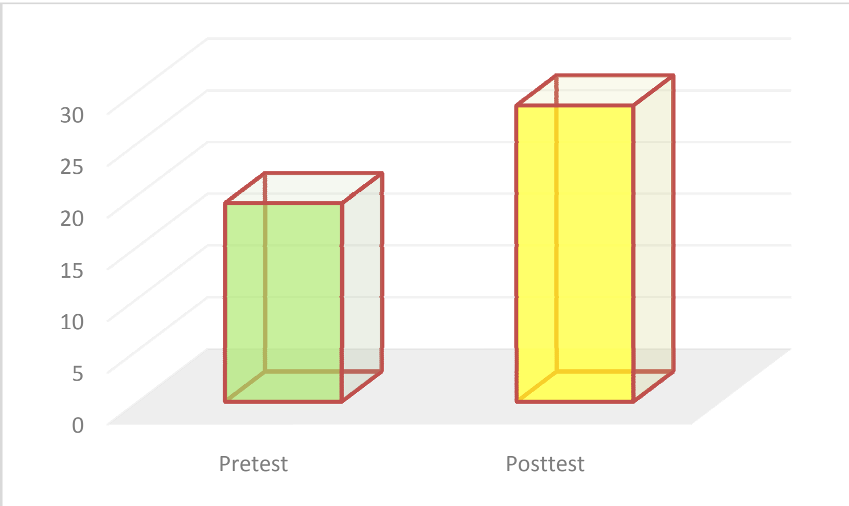


Figure 15: *Graphical Representation showing Pre test and Post test Mean scores of Scientific Creativity in Experimental Group II*

Comparison between the mean Pre test and Post test scores of Scientific Creativity of Experimental group III.

The difference between the pre test and post test mean scores of the Experimental group III (Mc Cormack and Yager's Taxonomy) were tested for significance by finding the critical ratio, using paired sample 't' test. The data and results of the test of significance were given in the table below.

Table 24

Data and result of Pre test and Post test scores of Scientific Creativity in the Experimental Group III

Tests	Mean	N	Std. Deviation	r	t	Sig
Pre test	20.89	70	7.412	.089	13.04	P<0.01
Post test	35.37	70	4.926			

The obtained't' value is 13.04, which is highly significant at 0.01 level of significance, that means there exists a significant difference between pre test and post test mean scores among the Mc Cormack and Yager's Taxonomy group. Since the mean of post test 35.37 is greater than that of the pre test mean 20.89, it is inferred that instruction based on Mc Cormack and Yager's Taxonomy is effective in developing Scientific Creativity.

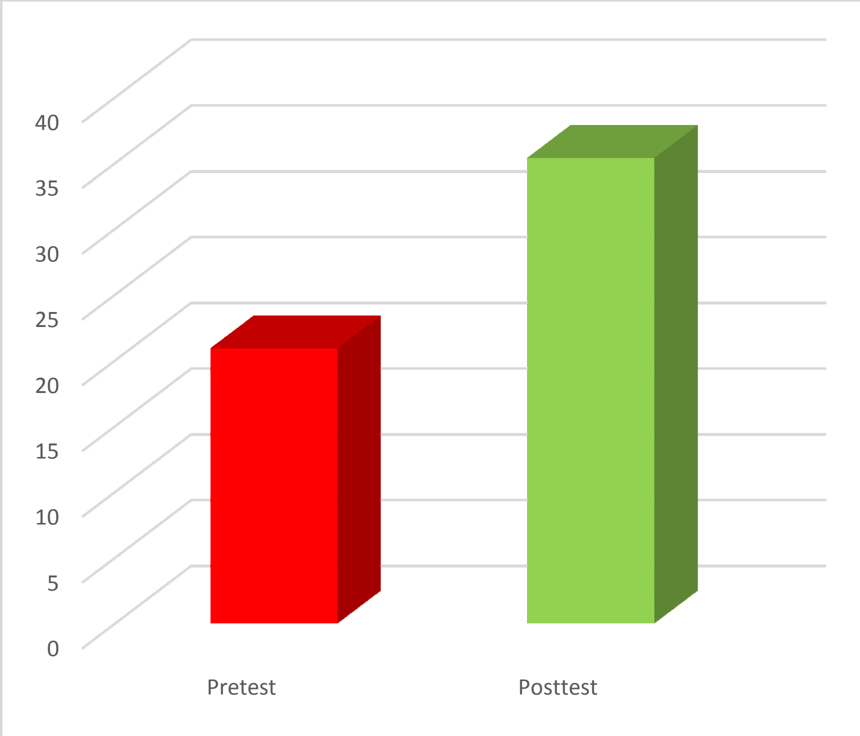


Figure 16: *Graphical Representation showing Pre test and Post test Mean scores of Scientific Creativity in Experimental Group III*

Comparison between the Mean Gain Scores of Scientific Creativity between Experimental Group I and Experimental Group II

The difference between the Mean Gain Scores of the Experimental group I(SOLO Taxonomy) and Experimental Group II (Revised Bloom's Taxonomy) were tested for significance by finding the critical ratio, using Independent Sample't' test. The data and results of the test of significance are given in the table below.

Table 25

Data and result of Pre test and Post test Gain scores of Scientific Creativity of Experimental group I (SOLO) and Experimental Group II (Revised Bloom's)

Tests	Mean	N	Std. Deviation	t	Sig
Revised Bloom's Taxonomy Based Instruction	9.44	70	6.51	0.259	P>0.05
SOLO Taxonomy based Instruction	9.15	70	6.4		

The obtained't' value is .259, which is not significant at 0.05 level of significance. It means that, there exists no significant difference between Mean Gain Scores of Revised Bloom's Taxonomy Group and SOLO Taxonomy Group in their Scientific Creativity.

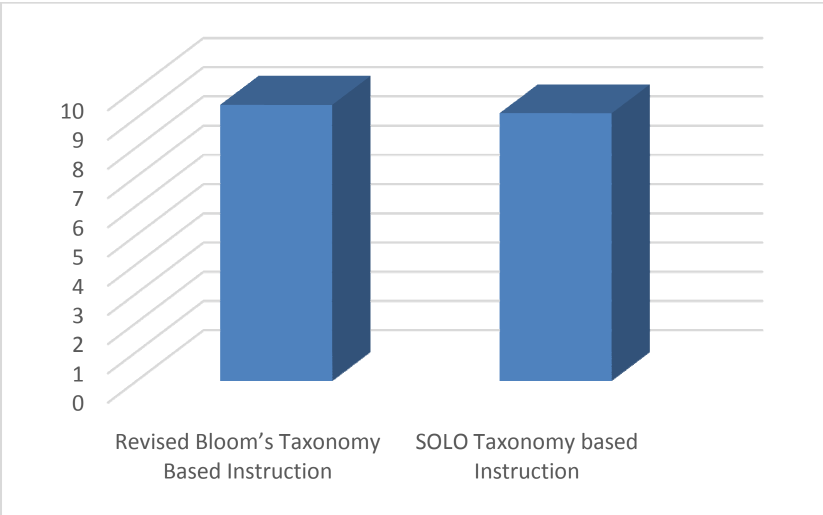


Figure 17: *Graphical Representation showing Pre test and Post test Gain scores of Scientific Creativity among Experimental group I (SOLO) and Experimental Group II (Revised Bloom's Taxonomy)*

Comparison between the Mean Gain Scores of Scientific Creativity among Experimental group II and Experimental Group III

The difference between the mean gain scores of the Experimental group II (Revised Bloom's Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy) were tested for significance by finding the Critical Ratio, using Independent sample't' test. The data and results of the test of significance were given in the table below.

Table 26

Data and result of Pre test and Post test Gain scores of Scientific Creativity among Experimental group II and Experimental Group III

Tests	Mean	N	Std. Deviation	t	Sig
Revised Bloom's	9.15	70	6.4	3.94	P<0.01
Mc Cormack and Yager's	14.4	70	9.25		

The obtained't' value is 3.94, which is significant at 0.01 level of significance that means there exists a significant difference between mean gain scores in Revised Bloom's and Mc Cormack and Yager's Taxonomy group. Since the mean gain of Mc Cormack and Yager's Taxonomy group, 14.4 is greater than that of the mean gain of Revised Bloom's 9.15, it is inferred that students from Mc Cormack and Yager's Taxonomy group have high gain in their Scientific Creativity score.

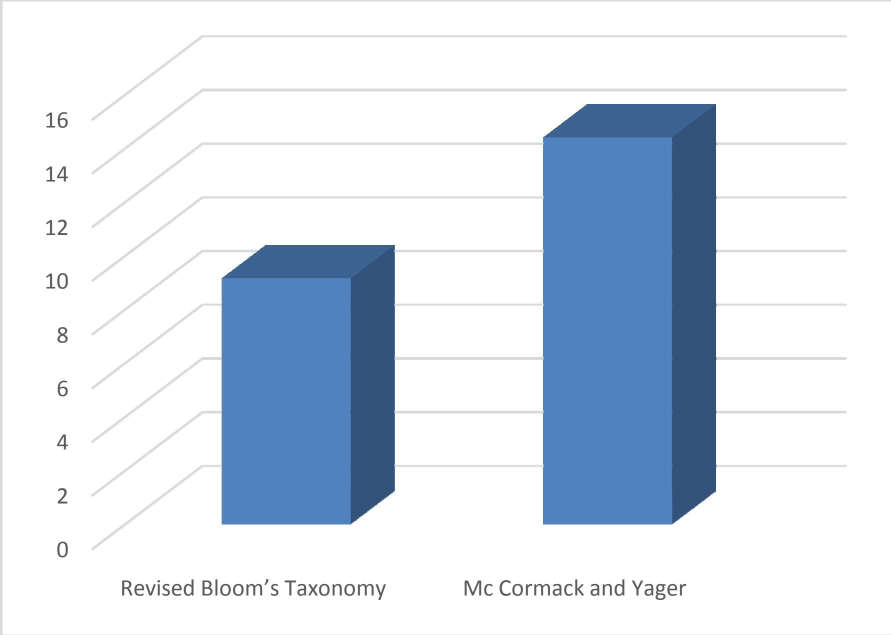


Figure 18: *Graphical Representation showing Pre test and Post test Gain scores of Scientific Creativity among Experimental Group II and Experimental Group III*

Comparison between the Mean Gain Scores of Scientific Creativity among Experimental group II and Experimental Group III

The difference between the Mean Gain Scores of the Experimental group I (SOLO Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy) were tested for significance by finding the Critical Ratio, using independent sample 't' test. The data and results of the test of significance were given in the table below.

Table 27

Data and result of Pre test and Post test Gain scores of Scientific Creativity among Experimental group I and Experimental Group III

Tests	Mean	N	Std. Deviation	t	Sig
SOLO Taxonomy Group	9.44	70	9.25	3.72	P<0.01
Mc Cormack and Yager's Taxonomy Group	14.4	70	6.51		

The obtained't' value is 3.72, which is highly significant at 0.01 level of significance. It means that, there exists a significant difference between mean gain scores among SOLO and Mc Cormack and Yager's Taxonomy group. Since the mean gain of Mc Cormack and Yager's Taxonomy group 14.4, is greater than that of the mean gain of SOLO 9.4, it is inferred that students from Mc Cormack and Yager's Taxonomy group have high gain in their Scientific Creativity score.

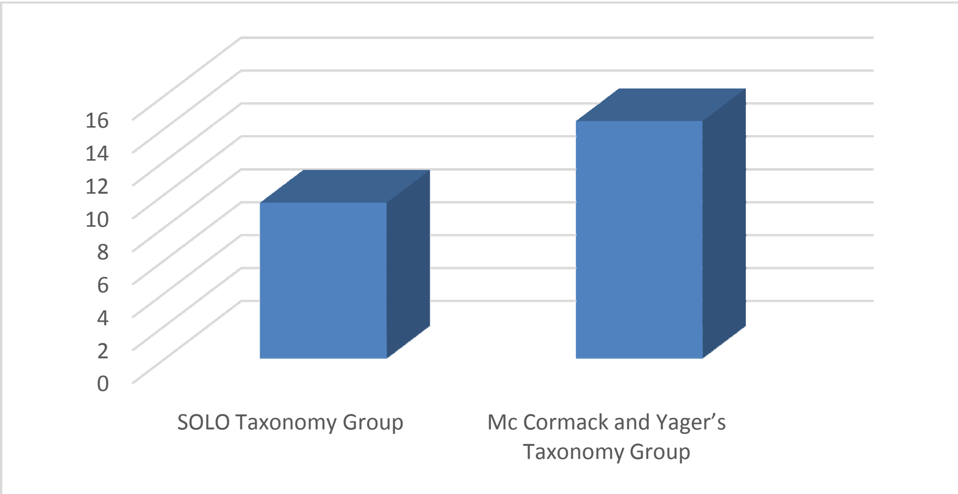


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Figure 19: *Graphical Representation showing Pre test and Post test Gain scores of Scientific Creativity among Experimental Group II and Experimental Group III*

Comparison of Effectiveness of Instructions based on Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy on Scientific Creativity of secondary school students

In this section investigator compared the post test score for Scientific Creativity of the secondary school students in the three groups using Univariate Analysis. Here the investigator took pre test as co-variate. Following tables show the results.

Table 28

Data and Results of the Univariate analysis, for testing the Effectiveness of Instructions based on Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy on Scientific Creativity of secondary school students

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Pre test Scientific Creativity	180.844	1	180.844	8.191	P<0.01
Group	2219.142	2	1109.571	50.254	P<0.01
Error	4548.371	206	22.079		
Total	203389.000	210			

Above table shows the obtained 'F' for the error is 50.25 which is highly significant at 0.01 level of significance (p<0.01). It means that, instructions based on Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy were effective for developing Scientific Creativity among secondary school students.

The adjusted means of post test scores(x, y means) of students in the each experimental group were calculated. The difference between the adjusted y means was tested for significance. The data for adjusted means of post test scores of students in experimental groups were given in the following table.

Table 29

Data for adjusted means of post test scores for Scientific Creativity among secondary school students who received instructions based on Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy

Groups	N	Mx	My	M_{XY}		t
SOLO Taxonomy(A)	70	18.56	27.71	27.84	A-B	1.02
Bloom's Taxonomy(B)	70	19.17	28.61	28.66	B-C	9.13*
Mc Cormack and Yager's(C)	70	20.89	35.37	35.18	A-C	8.17*
Total	210	19.54	30.5			

Above table shows the adjusted post test mean score in each groups for the instructions based on Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy on Scientific Creativity of secondary school students. The adjusted mean score of Mc Cormack and Yager's is 35.18, which is greater than the adjusted mean score of SOLO Taxonomy 27.84, and Revised Bloom's Taxonomy 28.66. In order to find out the significant mean differences among the each taxonomy investigator used pair wise comparison. Following table shows the pair wise comparison.

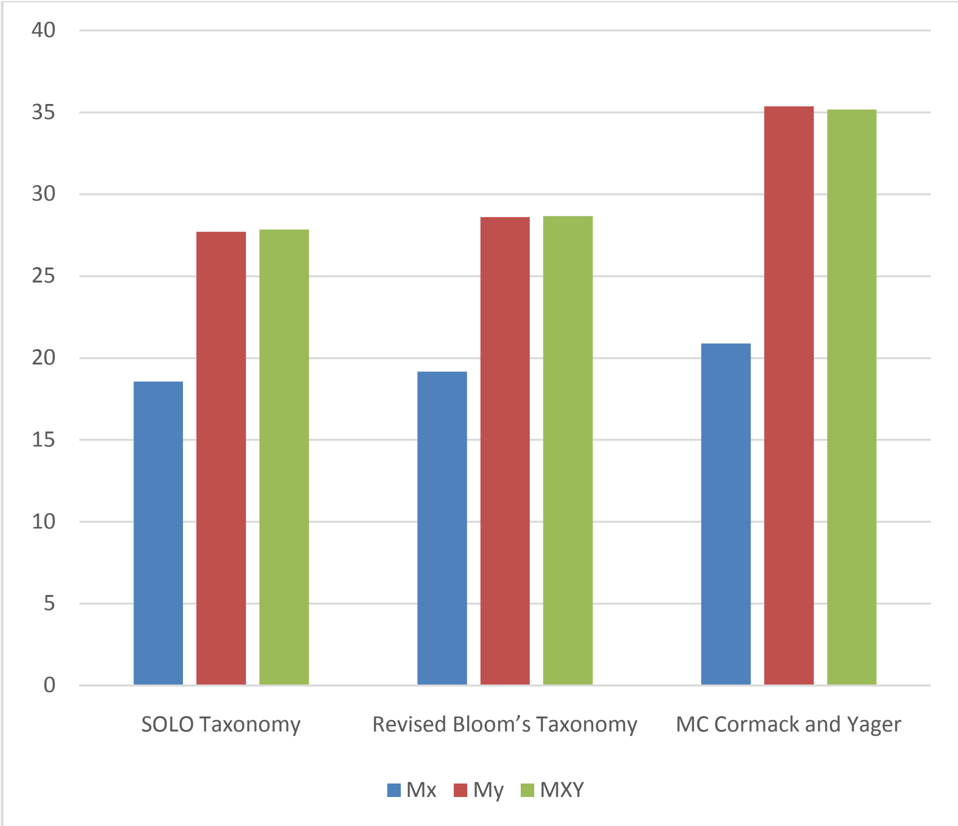


Figure 20: *Graphical Representation showing Pre test and Post test adjusted means of Scientific Creativity of Experimental Group II and Experimental Group III*

Table 30

Data and result of the significant mean differences among Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy using Pair wise Comparisons

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
SOLO taxonomy	Revised Bloom's Taxonomy	.816	.795	P>0.05
	Mc Cormack and Yager's Taxonomy	-7.339*	.802	P<0.01
Revised Bloom's Taxonomy	SOLO taxonomy	-.816	.795	P>0.05
	Mc Cormack and Yager's Taxonomy	-6.523*	.798	P<0.01
Mc Cormack and Yager's Taxonomy	SOLO taxonomy	7.339*	.802	P<0.01
	Revised Bloom's Taxonomy	6.523*	.798	P<0.01

Above table shows, that the obtained mean difference is not significant between Revised Bloom's with SOLO Taxonomy is .816 (p>0.05) and Revised Bloom's with Mc Cormack and Yager's Taxonomy is 6.52. the differences are highly significant. In the case of SOLO with Mc Cormack and Yager's Taxonomy also, the mean difference (7.33) is highly significant. Among the mean differences Mc Cormack and Yager's Taxonomy have high difference compared to SOLO and Revised Bloom's. So it can be concluded that Mc Cormack and Yager's Taxonomy (35.18) is more effective to develop Scientific Creativity among secondary school students and then comes Revised Bloom's Taxonomy (28.66) for developing Scientific Creativity. From the present study, it was found that SOLO Taxonomy comes below the other two taxonomies in developing Scientific Creativity among secondary school students. It can be represented below through estimated marginal mean plot.

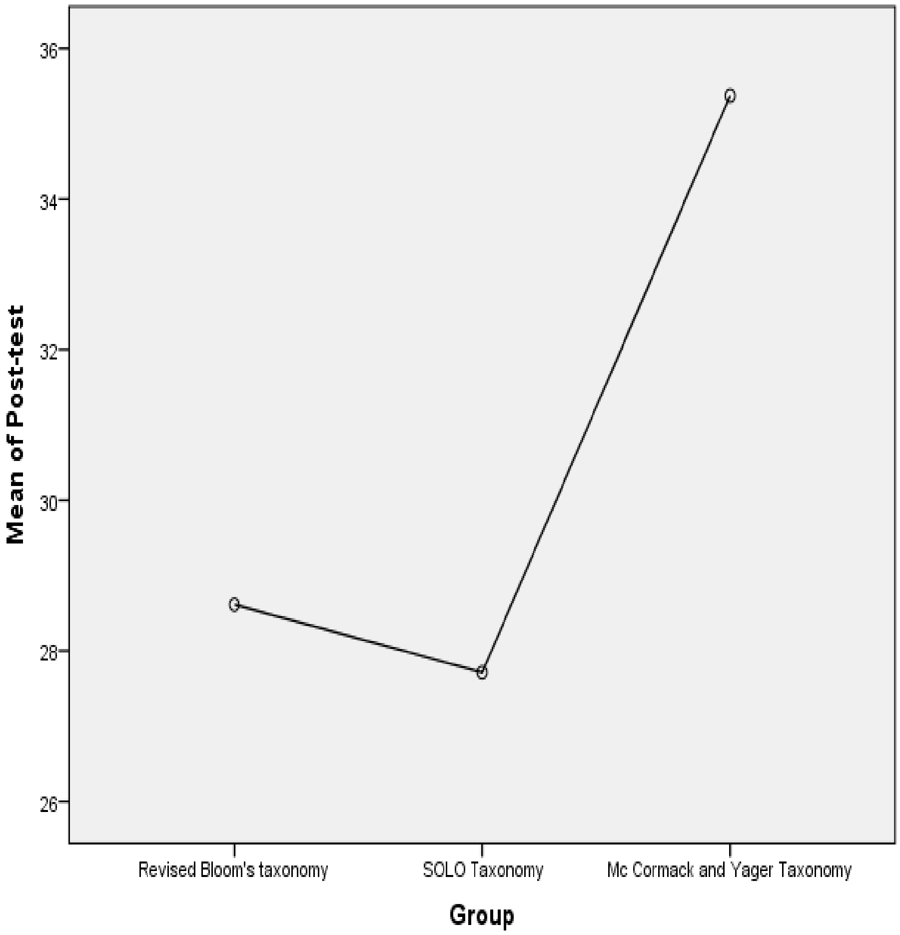


Figure 21: *Graphical Representation showing Estimated Marginal Mean plot of Scientific Creativity of Experimental Group I, Experimental Group II and Experimental Group III*

Comparison of Metacognitive Awareness

Comparison of Metacognitive Awareness of Secondary School Students in the Experimental Group I (SOLO Taxonomy), Experimental Group II (Revised Bloom's Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy)

After equating the group, the investigator administered pre test in Scientific Attitude, Scientific Creativity, and Metacognitive Awareness among the three experimental groups. Then administered intervention strategy in each experimental group like Experimental Group I (SOLO Taxonomy), Experimental Group II (Revised Bloom's Taxonomy), and Experimental Group III (Mc Cormack and Yager's Taxonomy).After the intervention investigator administered same test as post test in all the groups. Then tabulated the scores in the pre test and post test and condensed it in to the descriptive statistics of pre test and post test for analyzing the preliminary features of the data. Following tables shows the descriptive statistics of the pre test and post test scores of the each group with regard to the learning outcome, Metacognitive Awareness.

Descriptive statistics of pre test scores of Metacognitive Awareness of the Secondary school students in the Experimental Group I (SOLO Taxonomy), Experimental Group II (Revised Bloom's Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy)

a) Before the experiment

Before starting the experiment, Metacognitive Awareness test was administered by the investigator as pre test to all the groups. Each group consisting a total number of 70 students. The pre test scores obtained by the students in the three groups were condensed into arithmetic mean, median, mode, standard deviation and skewness. This was to get a general picture of the performance of students in the three groups before the experiment.

Table 31

Descriptive statistics of Metacognitive Awareness among secondary school students before the experiment

Statistics	SOLO Taxonomy	Revised Bloom's Taxonomy	Mc Cormack and Yager's Taxonomy
Mean	271.04	275.44	266.11
Median	279.50	284.00	271.00
Mode	268	285	265
Std. Deviation	30.270	27.185	28.924
Skewness	-.565	-.748	-.683
Kurtosis	.273	.074	.189

The maximum score being 330 for Metacognitive Awareness, the obtained mean score in SOLO Taxonomy is 271.04, Revised Bloom's Taxonomy group is 275.44, and that of Mc Cormack and Yager's Taxonomy group is 266.11. All these values indicated that, the average Metacognitive Awareness of the students in each group was more or less the same.

The median scores are 279.50, 284.00, and 271.00 for SOLO Taxonomy, Revised Bloom's Taxonomy, and Mc Cormack and Yager's Taxonomy group students respectively, which indicated the middle score of the Metacognitive Awareness in the group. The median value represent that 50% of the students are above and below the value.

The mode value obtained for, SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy group are 20, 18, and 28 respectively. These are the most repeating scores in the

Metacognitive Awareness test. The standard deviation of the SOLO Taxonomy group is 30.20, Revised Bloom's Taxonomy group is 27.18 and Mc Cormack and Yager's Taxonomy group is 28.92. These values show the variations of scores in each group before the intervention.

The skewness obtained for the Revised Revised Bloom's, Mc Cormack, and Yager's Taxonomy and for SOLO Taxonomy is negative. Kurtosis value of all the group are positive that means, the distribution is platykurtic. Graphical representation of Measures of central tendency is shown below. The values of measures central tendency approaches to normality.

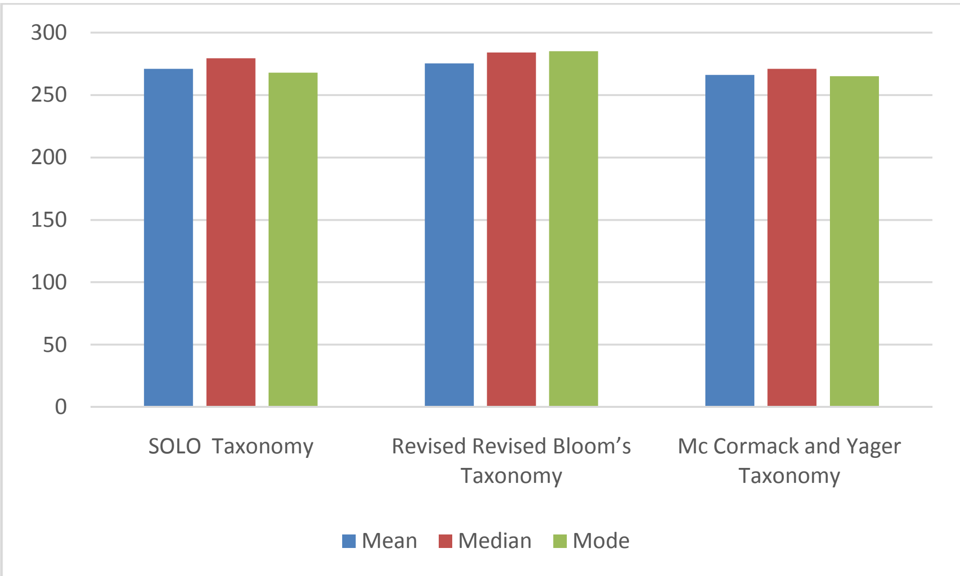


Figure 22: *Graphical Representation of Measures of Central Tendency of Pre test Scores of Metacognitive Awareness of the secondary school students in the three experimental groups*

b) After the Experiment

The same Metacognitive Awareness test was administered by the investigator as post test to all the groups. Each group consisting a total number of 70 students. The post test scores obtained by the students in three groups were condensed into Arithmetic Mean, Median, Mode, Standard Deviation and Skewness. This was done to get a general picture of the distribution.

Table 32

Descriptive statistics of Metacognitive Awareness among Secondary School Students after the experiment

Statistics	SOLO Taxonomy	Revised Bloom's Taxonomy	Mc Cormack and Yager's Taxonomy
Mean	322.24	310.29	297.21
Median	325.00	317.50	298.00
Mode	325	330	305
Std. Deviation	9.150	24.045	12.146
Skewness	-1.953	-1.768	-1.636
Kurtosis	3.147	3.018	2.61

The maximum score being 330 for the Metacognitive Awareness, the obtained mean score of SOLO Taxonomy group is 322.24, Revised Bloom's Taxonomy group is 310.29, and Mc Cormack and Yager's Taxonomy group is 297.21. All these values indicated that the students from each group have different levels of Metacognitive Awareness after the experiment.

The Median scores obtained are 325.50, 317.50 and 298 for SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy group students respectively, which indicated the middle score of the Metacognitive Awareness in the each group. The median value represents that 50% of the students lies above and below the value.

The mode value obtained for SOLO Taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy group are

325.00, 317.50 and 298.00 respectively. Mode value signifies most repeating scores in the Metacognitive Awareness test. The Standard Deviation of the SOLO Taxonomy Group is 9.15, Revised Bloom's Taxonomy group is 24.04, and Mc Cormack and Yager's Taxonomy group is 12.14. These values show that there is variation of scores in each group after the intervention.

Skewness obtained for Revised Bloom's Taxonomy, Mc Cormack and Yager's Taxonomy and SOLO Taxonomy, is positive. And the Kurtosis value of all the groups is positive; that means the distribution is leptokurtic. Graphical representation of Measures of central tendency is shown below.

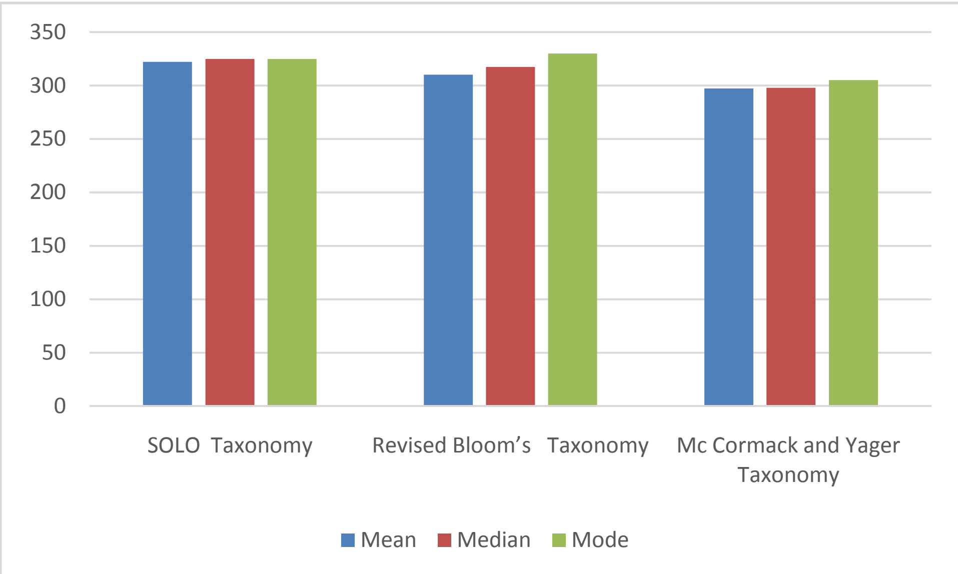


Figure 23: *Graphical Representation showing Measures of Central Tendency of Post test Scores of Secondary School Students in the three Experimental Groups*

Effectiveness of Instructions Based on, SOLO Taxonomy, Revised Bloom's Taxonomy, and Mc Cormack and Yager's Taxonomy on Metacognitive Awareness of Secondary School Students

One of the purposes of this study is to compare the effectiveness of instruction based on the SOLO, Revised Bloom's and Mc Cormack and Yager's Taxonomy on Metacognitive Awareness of secondary school students. For this the investigator developed following hypothesis, and tested these hypotheses using ‘t’ test, ‘F’ test, such as ANOVA and ANCOVA followed by adjusted post test.

1. There will be no significant difference between the mean pre test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom’s Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager’s Taxonomy) for Metacognitive Awareness of secondary school students.
2. There will be no significant difference between the mean post test scores of Experimental group I, Experimental group II and Experimental group III for Metacognitive Awareness of secondary school students.
3. There will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group I.
4. There will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group II.
5. There will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group III.
6. There will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group I and Experimental Group II.
7. There will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group I and Experimental Group III.

8. There will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group II and Experimental Group III.

Comparison of pre test scores of Metacognitive Awareness among Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom's Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager's Taxonomy)

For this, the investigator compared all the pre test scores of each experimental groups using One Way Analysis of Variance. The data and results of the test of significance were given in the table below.

Table 33

Data and result of pre test scores of Metacognitive Awareness in each Experimental Group

Source of variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3049.038	2	1524.519	1.83	p>0.05
Within Groups	171941.229	207	830.634		
Total	174990.267	209			

The obtained 'F' value is 1.83 which is not significant at 0.05 level of significance (p>0.05). This shows that there is no significant differences in the pre test mean scores among the students in each experimental group. Therefore all the three experimental groups do not differ significantly in their Metacognitive Awareness. So it is inferred that, before the intervention three groups were more or less same in Metacognitive Awareness.

Comparison of post test scores in Metacognitive Awareness among Experimental group I, Experimental group II and Experimental group III

For this the investigator compared all the post test scores in each experimental groups using One Way Analysis of Variance. The data and results of the test of significance were given in the table below.

Table 34

Data and result of post test scores of Metacognitive Awareness in the each experimental group

Source of variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	21939.514	2	10969.757	40.65	P<0.01
Within Groups	55848.943	207	269.802		
Total	77788.457	209			

The obtained 'F' value is 40.65 which is significant at 0.01 level of significance ($p<0.01$). This shows that there is a significant difference in the post test means scores of the students in the each experimental group. Therefore the all the three experiment groups differ significantly in their Metacognitive Awareness after the intervention. So it is inferred that after the intervention three groups differ significantly in their Metacognitive Awareness. In order to find out the initial difference among the three groups investigator used Scheffe post hoc test.

Table 35

Data and results of the Scheffe post hoc test for the difference in Metacognitive Awareness

Group	N	Subset for alpha = 0.05		
		1	2	3
Mc Cormack and Yager's Taxonomy	70	297.21		
Revised Bloom's Taxonomy	70		310.29	
SOLO taxonomy	70			322.24

Above table shows that the obtained mean scores of Mc Cormack and Yager's Taxonomy is 297, SOLO taxonomy 322.24 and Revised Blooms Taxonomy is 310. So it is clear that SOLO Taxonomy significantly differ from Mc Cormack and Yager's Taxonomy and Revised Bloom Taxonomy for Metacognition. It can be represented below through mean plot.

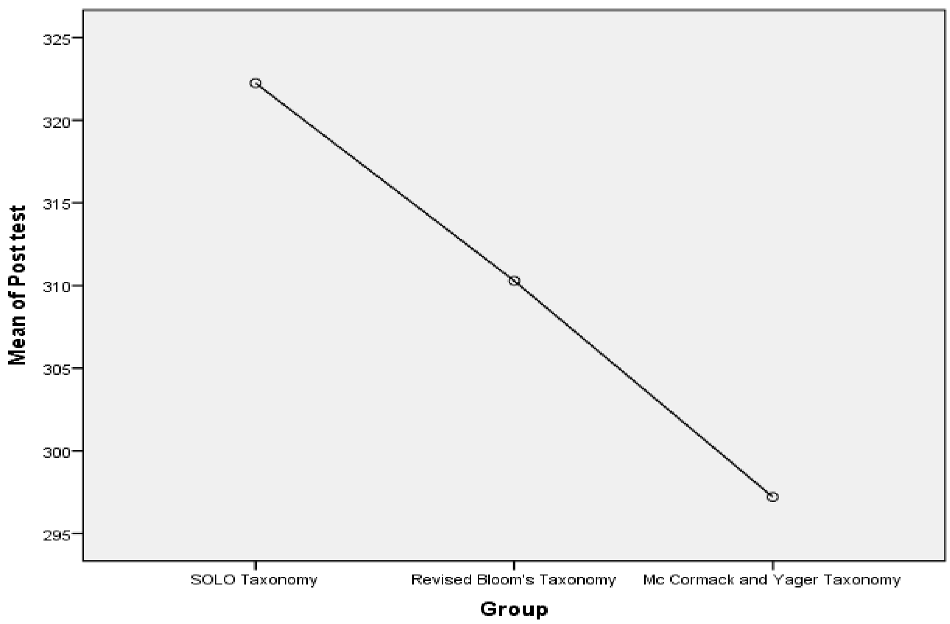


Figure 24: *Mean plot showing the difference in Metacognitive Awareness of students in the experimental groups receiving instruction based on three taxonomies*

Comparison between the mean pre test and post test scores of Metacognitive Awareness of Experimental Group I

The difference between the pre test and post test mean scores of the Experimental group I (SOLO Taxonomy) were tested for significance by finding the Critical Ratio using Paired Sample‘t’ test. The data and results of the test of significance were given in the table below.

Table 36

Data and result of Pre test and Post test scores of Metacognitive Awareness in Experimental Group I

Tests	Mean	N	Std. Deviation	r	t	Sig
Pre test	271.04	70	30.270	.009	13.58	P<0.01
Post test	322.24	70	9.150			

The obtained ‘t’ value is 13.58, which is highly significant at 0.01 level of significance. It means that, there exist a significant difference between pre test and post test mean scores in the SOLO Taxonomy group. Since the mean of post test 322.24, is greater than that of the pre test mean 271.04, it is inferred that instruction based on the SOLO Taxonomy is effective in developing the Metacognitive Awareness.

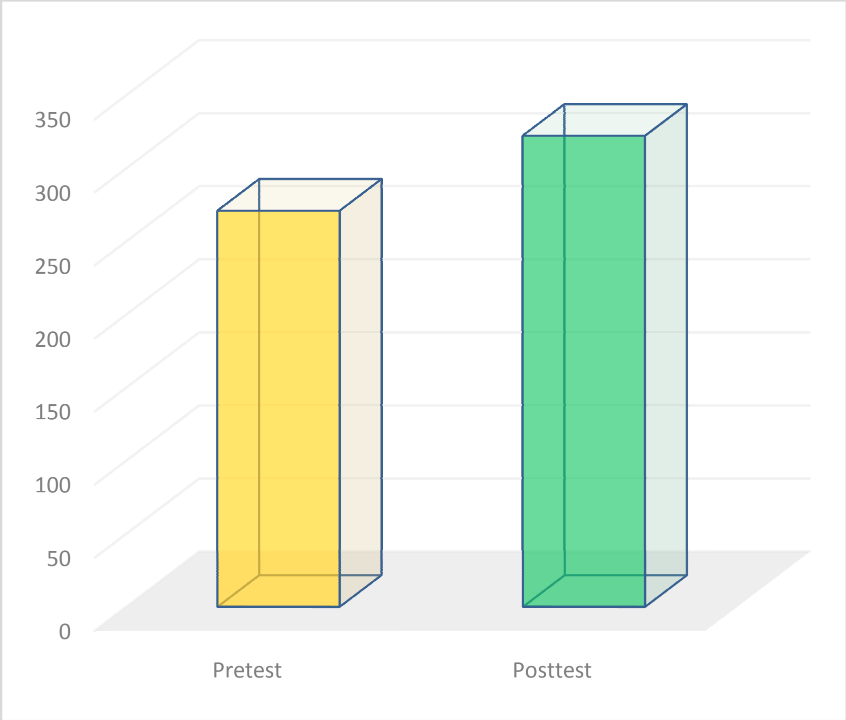


Figure 25: *Graphical Representation showing of pre test and post test Mean scores of Metacognitive Awareness in Experimental Group I*

Comparison between the mean Pre test and Post test scores of Metacognitive Awareness among Experimental Group II.

The difference between the pre test and post test mean scores of the Experimental group II (Revised Bloom's Taxonomy) were tested for significance by finding the Critical Ratio using paired sample 't' test. The data and results of the test of significance were given in the table below.

Table 37

Data and result of Pre test and Post test scores of Metacognitive Awareness in Experimental Group II

Tests	Mean	N	Std. Deviation	r	t	Sig
Pre test	275.44	70	27.185	.69	14.33	P<0.01
Post test	310.29	70	24.045			

The obtained 't' value is 14.33, which is highly significant at 0.01 level of significance. It means that, there exists a significant difference between pre test and post test mean scores in the Revised Bloom's Taxonomy group. Since the mean of post test 310.29 is greater than that of pre test mean 275.44, it is inferred that instruction based on the Revised Bloom's Taxonomy is effective in developing Metacognitive Awareness.

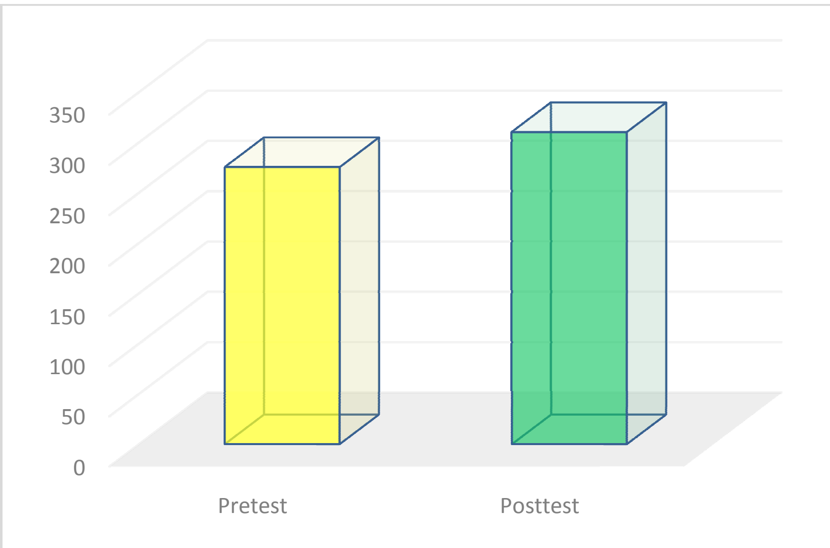


Figure 26: *Graphical Representation showing pre test and post test Mean scores of Metacognitive Awareness in Experimental Group II*

Comparison between the mean Pre test and Post test scores of Metacognitive Awareness of Experimental group III.

The difference between the pre test and post test mean scores of the Experimental group III (Mc Cormack and Yager's Taxonomy) were tested for significance by finding the critical ratio, using paired sample 't' test. The data and results of the test of significance were given in the table below.

Table 38

Data and result of Pre test and Post test scores of Metacognitive Awareness in the Experimental Group III

Tests	Mean	N	Std. Deviation	r	t	Sig
Pre test	266.11	70	28.924	.081	8.54	P<0.01
Post test	297.21	70	12.146			

The obtained 't' value is 8.54, which is highly significant at 0.01 level of significance. It means that there exists a significant difference between pre test and post test mean scores in the Mc Cormack and Yager's Taxonomy group. Since the mean of post test 297.21 is greater than that of the pre test mean 266.11, it is inferred that instruction based on the SOLO Taxonomy is effective in developing Metacognitive Awareness.

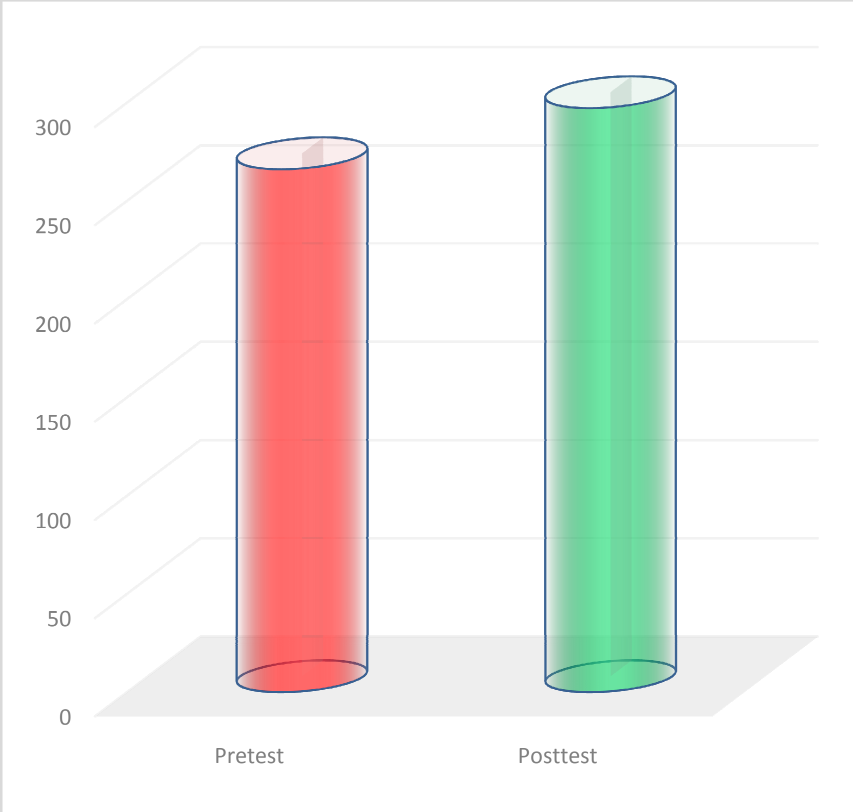


Figure 27: *Graphical Representation showing of Pre test and Post test Mean scores of Metacognitive Awareness in Experimental Group III*

Comparison between the Mean Gain Scores of Metacognitive Awareness between Experimental group I and Experimental Group II

The difference between the Mean Gain Scores of the Experimental group I(SOLO Taxonomy) and Experimental Group II (Revised Bloom's Taxonomy) were tested for significance by finding the critical ratio, using Independent Sample't' test. The data and results of the test of significance were given in the table below.

Table 39

Data and result of Pre test and Post test Gain scores of Metacognitive Awareness of Experimental group I (SOLO) and Experimental Group II (Revised Bloom's)

Tests	Mean	N	Std. Deviation	t	Sig
SOLO Taxonomy based Instruction	51.2	70	31.54	3.64	P<0.01
Revised Bloom's Taxonomy Based Instruction	34.84	70	20.34		

The obtained 't' value is 3.64, which is significant at 0.01 level of significance; it means that there exists a significant difference between Mean Gain Scores of Revised Bloom's Taxonomy Group and SOLO Taxonomy Group in their Metacognitive Awareness. The obtained mean score of SOLO taxonomy 51.2 is greater than the mean score of Revised Bloom's taxonomy 34.84. So it is inferred that students from SOLO group have high level of Metacognitive Awareness.

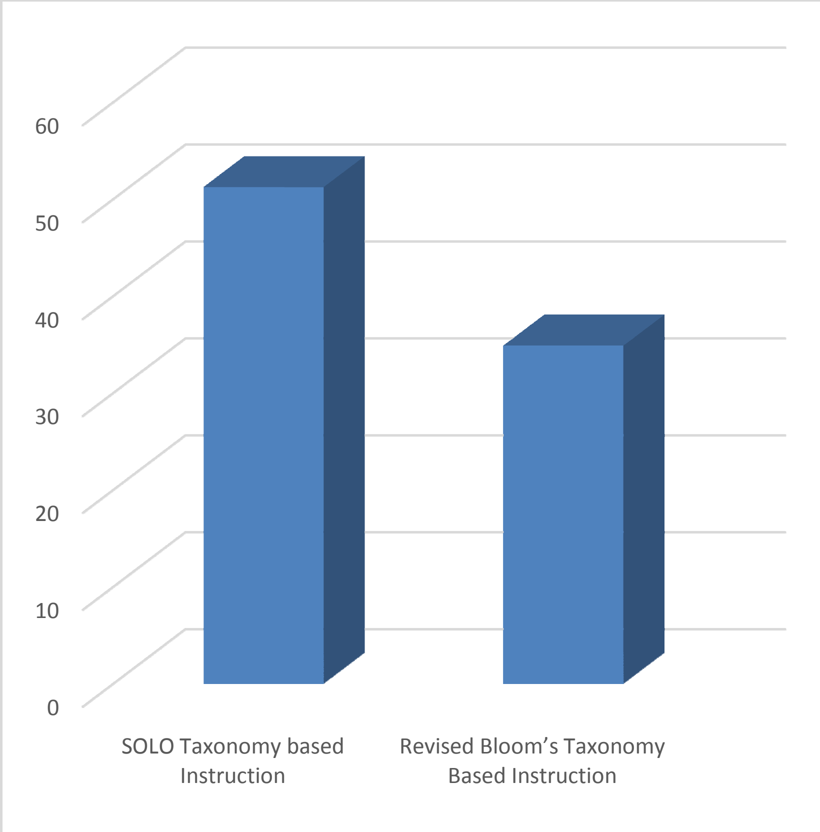


Figure 28: *Graphical Representation showing pre test and post test Gain Scores of Metacognitive Awareness among Experimental group I (SOLO) and Experimental Group II (Revised Bloom's)*

Comparison between the Mean Gain Scores of Metacognitive Awareness among Experimental Group II and Experimental Group III

The difference between the mean gain scores of the Experimental group II (Revised Bloom's Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy) were tested for significance by finding the Critical Ratio, using Independent Sample't' test. The data and results of the test of significance were given in the table below.

Table 40

Data and result of pre test and post test gain scores of Metacognitive Awareness among Experimental group II and Experimental Group III

Tests	Mean	N	Std. Deviation	t	Sig
Revised Bloom's	34.84	70	20.34	.85	P>0.05
Mc Cormack and Yager's	31.1	70	30.45		

The obtained't' value is .85, which is not significant at 0.05 level of significance. It means that there exists no significant difference between gain mean scores in the Revised Bloom's and Mc Cormack and Yager's Taxonomy group. Since the mean gain of Mc Cormack and Yager's Taxonomy group and the mean gain of Revised Bloom's are more or less same, it is inferred that students from Mc Cormack and Yager's Taxonomy group and Revised Bloom's have almost same level of mean gain in their Metacognitive Awareness score.

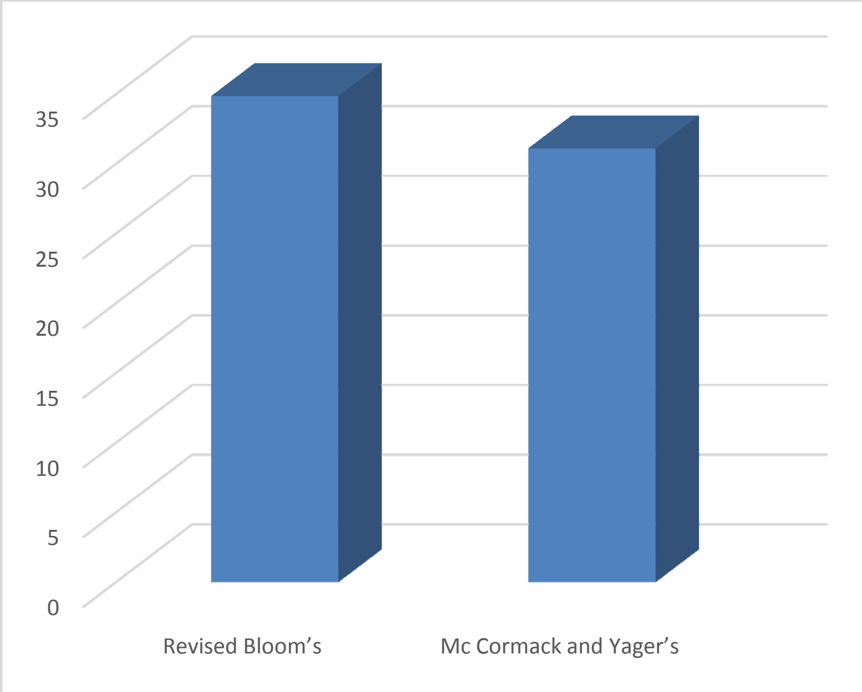


Figure 29: *Graphical Representation showing pre test and post test gain scores of Metacognitive Awareness among Experimental Group II and Experimental Group III*

Comparison between the Mean Gain Scores of Metacognitive Awareness of Experimental group I and Experimental Group III

The difference between the Mean Gain Scores of the Experimental group I (SOLO Taxonomy) and Experimental Group III (Mc Cormack and Yager's Taxonomy) were tested for significance by finding the Critical Ratio, using independent sample 't' test. The data and results of the test of significance were given in the table below.

Table 41

Data and result of pre test and post test gain scores of Metacognitive Awareness among Experimental group I and Experimental Group III

Tests	Mean	N	Std. Deviation	t	Sig
SOLO Taxonomy Group	51.2	70	31.54	3.83	P<0.01
Mc Cormack and Yager's Taxonomy Group	31.1	70	30.45		

The obtained 't' value is 3.83, which is highly significant at 0.01 level of significance. It means that there exists a significant difference between mean gain scores among SOLO and Mc Cormack and Yager's Taxonomy group. Since the mean gain of SOLO Taxonomy group 51.2, is greater than that of the mean gain of Mc Cormack and Yager's 31.1, it is inferred that students from SOLO Taxonomy group have high gain in their Metacognitive Awareness score.

Figure 30: *Graphical Representation showing pre test and post test gain scores of Metacognitive Awareness among Experimental Group II and Experimental Group III*

Comparison of Effectiveness of Instructions based on Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy on Metacognitive Awareness of secondary school students

In this section investigator compared the post test score of the Metacognitive Awareness of secondary school students in the three groups using Univariate Analysis. Here the investigator took pre test as co-variate. Following tables show the results.

Table 42

Data and Results of the Univariate analysis, for testing the Effectiveness of Instructions based on Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy for Metacognitive Awareness of secondary school students

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Pre test Metacognitive Awareness	6449.510	1	6449.510	26.895	P<0.01
Group	20225.239	2	10112.619	42.171	P<0.01
Error	49399.433	206	239.803		
Total	20247630.00	210			

Above table shows the obtained 'F' for the error is 42.17 which is highly significant at 0.01 level of significance ($p<0.01$). It means that instructions based on Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy were effective for developing Metacognitive Awareness among secondary school students.

The adjusted means of post test scores (x, y means) of students in the each experimental group were calculated. The difference between the adjusted y means was tested for significance. The data for adjusted means of post test scores of students in experimental and control groups were given in the following table.

Table 43

Data for adjusted means of post test scores for Metacognitive Awareness among secondary school students who received instructions based on Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy

Groups	N	Mx	My	M_{XY}		t
SOLO Taxonomy (A)	70	271.04	322.24	322.42	A-B	4.88*
Revised Bloom's Taxonomy(B)	70	275.44	310.29	309.73	B-C	9.18*
Mc Cormack and Yager's(C)	70	266.11	297.21	298.15	A-c	4.26*
Total	210	270.86	309.11			

*significant at 0.01

Above table shows, the adjusted post test mean score in the each group for instructions based on Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy on Metacognitive Awareness of secondary school students. The adjusted mean score of SOLO Taxonomy is 322.42, which is greater than the adjusted mean score of Revised Bloom's Taxonomy 309.73, and Mc Cormack and Yager's Taxonomy 298.15. In order to find out the significant mean differences among the each taxonomy investigator used pair wise comparison. Following table shows the pair wise comparison.

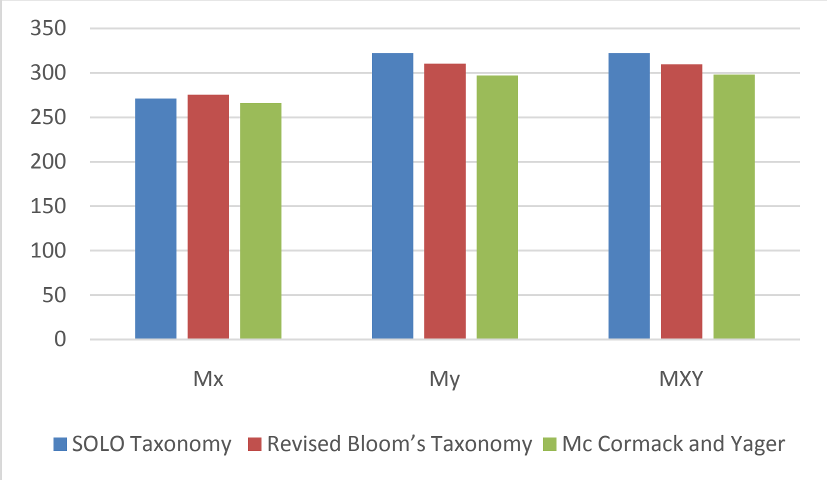


Figure 31: *Graphical Representation showing pre test and post test adjusted means of Metacognitive Awareness among Experimental Group II and Experimental Group III*

Table 44

Data and result of the significant mean differences among the Revised Bloom's Taxonomy, SOLO Taxonomy, and Mc Cormack and Yager's Taxonomy using Pair wise Comparisons

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
SOLO taxonomy	Revised Bloom's Taxonomy	12.809*	2.623	P<0.01
	Mc Cormack and Yager's Taxonomy	24.074*	2.624	P<0.01
Revised Bloom's Taxonomy	SOLO taxonomy	-12.809*	2.623	P<0.01
	Mc Cormack and Yager's Taxonomy	11.265*	2.641	P<0.01
Mc Cormack and Yager's Taxonomy	SOLO taxonomy	-24.074*	2.624	P<0.01
	Revised Bloom's Taxonomy	-11.265*	2.641	P<0.01

Above table shows, that the obtained mean difference is significant between SOLO Taxonomy with Revised Bloom's is 12.80 and SOLO with Mc Cormack and Yager's Taxonomy is 24.07. Both differences are highly significant. In the case of Revised Bloom's with Mc Cormack and Yager's Taxonomy, also the mean difference (11.26) is highly significant. Among the mean differences Mc Cormack and Yager's Taxonomy have high difference compared to SOLO and Revised Bloom's. So it can be concluded that SOLO Taxonomy is more effective to develop Metacognitive Awareness among secondary school students and then comes Mc Cormack and Yager's Taxonomy and then Revised Bloom's Taxonomy. From the present study, it is found that Mc Cormack and Yager's Taxonomy comes below the other two taxonomies in developing Metacognitive Awareness among secondary school students. It can be represented below through estimated marginal mean plot.

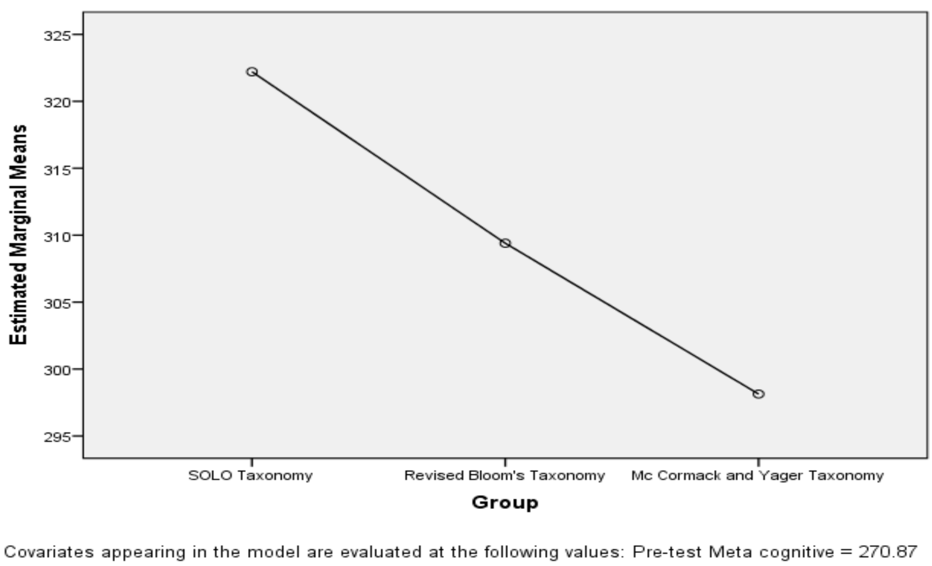


Figure 32*: Graphical Representation showing Estimated Marginal Mean Plot of Metacognitive Awareness of Experimental Group I Experimental Group II and Experimental Group III*

Chapter V

SUMMARY OF PROCEDURES, FINDINGS, AND SUGGESTIONS

- **Restatement of the Problem**
- **Hypothesis of the Study**
- **Objectives of the Study**
- **Methodology**
- **Findings of the Study**
- **Tenability of the Hypothesis**

This chapter gives summary of important findings, conclusions and tenability of hypothesis, suggestions for improving science education and suggestions for further research. The main focus of this chapter is the major findings, conclusions, educational implications of the study and suggestions for further research.

Restatement of the problem

The problem of the present study is entitled **"EFFECTIVENESS OF AN INSTRUCTION BASED ON SOLO TAXONOMY, REVISED BLOOM'S TAXONOMY AND Mc CORMACK AND YAGER'S TAXONOMY ON CERTAIN LEARNING OUTCOMES OF SECONDARY SCHOOL STUDENTS"**.

Hypotheses of the Study

Hypotheses of the study were formulated as follows:

1. There will be no significant difference between the mean pre test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom's Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager's Taxonomy) for Scientific Attitude of secondary school students.
2. There will be no significant difference between the mean post test scores of Experimental group I, Experimental group II and Experimental group III for Scientific Attitude of secondary school students.

3. There will be no significant difference between the mean pre test and post test scores of Scientific Attitude of Experimental group I.
4. There will be no significant difference between the mean pre test and post test scores of Scientific Attitude of Experimental group II.
5. There will be no significant difference between the mean pre test and post test scores of Scientific Attitude of Experimental group III.
6. There will be no significant difference between the mean gain scores of Scientific Attitude of Experimental group I and Experimental Group II.
7. There will be no significant difference between the mean gain scores of Scientific Attitude of Experimental group I and Experimental Group III.
8. There will be no significant difference between the mean gain scores of Scientific Attitude of Experimental group II and Experimental Group III.
9. There will be no significant difference between the mean pre test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom's Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager's Taxonomy) for Scientific Creativity of secondary school students.
10. There will be no significant difference between the mean post test scores of Experimental group I, Experimental group II, and Experimental group III for Scientific Creativity of secondary school students.

11. There will be no significant difference between the mean pre test and post test scores of Scientific Creativity of Experimental group I.
12. There will be no significant difference between the mean pre test and post test scores of Scientific Creativity of Experimental group II.
13. There will be no significant difference between the mean pre test and post test scores of Scientific Creativity of Experimental group III.
14. There will be no significant difference between the mean gain scores of Scientific Creativity of Experimental group I and Experimental Group II.
15. There will be no significant difference between the mean gain scores of Scientific Creativity of Experimental group I and Experimental Group III.
16. There will be no significant difference between the mean gain scores of Scientific Creativity of Experimental group II and Experimental Group III.
17. There will be no significant difference between the mean pre test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom's Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager's Taxonomy) for Metacognitive Awareness of secondary school students.
18. There will be no significant difference between the mean post test scores of Experimental group I, Experimental group II, and Experimental group III for Metacognitive Awareness of secondary school students.

19. There will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group I.
20. There will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group II.
21. There will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group III.
22. There will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group I and Experimental Group II.
23. There will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group I and Experimental Group III.
24. There will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group II and Experimental Group III.

Objectives of the Study

1. To find out the effectiveness of instructions based on SOLO taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on Scientific Attitude of secondary school students.
2. To find out the effectiveness of instructions based on SOLO taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on Scientific Creativity of secondary school students.

3. To find out the effectiveness of instructions based on SOLO taxonomy, Revised Bloom’s Taxonomy and Mc Cormack and Yager’s Taxonomy on Metacognitive Awareness of secondary school students.
4. To compare the effectiveness of instructions based on SOLO taxonomy, Revised Bloom’s Taxonomy and Mc Cormack and Yager’s Taxonomy on Scientific Attitude, Scientific Creativity, and Metacognitive Awareness of secondary school students.

Methodology

Experimental method was adopted for the present study. The population of the study was the secondary school students of Kerala.

Sample

The present study was conducted on a sample of 210 students of standard VIII drawn from three schools of Changanachery. The schools selected for the study are NSS Boys High school, Perunna, NSS Girls High School Perunna and NSS HSS Kidangoor. Among the 210 students of Experiment group, 70 students were treated with instruction based on SOLO Taxonomy (Experimental Group I) and 70 were treated with instruction based on Revised Bloom’s Taxonomy (Experimental group II) and the others were treated with instruction based on Mc Cormack and Yager’s Taxonomy (Experimental group III).

Tools used for the study

The following tools were used in the experimentation.

1. Raven’s standard progressive matrices
2. Scientific Attitude Scale (Meera and Revati,2016)
3. Metacognitive Awareness Inventory (Meera and Revati,2016)

4. Scientific Creativity Test (Weiping Hu and PhilipAdey,2002)
5. Lesson transcripts based on SOLO Taxonomy (Meera and Revati,2016)
6. Lesson transcripts based on Revised Bloom's Taxonomy (Meera and Revati,2016)
7. Lesson transcripts based on Mc Cormack and Yager's Taxonomy (Meera and Revati,2016)

Statistical Techniques employed

- Descriptive statistics like Mean, Median, Mode, Standard deviation
- Test of significance of difference between the means cores of three dependent groups
- Analysis of Variance (ANOVA) followed by Sheffe post hoc test
- Analysis of Co- Variance (ANCOVA)

FINDINGS OF THE STUDY

1. **To find out the effectiveness of an instruction based on SOLO taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on Scientific Attitude of secondary school students.**

Instructions based on SOLO taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy is effective for the development of Scientific Attitude among Secondary school students. This conclusion is arrived based on the following statistical inference.

While comparing the pre test and post test mean score, the obtained't' value is 6.82, in the experimental Group I, 10.45 for the experimental Group II and 18.09, for experimental Group III. All the 't' values are significant at 0.01 levels of significance. Considering the mean gain scores of Scientific Attitude for Experimental group I (SOLO) and Experimental Group II (Revised Bloom's) the 't' value is 2.34, and gain scores of Scientific Attitude for Experimental group II and Experimental Group III, the obtained 't' value is 9.74 and gain scores of Scientific Attitude for Experimental group I and Experimental Group III the 't' value is 4.33. All these't' value are significant. And obtained 'F' for the Error is 46.723 which is highly significant at 0.01 level of significance ($p<0.01$), more over the obtained mean difference between Revised Bloom's Taxonomy with SOLO Taxonomy is 11.193 and Revised Bloom's Taxonomy with Mc Cormack and Yager's Taxonomy is 27.02. Both differences are highly significant. In the case of SOLO with Mc Cormack and Yager's Taxonomy, also the mean difference (15.83) is highly significant. Among the mean differences, Mc Cormack and Yager's Taxonomy have high difference compared to SOLO and Revised Bloom's. So it can be concluded that Mc Cormack and Yager's Taxonomy is more effective to develop Scientific Attitude among secondary school students and then comes SOLO Taxonomy for developing Scientific Attitude. These findings confirm the conclusions of Neil and Rita (2011). From the present study, it was found that Revised Bloom's Taxonomy comes below the other two taxonomies in developing Scientific Attitude among secondary school students.

From this statistical observation, it can be concluded that Mc Cormack and Yager's Taxonomy is highly effective to develop Scientific Attitude among secondary school students and then comes SOLO Taxonomy.

2. ***To find out the effectiveness of instructions based on SOLO taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on Scientific Creativity of secondary school students.***

Instructions based on SOLO taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy is effective to develop Scientific Creativity among secondary school students. This conclusion was arrived based on the following statistical inference.

While comparing the pre test and post test mean score, the obtained 't' value is 11.87 in the experimental Group I ,the obtained 't' value is 12.12, in experimental Group II, and the obtained 't' value is 13.04, for experimental Group III. All the 't' values are significant at 0.01 level of significance. The mean gain score scores of Scientific Creativity of Experimental group I (SOLO) and Experimental Group II (Revised Bloom's), the 't' value is .259, which is not significant ($p>0.05$) and gain scores of Scientific Creativity of Experimental group II and Experimental Group III, the obtained 't' value is 3.94 and gain scores of Scientific Creativity of Experimental group I and Experimental Group III, the 't' value is 3.72. Both 't' values were significant. And obtained 'F' for the Error is 50.25 which is highly significant at 0.01 level of significance ($p<0.01$). Moreover the obtained mean difference is significant between Revised Bloom's Taxonomy with SOLO Taxonomy (.816) and Revised Bloom's Taxonomy with Mc Cormack and Yager's Taxonomy is 6.52. Both differences are highly significant. In the case of SOLO with Mc Cormack and Yager's Taxonomy also, the mean difference (7.33) is highly significant. Among the mean differences Mc Cormack and Yager's Taxonomy have high difference compared to SOLO and Revised Bloom's Taxonomy. This finding supports the results of David (2011) and Uger (2015). So it can be concluded that Mc Cormack and Yager's Taxonomy is more effective to develop

Scientific Creativity among secondary school students and then comes Revised Bloom's Taxonomy. From the present study, it was found that SOLO Taxonomy comes below the other two taxonomies in developing Scientific Creativity among secondary school students.

From this statistical observation, it can be concluded that Mc Cormack and Yager's Taxonomy is more effective to develop Scientific Creativity among secondary school students followed by Revised Bloom's Taxonomy and SOLO Taxonomy.

3. ***To find out the effectiveness of instructions based on SOLO taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on Metacognitive Awareness of secondary school students.***

Instructions based on SOLO taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy is effective to develop Metacognitive Awareness among secondary school students. This conclusion was arrived based on the following statistical inference.

While comparing the pre test and post test mean score, the obtained't' value is 13.58, in the Experimental Group I, the obtained 't' value is 14.33 for the Experimental Group II and the obtained 't' value is 8.54, for experimental Group III. All the 't' values are significant at 0.01 level of significance ($p<0.01$). The mean gain score scores of Metacognitive Awareness of Experimental group I (SOLO) and Experimental Group II (Revised Bloom's), the 't' value is 3.64, and gain scores of Metacognitive Awareness of Experimental group II and Experimental Group III, the obtained 't' value is .85 which is not significant ($p>0.05$) and gain scores of Metacognitive Awareness of Experimental group I and Experimental Group III the t value is 3.83 ;

both ‘t’ values are significant. The obtained ‘F’ for the Error is 42.17; which is highly significant at 0.01 level of significance ($p<0.01$). Moreover the obtained mean difference is significant between SOLO Taxonomy with Revised Bloom’s Taxonomy is 12.80, and SOLO with Mc Cormack and Yager’s Taxonomy is 24.07. Both differences are highly significant. In the case of Revised Bloom’s Taxonomy with Mc Cormack and Yager’s Taxonomy also, the mean difference (11.26) is highly significant. Among the mean differences Mc Cormack and Yager’s Taxonomy have high difference compared to SOLO and Bloom’s. So it can be concluded that SOLO Taxonomy is highly effective to develop Metacognitive Awareness among secondary school students and then Mc Cormack and Yager’s Taxonomy and Revised Bloom’s Taxonomy which have same level of Metacognitive Awareness. From the present study, it is found that Mc Cormack and Yager’s Taxonomy comes below the other two taxonomies in developing Metacognitive Awareness among secondary school students. These findings confirm the conclusions of Miranda (2008), Carolyn (2009), Brown (2013) and Canfield (2016).

From this statistical observation, it can be concluded that SOLO Taxonomy is highly effective to develop Metacognitive Awareness among secondary school students and then Revised Bloom’s Taxonomy followed by Mc Cormack and Yager’s Taxonomy.

4. **To compare the effectiveness of instructions based on SOLO taxonomy, Revised Bloom’s Taxonomy and Mc Cormack and Yager’s Taxonomy on Scientific Attitude, Scientific Creativity and Metacognitive Awareness of secondary school students.**

Instructions based on SOLO taxonomy, Revised Bloom’s Taxonomy and Mc Cormack and Yager’s Taxonomy was effective to develop Scientific Attitude, Scientific Creativity and Metacognitive

Awareness among secondary school students. This conclusion is arrived based on the following statistical inference.

The obtained 'F' for the Error of Scientific Attitude is 40.69, Scientific Creativity is 53.67 and Metacognitive Awareness is 40.65, which are highly significant at 0.01 level of significance ($p.<0.01$). That means after the intervention of instructions based on Revised Bloom's Taxonomy, SOLO taxonomy, and Mc Cormack and Yager's Taxonomy; it was proved that these taxonomies are effective for developing Scientific Attitude, Scientific Creativity and Metacognitive Awareness among secondary school students. More over all the mean difference is significant except Revised Bloom's Taxonomy with SOLO taxonomy ($p>0.05$) in the case of Scientific Creativity. That means all the taxonomy is effective for developing Scientific Attitude, Scientific Creativity and Metacognitive Awareness. Mc Cormack and Yager's Taxonomy is the most effective taxonomy to develop Scientific Attitude among secondary school students and then comes SOLO Taxonomy for developing Scientific Attitude. It is found that Revised Bloom's Taxonomy comes below the other two taxonomies in developing Scientific Attitude among secondary school students. Mc Cormack and Yager's Taxonomy is effective to develop Scientific Creativity among secondary school students and then comes Revised Bloom's Taxonomy for developing Scientific Creativity. It is found that SOLO Taxonomy comes below the other two taxonomies in developing Scientific Creativity among secondary school students. SOLO Taxonomy is highly effective to develop Metacognitive Awareness among secondary school students and then comes Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy which have almost same level of Metacognitive Awareness. It was found that Mc Cormack and Yager's Taxonomy comes below the other two taxonomies in developing Metacognitive Awareness among secondary school students.

Tenability of the Hypothesis

The tenability of hypotheses was examined in the light of the above findings. The details are as follows.

1. **The first hypothesis states that there will be no significant difference between the mean Pre test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom's Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager's Taxonomy) for Scientific Attitude of secondary school students.**

Data and result of pre test scores of Scientific Attitude in each Experimental Group shows that the obtained 'F' value is 1.44, which is not significant at 0.05 level of significance ($p>0.05$). This shows that there is no significant differences in the pre test mean scores among the students in each experimental group. Therefore all the three experimental groups do not differ significantly in their Scientific Attitude. So it is inferred that, before the intervention, three groups were more or less same in Scientific Attitude. So the hypothesis is accepted; that means there is no difference among the mean pre test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom's Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager's Taxonomy) for Scientific Attitude of secondary school students.

2. **There will be no significant difference between the mean post test scores of Experimental group I, Experimental group II, and Experimental group III for Scientific Attitude of secondary school students.**

The obtained ‘F’ value is 40.69 which is significant at 0.01 level of significance ($p<0.01$). This shows that there is significant difference in the post test means scores of Scientific Attitude in each experimental group. Therefore the all three experiment groups differ significantly in their Scientific Attitude after the intervention. So it is inferred that after the intervention three groups differ in Scientific Attitude. So the hypothesis is rejected that there will be no significant difference among the mean post test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom’s Taxonomy), Experimental group III (Group receiving instruction based on Mc Cormack and Yager’s Taxonomy) for Scientific Attitude among secondary school students .

3. **There will be no significant difference between the mean pre test and post test scores of Scientific Attitude of Experimental group I**

Data and result of pre test and post test scores Scientific Attitude in Experimental Group I shows that the obtained ‘t’ value is 6.82, which is highly significant at 0.01 level of significance. That means there exist a significant difference between pre test and post test mean scores in the SOLO Taxonomy group. Since the mean of post test, 181.03 is greater than that of the pre test mean 158.66; it is inferred that instruction based on the SOLO Taxonomy is effective in developing the Scientific Attitude. So the hypothesis, there will be no significant difference between the mean pre test and post test scores of Scientific Attitude of Experimental group II is rejected.

4. **There will be no significant difference between the mean pre test and post test scores of Scientific Attitude of Experimental group II**

Data and result of pre test and post test scores of Scientific Attitude in Experimental Group II shows that the obtained 't' value is 10.45, which is highly significant at 0.01 level of significance. It means that there exists a significant difference between pre test and post test mean scores in the Revised Bloom's Taxonomy group. Since the mean of post test 167.47 is greater than that of pre test mean 152.96, it is inferred that instruction based on the Revised Bloom's Taxonomy is effective in developing Scientific Attitude. So the hypothesis, there will be no significant difference between the mean pre test and post test scores of Scientific Attitude of Experimental group II is rejected.

5. **There will be no significant difference between the mean pre test and post test scores of Scientific Attitude of Experimental group III**

Data and result of pre test and post test scores of Scientific Attitude in the Experimental Group III shows that the obtained 't' value is 18.09, which is highly significant at 0.01 level of significance; which means, there exists a significant difference between pre test and post test mean scores in the Mc Cormack and Yager's Taxonomy group. Since the mean of post test 195.67, is greater than that of the pre test mean 155.79, it is inferred that instruction based on the SOLO Taxonomy is effective in developing Scientific Attitude. So the hypothesis, there will be no significant difference between the mean pre test and post test scores of Scientific Attitude of Experimental group III is rejected.

6. **There will be no significant difference between the mean gain scores of Scientific Attitude of Experimental group I and Experimental Group II**

Data and result of pre test and post test gain scores of Scientific Attitude of Experimental group I (SOLO) and Experimental Group II (Revised Bloom's) shows that the obtained 't' value is 2.34, which is highly significant at 0.05 level of significance that means, there exists a significant difference between mean gain scores of Revised Bloom's Taxonomy Group and SOLO Taxonomy Group. Since the mean gain of SOLO Taxonomy group, 22.81 is greater than that of the mean gain of Revised Bloom's Taxonomy 14.51; it is inferred that students from SOLO Taxonomy group have high gain in their Scientific Attitude. So the hypothesis, there will be no significant difference between the mean Gain scores of Scientific Attitude of Experimental group I and Experimental Group II is rejected.

7. **There will be no significant difference between the mean gain scores of Scientific Attitude of Experimental group II and Experimental Group III.**

Data and result of pre test and post test gain scores of Scientific Attitude among Experimental group II and Experimental Group III shows that the obtained 't' value is 9.74, which is highly significant at 0.01 level of significance. That means; there exists a significant difference between mean gain scores among the Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy group. Since the mean gain of Mc Cormack and Yager's Taxonomy group, 39.88 is greater than that of the mean gain of Revised Bloom's Taxonomy 14.51, it is inferred that students from Mc Cormack and Yager's Taxonomy group have high gain in their Scientific Attitude score. So the hypothesis, there will be no significant difference between the mean gain scores of Scientific Attitude of Experimental group II and Experimental Group III is rejected.

8. **There will be no significant difference between the mean Gain scores of Scientific Attitude of Experimental group I and Experimental Group III**

Data and result of pre test and post test gain scores of Scientific Attitude among Experimental group I and Experimental Group III shows that the obtained 't' value is 4.33, which is highly significant at 0.01 level of significance. That means there exists a significant difference between mean gain scores of SOLO and Mc Cormack and Yager's Taxonomy group. Since the mean gain of Mc Cormack and Yager's Taxonomy group 39.88, is greater than that of the mean gain of SOLO, 22.81; it is inferred that students from Mc Cormack and Yager's Taxonomy group have high gain in their Scientific Attitude score. So the hypothesis, there will be no significant difference between the mean gain scores of Scientific Attitude of Experimental group I and Experimental Group III is rejected.

9. **There will be no significant difference between the mean pre test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom's Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager's Taxonomy) for Scientific Creativity of secondary school students**

Data and result of pre test scores of Scientific Creativity in each Experimental Group shows that the obtained ‘F’ value is 2.18, which is not significant at 0.05 level of significance ($p>0.05$). This shows that there is no significant differences in the pre test mean scores of students in each experimental group. Therefore all the three experimental groups do not differ significantly in their Scientific Creativity. So it is inferred that, before the intervention, three groups were more or less same in Scientific Creativity. So the hypothesis is accepted; that means there is no difference among the mean pre test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom’s Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager’s Taxonomy) for Scientific Creativity among secondary school students.

10. **There will be no significant difference between the mean post test scores of Experimental group I, Experimental group II, and Experimental group III for Scientific Creativity of secondary school students.**

Data and result of post test scores of Scientific Creativity in the each experimental group shows that the obtained ‘F’ value is 53.67 which is significant at 0.01 level of significance ($p<0.01$). This shows that there is a significant difference in the post test means scores of the students in the each experimental group. Therefore the all three experiment groups differ significantly in their scientific Creativity after the intervention . So it is inferred that after the intervention three groups differ significantly in their Scientific Creativity. So the hypothesis is rejected that, there will be no significant difference among the mean post test scores of Experimental group I , Experimental group II

,Experimental group III for Scientific Creativity of secondary school students.

11. **There will be no significant difference between the mean pre test and post test scores of Scientific Creativity of Experimental group I**.

Data and result of pre test and post test scores Scientific Creativity in Experimental Group I shows that the obtained ‘t’ value is 11.87, which is highly significant at 0.01 level of significance; that means there exists a significant difference between pre test and post test mean scores in the SOLO Taxonomy. Since the mean of post test 18.56 is greater than that of pre test mean 27.71, it is inferred that instruction based on the SOLO Taxonomy is effective in developing Scientific Attitude. So the hypothesis, there will be no significant difference between the mean pre test and post test scores of Scientific Creativity of Experimental group II is rejected.

12. **There will be no significant difference between the mean Pre test and Post test scores of Scientific Creativity of Experimental group II**

Data and result of pre test and post test scores of Scientific Creativity in Experimental Group I shows that the obtained ‘t’ value is 12.12, which is highly significant at 0.01 level of significance; that means there exist a significant difference between pre test and post test mean scores of Revised Bloom’s Taxonomy group. Since the mean of post test score, 28.61 is greater than that of the pre test mean 19.17, it is inferred that instruction based on the Revised Bloom’s Taxonomy is effective in developing Scientific Creativity. So the hypothesis, there will be no significant difference between the mean pre test and post test scores of Scientific Creativity of Experimental group II is rejected.

13. **There will be no significant difference between the mean pre test and post test scores of Scientific Creativity of Experimental group III**

Data and result of pre test and post test scores Scientific Creativity in the Experimental Group III shows that the obtained ‘t’ value is 13.04, which is highly significant at 0.01 level of significance, that means there exists a significant difference between pre test and post test mean scores among the Mc Cormack and Yager’s Taxonomy group. Since the mean of post test 35.37, is greater than that of the pre test mean 20.89, it is inferred that instruction based on the SOLO Taxonomy is effective in developing Scientific Attitude. So the hypothesis, there will be no significant difference between the mean pre test and post test scores of Scientific Creativity of Experimental group III is rejected.

14. **There will be no significant difference between the mean gain scores of Scientific Creativity of Experimental group I and Experimental Group II**

Data and result of pre test and post test gain scores of Scientific Creativity of Experimental group I (SOLO) and Experimental Group II(Bloom’s) shows that the obtained ‘t’ value is .259, is not significant at 0.05 level of significance; that means, there exists no significant difference between mean gain scores of Revised Bloom’s Taxonomy Group and SOLO Taxonomy Group in their Scientific Creativity. So the hypothesis, there will be no significant difference between the mean

Gain scores of Scientific Creativity of Experimental group I and Experimental Group II is rejected.

15. There will be no significant difference between the mean gain scores of Scientific Creativity of Experimental group I and Experimental Group III

Data and result of pre test and post test gain scores of Scientific Creativity among Experimental group I and Experimental Group III shows that the obtained ‘t’ value is 3.72, which is highly significant at 0.01 level of significance. It means that there exist a significant difference between mean gain scores among SOLO and Mc Cormack and Yager’s Taxonomy group. Since the mean gain of Mc Cormack and Yager’s Taxonomy group 14.4, is greater than that of the mean gain of SOLO 9.4, it is inferred that students from Mc Cormack and Yager’s Taxonomy group have high gain in their Scientific Creativity score. So the hypothesis, there will be no significant difference between the mean Gain scores of Scientific Creativity of Experimental group I and Experimental Group III is rejected.

16. There will be no significant difference between the mean gain scores of Scientific Creativity of Experimental group II and Experimental Group III

Data and result of pre test and post test gain scores of Scientific Creativity among Experimental group II and Experimental Group III shows that the obtained ‘t’ value is 3.94, which is highly significant at 0.01 level of significance. That means there exists a significant difference between mean gain scores in Revised Bloom’s Taxonomy and Mc Cormack and Yager’s Taxonomy group. Since the mean gain of Mc Cormack and Yager’s Taxonomy group, 14.4 is greater than that of the mean gain of Revised Bloom's Taxonomy 9.15, it is inferred that students from Mc Cormack and Yager's Taxonomy group have high gain in their Scientific Creativity score. So the hypothesis, there will be no significant difference between the Mean Gain scores of Scientific Creativity of Experimental group II and Experimental Group III is rejected.

17. **There will be no significant difference between the mean pre test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom's Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager's Taxonomy) for Metacognitive Awareness of secondary school students**

Data and result of pre test scores of Metacognitive Awareness in each Experimental Group shows that the obtained 'F' value, 1.83 which is not significant at 0.05 level of significance ($p>0.05$). This shows that there is no significant differences in the pre test mean scores among the students in each experimental group. Therefore all the three experimental groups do not differ significantly in their Metacognitive Awareness. So it is inferred that, before the intervention, three groups were more or less same in Metacognitive Awareness. So the hypothesis is accepted; that means there is no difference among the mean pre test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom's Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager's Taxonomy) for Metacognitive Awareness of secondary school students.

18. **There will be no significant difference between the mean post test scores of Experimental group I, Experimental group II, and Experimental group III for Metacognitive Awareness of secondary school students.**

The obtained 'F' value is 40.65 which is significant at 0.01 level of significance ($p<0.01$). This shows that there is a significant difference in the post test means scores of the students in the each experimental group. Therefore the all the three experiment groups differ significantly in their Metacognitive Awareness after the intervention. So it is inferred that after the intervention three groups differ significantly in their Metacognitive Awareness. So the hypothesis is rejected that means there is no significant difference among the mean post test scores of Experimental group I (Group receiving instruction based on SOLO Taxonomy), Experimental group II (Group receiving instruction based on Revised Bloom's Taxonomy) and Experimental group III (Group receiving instruction based on Mc Cormack and Yager's Taxonomy) for Metacognitive Awareness of secondary school students.

19. **There will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group I**

Data and result of pre test and post test scores of Metacognitive Awareness in Experimental Group I shows that the obtained 't' value, 13.58, which is highly significant at 0.01 level of significance. That means there exist a significant difference between pre test and post test mean scores in the SOLO Taxonomy group. Since the mean of post test 322.24, is greater than that of the pre test mean 271.04, it is inferred that instruction based on the SOLO Taxonomy is effective in developing the Metacognitive Awareness. So the hypothesis, there will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group I is rejected.

20. There will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group II

Data and result of pre test and post test scores of Metacognitive Awareness in Experimental Group I shows that the obtained ‘t’ value is 14.33, which is highly significant at 0.01 level of significance. It means that, there exists a significant difference between pre test and post test mean scores in the Revised Bloom’s Taxonomy group. Since the mean of post test 310.29, is greater than that of pre test mean 275.44, it is inferred that instruction based on the Revised Bloom’s Taxonomy is effective in developing Metacognitive Awareness. So the hypothesis, there will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group II is rejected.

21. There will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group III

Data and result of pre test and post test scores of Metacognitive Awareness in the Experimental Group III shows that the obtained ‘t’ value is 8.54, which is highly significant at 0.01 level of significance. It means that, there exists a significant difference between pre test and post test mean scores in the Mc Cormack and Yager’s Taxonomy group. Since the mean of post test 297.21 is greater than that of the pre test mean 266.11, it is inferred that instruction based on the SOLO Taxonomy is effective in developing Metacognitive Awareness. So the hypothesis, there will be no significant difference between the mean pre test and post test scores of Metacognitive Awareness of Experimental group III is rejected.

22. There will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group I and Experimental Group II

Data and result of pre test and post test gain scores of Metacognitive Awareness of Experimental group I (SOLO) and Experimental Group II (Revised Bloom's) shows that the obtained 't' value is 3.64, which is significant at 0.01 level of significance. It means that; there exists significant difference between mean gain scores of Revised Bloom's Taxonomy Group and SOLO Taxonomy Group in their Metacognitive Awareness. The obtained mean score of SOLO taxonomy 51.2, is greater than the mean score of Revised Bloom's Taxonomy 34.84. So it is inferred that students from SOLO group have high level of Metacognitive Awareness. So the hypothesis, there will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group I and Experimental Group II is rejected.

23. There will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group I and Experimental Group III

Data and result of pre test and post test gain scores of Metacognitive Awareness among Experimental group I and Experimental Group III shows that the obtained 't' value is 3.83, which is highly significant at 0.01 level of significance. It means that; there exists a significant difference between mean gain scores among SOLO and Mc Cormack and Yager's Taxonomy group. Since the mean gain of SOLO Taxonomy group 51.2, is greater than that of the mean gain of Mc Cormack and Yager's 31.1, it is inferred that students from Mc Cormack and Yager's Taxonomy group have high gain in their Metacognitive Awareness score. So the hypothesis, there will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group I and Experimental Group III is rejected.

24. There will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group II and Experimental Group III

Data and result of pre test and post test gain scores of Metacognitive Awareness among Experimental group II and Experimental Group III shows that the obtained 't' value is .85, which is not significant at 0.05 level of significance. It means that; there exists no significant difference between mean gain scores in the Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy group. So the hypothesis, there will be no significant difference between the mean gain scores of Metacognitive Awareness of Experimental group II and Experimental Group III is accepted.

Conclusions

The obtained mean difference for Scientific Attitude is significant between the groups taught using Revised Bloom's Taxonomy with SOLO Taxonomy, Revised Bloom's Taxonomy with Mc Cormack and Yager's Taxonomy and SOLO with Mc Cormack and Yager's Taxonomy. Among the mean differences Mc Cormack and Yager's Taxonomy have high difference compared to SOLO and Bloom's. So it can be concluded that Mc Cormack and Yager's Taxonomy is the most effective taxonomy to develop Scientific Attitude among secondary school students and then comes SOLO Taxonomy for developing Scientific Attitude. From the present study, it is found that Revised Bloom's Taxonomy comes below the other two taxonomies in developing Scientific Attitude among secondary school students.

While exploring the Effectiveness of instructions based on SOLO taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on Scientific Creativity of secondary school students; the obtained mean difference is significant between Revised Bloom's Taxonomy with SOLO Taxonomy, Revised Bloom's Taxonomy with Mc Cormack and Yager's Taxonomy and SOLO with Mc Cormack and Yager's Taxonomy. Among the mean differences Mc Cormack and Yager's Taxonomy have high difference compared to SOLO and Bloom's. So it can be concluded that Mc Cormack and Yager's Taxonomy is effective to develop Scientific Creativity among secondary school students and then comes Revised Bloom's Taxonomy for developing Scientific Creativity. From the present study, it was found that SOLO Taxonomy comes below the other two taxonomies in developing Scientific Creativity among secondary school students.

Investigations to find out the effectiveness of instructions based on SOLO taxonomy, Revised Bloom's Taxonomy and Mc Cormack and Yager's Taxonomy on Metacognitive Awareness of secondary school students showed that, obtained mean difference is significant between SOLO Taxonomy with Bloom's and SOLO with Mc Cormack and Yager's Taxonomy. Among the mean differences SOLO Taxonomy have high difference compared to Mc Cormack and Yager's and Bloom's. So it can be concluded that SOLO Taxonomy is highly effective to develop Metacognitive Awareness among secondary school students and then comes Mc Cormack and Yager’s Taxonomy and Revised Bloom’s Taxonomy, which have almost same level of Metacognitive Awareness. From the present study, it was found that Mc Cormack and Yager’s Taxonomy comes below the other two taxonomies in developing Metacognitive Awareness among secondary school students.

Comparison of the effectiveness of instructions based on SOLO taxonomy, Revised Bloom’s Taxonomy and Mc Cormack and Yager’s Taxonomy on Scientific Attitude, Scientific Creativity and Metacognitive Awareness of secondary school students revealed that all the taxonomies are effective to develop Scientific Attitude, Scientific Creativity and Metacognitive Awareness of Secondary School students.

Educational Implications

In the present study the objective was to find out the “Effectiveness of an Instruction Based on SOLO Taxonomy, Revised Bloom’s Taxonomy and Mc Cormack and Yager’s Taxonomy on Certain Learning Outcomes of Secondary School Students”. The findings of the study point out some important facts that require the attention of the educational practitioners. The implications of the study are outlined below.

Education is one of the most important aspects of human development and comprises the most influential social institution in any society (Baytak &Akbiyik, 2012). In general, education aims to transmit a common set of beliefs, values, norms and understanding from the adult generation to the youth. Educational taxonomy help teachers to identify the learning expected from the student. The value of using educational taxonomies in the development of learning outcomes represents a tool for planning, implementing and assessing instruction. Educational taxonomy provides educators with a common frame of reference that classifies various types of learning outcomes. In addition, it illustrates the wide array of learning outcomes that can be included in any given instructional area (Almarico& Baker 2004). Present study provides a clear reference on what type of teaching methodologies are suitable for developing science related learning objectives, since it serves as a common language about learning goals to facilitate communication across persons, subject areas and grade levels.

An objective is a goal or endpoint of something towards which actions are directed. Objectives generally indicate the end points of a journey. They specify where you want to be or what you intended to achieve at the end of a process. An educational objective is that which a specific educational instruction is expected to make or accomplish. It is the outcome of any educational instruction. It is the purpose for which any particular educational undertaking is carried out. Present study suggests relevance of educational taxonomy for the attainment of science related learning outcomes since objective based instruction is the backbone of any type of education.

Schools are the institutions consciously created to ensure desirable changes in human behaviour towards ultimate realization of the national goals. They have to make conscious efforts to ensure the attainment of educational goals. This can be done through a systematic translation of objectives and then to instructional objectives. Here instructional objectives are stated in a form by which they have to be operated in the class room. They are therefore referred to as instructional objectives. They are specifically based on the intended learning outcomes. The findings of the study revealed that writing of learner centred educational objectives helps to develop science related learning objectives. These instructional objectives are therefore stated in behavioural terms, which the learner will exhibit in order to show that he has learnt.

Instructional objectives are very important component of teaching system, as they provide necessary feedback for the adjustment of curriculum, teaching method, teaching aids and assessment. They also show how much appropriate the curriculum is. Learning taxonomies are valuable tool for classifying learning objectives. Educational taxonomy is a helpful and frequently used resource to write student learning outcomes. The major idea of the taxonomy is that what educators want students to know can be arranged in a hierarchy from less to more complex. The levels are successive, so that one level is mastered before the next level can be reached. Present investigation revealed that the arrangement of learning experiences according to the learning objectives in educational taxonomies is effective to bring about desired learning outcomes. Study also found out that, even though the three taxonomies are suitable for the accomplishment of science related learning outcome, SOLO Taxonomy is the best one to develop cognition about learning.

In science education, taxonomies are very important for achieving science related process and product outcomes. So educational taxonomy is that platform upon which scientific ideas can be framed in an effective way. In the absence of a proper taxonomy teachers and students will be mislead towards their journey for the attainment of scientific knowledge and processes. Study indicated that all the three taxonomies are effective to develop Scientific Attitude and Scientific Creativity, and Metacognitive Awareness. Mc Cormack and Yager's taxonomy is the best taxonomy to develop Scientific Attitude and

Scientific Creativity, among secondary school students and SOLO Taxonomy proved to be the best taxonomy compared to other two taxonomy for developing Metacognition.

As there is no emphasis on Scientific Creativity, Scientific Attitude and Metacognition in secondary school science classes, it is necessary to incorporate the relevant aspects of Scientific Attitude and Scientific Creativity in secondary school science curriculum. Teaching science should be in such a way, that it helps a student to develop scientific approach towards life. Inculcation of values like spirit of enquiry, courage to question, objectivity, honesty and truthfulness, which are the precursors of the development of good citizen in the society. Science education will be strengthened so as to develop well defined abilities and values, such as the spirit of enquiry, creativity, objectivity, the courage to question and an aesthetic sensibility. Science education programme will be designed to enable the learner to acquire problem solving and decision making skills and to discover the relationship of science with health, agriculture, industry and other aspects of daily life. Every effort should be made to internalise science education to the vast numbers who have remained outside the pale of formal education.

Present study indicated that teachers should apply a process product description in teaching methods to make a difference in student outcome. Scientific activities which require exploration of non reading nature should be carried out by individual or small groups of students. Teaching methods should be changed from teacher centred to pupil centred approaches like heuristic method, assignment method, project and problem solving methods, laboratory and experimental methods, discussion methods, etc. Preparation of new syllabus and instructional materials and steps to improve teacher training programmes must be emphasized. Due to the limited financial resources of our country, it will be beneficial to provide combined lecture hall cum laboratory in high schools to facilitate the science teaching and learning in secondary schools. Traditional teaching aids should give way to two dimensional and three dimensional aids, projected and non projected aids and sophisticated aids like television and computer. Use of these technological devices makes science teaching livelier in addition to localized low cost and no-cost aids.

Attitude and creativity are called the enabling domains by Mc Cormack and Yager. Science learning cannot occur in class rooms where science is not seen as fun, useful and exciting. Science class should consider student interests, ideas, problem identification, and solutions, which will encourage, each student. Teachers should be encouraged to adapt realistic methods of teaching science and thereby assuring active involvement of their students in science related processes, leading to a thorough understanding of the subject matter. Preparation of new syllabus and instructional materials, and steps to improve teacher-training programmes must be emphasized.

As advocated by Yager, constructivism has evolved as one of the prominent learning theories in the broad field of education. Constructivist approach pursues an authentic learning environment in which students are actively engaged in their own enquiries into problems relevant to them. It stresses communication and collaboration with peers and with their teacher. Traditional approaches will create a negative attitude to science classes. Therefore, science classes should be carried out in a constructivist learning environment to develop Scientific

Creativity and Scientific Attitude as implied in Mc Cormack and Yager's taxonomy.

Mc Cormack and Yager's taxonomy says that science process skills have to be included in science classrooms as part of the learning activities. Through these processes, students connect their every day experiences with their science topics which make science more reliant and it stimulates Scientific Attitude, Scientific Creativity and Metacognitive Awareness among them. Activities should be planned in such a way as to engage students in inquiry oriented life related learning situations, for this a teacher should integrate various resources including other subjects of study in science class rooms with social relevance. Teachers are the key agents who can use creative approach to science learning by which they can inculcate Scientific Creativity, Scientific Attitude and Metacognitive Awareness among their children.

Student's knowledge of their own cognition helps to regulate their intellectual processes. The present investigation suggests that SOLO Taxonomy provides a good platform for developing metacognitive abilities compared to Revised Bloom's Taxonomy and Yager's; as it goes through pre structural, uni structural, multi structural, and extended abstract stages. Learner develops an outlook about their learning which enhances the ability for metacognition. So it is recommended through the present study that teachers should include metacognitive and reflective thinking strategies in everyday learning situations. Use of discovery learning strategies, inductive thinking strategies, questioning etc. can improve metacognitive abilities of students.

Science education should be strengthened so as to develop well defined abilities and values, such as the spirit of enquiry, creativity, objectivity, the courage to question and an aesthetic sensibility. Science education programme should be designed to enable the learner to acquire problem solving and decision making skills and to discover the relationship of science with health, agriculture, industry and other aspects of daily life. Every effort should be made to internalise science education to the vast numbers who have remained outside the pale of formal education. Providing a combined lecture hall cum laboratory in high schools will facilitate the science teaching and learning in secondary schools. Use of two dimensional and three dimensional aids, will make science teaching livelier in addition to localized low cost and no-cost aids. Science learning cannot occur in class rooms where science is not seen as fun, useful and exciting. Science class should consider student interests, ideas, problem identification, and solutions, which will encourage, each student. Teachers should be encouraged to adapt realistic methods of teaching science and thereby assuring active involvement of their students in Science related processes, leading to a thorough understanding of the subject matter. Activities should be planned in such a way as to engage students in inquiry oriented life related learning situations, for this a teacher should integrate various resources including other subjects of study in science class rooms with social relevance. Teachers are the key agents who can use creative approach to science learning by which they can inculcate Scientific Creativity, Scientific Attitude and Metacognitive Awareness among their children.

Findings of the study revealed that among the three taxonomies, Mc Cormack and Yager's Taxonomy is more effective to develop Scientific Creativity and Scientific Attitude among secondary school students. Taxonomy of science education proposed by Mc Cormack and Yager considers creativity as one of the highest objectives. Using activity centred investigatory methods in the class room is advisable than conventional teacher centred methods. Even though the present secondary school curriculum of Kerala state adopted Yager's taxonomy as its base, schools find it difficult to apply it in the class rooms. As a result, students are far away from the expected objectives. So it is the need of the hour that all the officials starting from Government should take necessary steps for implementing the changes demanded by the secondary school science curriculum. Since the present study proved that no single taxonomy is considered most effective to produce all the three desired science learning outcomes, according to the educational and sociological situations in Kerala, curriculum can adopt the best objectives from these taxonomies for the development of science related learning outcomes. Improving infrastructural facilities including a science laboratory, science library, orientation classes and workshops for teachers, pooling resources from all areas in the society, providing reference materials to teachers etc. will be beneficial for fulfilling the aims of science education, like development of scientific attitude, scientific temper, scientific creativity, metacognition, decision making, problem solving attitude etc. According to Dr. Abdul Kalam , the ignited mind of the youth is the most powerful resource on the earth, so it is our duty to provide the medium through which they can stand as strong pillars to build the future of India to its best.

Suggestions for Further Research

1. The present study is conducted at secondary school level. This study can be repeated to different other levels such as primary school children, higher secondary school students, graduate and post graduate students.

2. Studies can be extended to find out the effectiveness of different taxonomies other than the taxonomies mentioned in the study.
3. The study can be repeated for a large number of students for a longer duration representing all districts in the state to ensure the validity of the results.
4. Studies can be conducted for developing learning packages for the effective transaction of science curriculum.
5. A survey study can be conducted to find teacher awareness about educational taxonomies effective for science teaching.
6. Parallel studies can be conducted to find out the effectiveness of different taxonomies on other variables related to science education such as scientific temper, problem solving attitude and decision making among children.
7. Studies can be conducted by taking a single taxonomy to find out its effectiveness on certain learning outcomes.
8. Studies can be conducted to compare the science learning outcomes based on gender and other psycho social variables.

BIBLIOGRAPHY

Abd-El-Khalick, F., Bell, R. L. & Lederman, N. G. (1998). The nature of science and instructional practice: making the unnatural natural. *Journal of Science Education*, 82, 417-437.

Ahuja, A. (2017). Study of Scientific Attitude in relation to Science Achievement Scores among Secondary School Students. *An international journal of education and applied social sciences*, 8(1), 9-16.

Aikenhead, G.S. (2003). STS Education: A Rose by Any Other Name. Published by Routledge Press.

Airasian, P.W. & Miranda, M. (2002). The Role of Assessment in the Revised Taxonomy. *Journal of theory into practice*, 41(4), 249-254.

Akcay, H., & Yager, R. E. (2010). The impacts of a science/technology/ society teaching approach on student understanding in five domains. *Journal of Science Education and Technology*, 20(4), 42-47.

Akinde, O.A. (2015). A pilot study of students' learning outcomes using didactic and socratic instructional methods: an assessment based on Bloom's taxonomy. *Retrieved from ERIC Database* (ED 1084171).

Aktamis, H., Ergin, O. (2008). The effect of science process skills education on student’s scientific creativity, scientific attitude and academic achievement. *Asia pacific forum of science learning and teaching,* 9(1) 1-20.

Akyol, Z., & Garrison, D.R. (2011). Assessing metacognition in an online community of inquiry. *The Internet and Higher Education*, 14, 183-190.

Alka, A. (2011). Developing a metacognition integrated multimedia science learning package for students at secondary level. Unpublished Ph D Dissertation, Mahatma Gandhi University, Kottayam.

Almerico, G. M., & Baker, R. K. (2004). Bloom’s Taxonomy Illustrative Verbs: Developing a Comprehensive List for Educator Use. *Florida Association of Teacher Educators Journal* 1(4), 1-10.

Alves, C.H.C. (2007). Learning science through work experience: a ciência viva science internships programme for senior secondary students. Unpublished Ph D thesis, University of Cambridge.

American Association for the advancement of science, (AAAS) (1967). Science a process approach (SAPA), Washinton DC: AAAS.

American Association for the Advancement of Science (AAAS). (1990). *Science for all Americans.* New York: Oxford University Press.

Anderson, J. R. (1990). Cognitive psychology and its implications (3rd ed.). New York: John Wiley.

Anderson, L. W., & Krathwohl, D. R. (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's Taxonomy of educational objectives. New York: Longman Publications.

Artherton, J.S. (2013). Learning and Teaching; Piaget's developmental theory. Retrieved 6 February 2017 from http://doceo.co. uk/l&t/learning/piaget.htm.

Asmali, K. (1994). A study of the relationship between science achievement, science interest, scientific attitude, process outcomes in science and scientific creativity of secondary school pupils. Unpublished M. Phil. Thesis, University of Kerala, Thiruvananthapuram.

Ausekar, P. (1995). A study of job satisfaction among teachers working in government and private schools. *The progress of education*. 121(3), 50-53.

Ayesha, S., & David J.E. (2011). Student-Content Interactions in Online Courses: The Role of Question Prompts in Facilitating Higher Level Engagement with Course Content. *Journal of Computing in Higher Education*. 23(2), 157-186.

Ball, L., & Washburn, J. (2001). A handbook of online learning. Sage publications. India.

Baytak, A., Akbiyik, C., & Usak, M. (2012). Parents' Perception over Use of ICT in Education Techniques. *Technologies of Education Management (TTEM)*, 7(3), 1158-1167.

Bei, C. (2009). Using SOLO Taxonomy inquiries the student's function concept understanding level. *Journal of mathematics education*. 23(5), 174-178.

Best, J.W. (1978). Research in education, New Delhi: Prentice Hall of India, Pvt. Ltd.

Best, J.W., & Khan, J.V. (2000). Research in education (7 Edn). New Delhi: Practice Hall of India.

Best, J.W., & Khan, J.V. (2009). Research in education (9 Edn). New Delhi: Practice Hall of India.

Bhattacharya, S. (1998). The Contested Terrain□: Perspectives on Education in India. New Delhi: Orient Black Swan.

Bhattacharya, T., Prasanth, R., & Bhattacharya, B. (2013). Qualitative outcome through computer assisted instruction. Mining Intelligence and knowledge exploration, 567- 578.

Biggs, J. & Collis, K. (1982). Evaluating the Quality of Learning: the SOLO taxonomy. New York. Academy Press.

Birgili, B. (2015). Creative and critical thinking skills in problem based learning environment. *Journal of gifted education and creativity*, 2(2), 71-80.

Bloom, B. S. (1976). Human characteristics and school learning. New York: Mc Graw-Hill.

Bloom, B. S., Engelhart. M. D., & Krathwohl, D. (1956). Taxonomy of educational objectivities: The classification of educational goals. Hand book I: Cognitive domain. New York: David McKay Co Inc.

Bloom, B. S. (1956). Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain. New York: David McKay Co Inc.

Bloom, B. S. (1976). Human characteristics and school learning. New York: McGraw-Hill.

Boulton, M.G., Lewis, L., & Mutch, S. (1996). Teachers as adult learners: their knowledge of their own learning and implications for teaching. 82-106.

Bourn, H. & Ghiselli, E.E. (1955). The value of aptitude in personal selection, Personal psychology, 26, 461-477

Bransford, J. D. (2000). How people learn: Brain, mind, experience, and school. Washington, D.C. : National Academy Press.

Bransford, J.D., Brown, A.L. and Cocking, R.R. (2000). How People Learn: Brain, Mind, Experience and School. Washington D.C.: National Academy Press, 3-23.

Brown, G.T.L., & Hattie, H. (2003). Redesigning classrooms: using SOLO to increase challenge. Leading learner Blog.

Brown, A.L. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms, Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Brown, C.W., & Ghiselli, E.E. (1955). Scientific Method in Psychology. Mc Graw Hill Book Company Inc, New York, 11-13.

Brown, S., Smith, B., & Phil, R. (2013). Hundred tips on assessment. Routledge 19-29.

Bruner, J.S. (1961). The Process of Education. New York: Vintage Books.

Buch, M.B. (1974). Fifth Survey of Research in Education. Baroda: Centre of Advanced study in Education.

Buch, M.B. (1990). Fifth Survey of Research in Education. Baroda: Centre of Advanced study in Education.

Burnette, C.P. (1999). Assessing the structure of learning outcomes from counselling using the SOLO Taxonomy: An exploratory study. *British journal of guidance and counselling*, 27(4), 567-580.

Canfield, P.J., & Mark, B. (1996). Interactive Student Centred Teaching Strategy of learning. *Journal of Clinical Pathology*, 23(1), 82-106.

Canfield, P.J., & Krockenberger, M.B. (2016). An Interactive, Student-Centered Approach, Adopting the SOLO Taxonomy, for Learning to Analyze Laboratory Data in Veterinary Clinical Pathology. *Journal of veterinary medical education*, 29(1).

Carolyn, R. F., & Frank, H. L. (2009). The evolution of educational objectives: Bloom's Taxonomy and beyond. *Journal on excellence in college teaching*, 20(1), 71-86.

Cecilia, G. B., (2016). Learn 2 Learn: A Metacognition Intervention for Improving Academic Performance and Motivation on Middle School-Aged Student. Unpublished Ph D theses, Trinity College, Hartford.

Chan, C., Tsui, M.S., & Hong, H. (2002). Applying the structure of the observed learning outcomes (SOLO) taxonomy on student's learning outcomes: An empirical study. *Assessment and evaluation in higher education Journal*, 27(6), 511-527.

Chandrashekharan, S. (2014). Developing Scientific Attitude, Critical Thinking and Creative Intelligence of higher secondary school biology students by applying synetics techniques. *International journal of humanities and social science inventions*, 3(6),1-8

Chaube, S. (2009). Effectiveness of constructivist approach on problem solving and metacognitive skills. *Asian journal of experimental sciences*, 23(52), 10-15.

Cherif, A.H., & Verma, S. (2010). Effective understanding of human body organs: A role playing activity for deep learning. *The American Biology Teacher*, 72(7), 447-450.

Cherif, A.H. (2010). A Martian invasion of teachable moments for environmental science and related issues. Science education review, 9 (1) 13-14

Chris, R. (2011). Profile for statistical understanding. Unpublished Doctoral Dissertation. Armidale, Australia: University of New England.

Çilenti, K. (1988). Scale for measuring Scientific Attitude. *Turkish Journal of Science Education*, 2009, 6(2), 54-62

Cobern, W.W. (2014). Different perspectives on the natural world: Biology professors and their students. Scientific literacy and cultural studies project.

Cobern, W.W. (1998). Constructivism for science teachers. Scientific literacy and cultural studies project.

Comte, A. (1830). Cours de philosophie positive, III, 45th lesson, 534 - 584.

Cooper, P. A. (1993). Paradigm shifts in designing instruction: From behaviorism to cognitivism to constructivism. *Educational Technology*, 33(5), 12–19.

Courtney., T.D. (1986). The significance of the SOLO Taxonomy for learning and teaching in Geography. (ERIC Document Reproduction Service No. EJ 358578) 5(2), 47-50.

Cronbach, L.J. (1975). Beyond the two disciplines of scientific psychology. *American Psychologist* 30: 671–84.

Crowe, A., Driks, A., & Wenderoth, M.P. (2008). Biology in bloom: implementing Bloom's Taxonomy to enhance student learning in biology. *CBE Life science Education journal*, 7(4), 368-381.

Curtis, F.D. (1924). A determination of the Scientific Attitudes. *Journal of chemical education*, 3(8), 928- 967.

Dass, P.M. (2004). New science coaches: preparation in the new rules of science education. In J, Weld. (Eds). Game of Science Education, Pearson Education, Inc. Allyn and Bacon : Boston.

David, C. & Jack, C. (2007). A new Bloom: Transforming Learning. *Journal of learning and Leading technology*, 34(5), 22-25.

DeHaan, R. L. (2009). Teaching Creativity and Inventive Problem Solving in Science, *CBE-Life Sciences Education*, (8) 3, 172-181.

De.Miranda, M.A. (2005). Pedagogical content knowledge and engineering and technology in teacher education: issues for thought. *Journal of the Japanese society of technology education*, 50 (1), 17-26.

Dewey, J. (1933). How we think : A restatement of the relation of reflective thinking to the educative process. MA: D. C. Heath & Co Publishers.

Didam, D. (2011). Should we be teaching knowledge or skills? Teacher network. Teacher’s blog.

Ditchfield, C. (1996). What contribution can research into conceptions of learning and teaching make to future developments in teacher education. Unpublished Dissertation, Lancaster University's Department of Educational Research.

Dul, O. (2011). Metacognitive strategies in developing EFL working skills. *Contemporary online language educational journal*, 1(2), 82-100.

Durga Rani, K. (2007). Educational Aspirations and Scientific Attitudes. Discovery publishing house, Delhi.

Dushi, G. (2006). Notes on the Importance of educational aims. Preserve articles.

Edwards, A.L. (1 957). Techniques of attitude scale construction. New York: Appleton-Century-Gofts, Inc.

Evan, M. (2012). SOLO Taxonomy: Giving students a sense of progress in learning. Edublogs. com.

Faheen, S.M., Yager, S.O,, & Yager, R.E. (2016). Successful use of science process skills by middle school students. National forum for teacher education journal, 25(3), 1-9.

Felker, D. W. (1974).Building Positive Self-concepts. (Helping Children to Like Themselves.) Minneapolis: Burgess Publishing Company.

Flavell, J. H. (1976). Metacognitive aspects of problem solving. The nature of intelligence, 12, 231-235.

Flavell, J. H. (1980). Nature & Development of Metacognition. Audio Transcripts.

Gardner, P.L. (1975). Attitudes to Science in Science Education 2:1-41.

Gardner, P.L. (1995). Measuring Attitudes to Science: Unidimensionality and Internal Consistency Revisited. *Research in Science Education.* 25(3), 283-289.

Garret, H.E. (1981). Statistics in psychology and education. Bombay: Vakils, Feffer and Simpsons.

Gay, L.R. (1996). Educational Research: Competencies for Analysis and Application. Beverly Hill, CA: Sage Publications.

Germann, P.J. (1988). Development of the attitude toward science in school assessment and its use to investigate the relationship between science achievement and attitude towards science in school. *Journal of Research in Science Teaching*, 25, 689-703.

Gillan, M., & Boulton, L. (2006).The SOLO Taxonomy as a means of shaping and assessing learning. *Higher education research and development*, 14(2), 143-154.

Gillan, M., & Lewis, B. (2006). The SOLO Taxonomy as means of shaping and assessing learning in higher education. *Higher Education Research and Development*, 31(10), 143-154.

Good, C.V. (1959). Teaching effectiveness. Dictionary of Education. New York: McGraw Hill.

Good, C.V., Barr, A.S & Scats, D.F. (1941). *Methodology of Educational Research*, New York, Appleton Century Crafts, Inc.

Goh, C. M., & Hu, G. (2014). Exploring the relationship between metacognitive awareness and listening performance with questionnaire data. *Journal of language awareness*, 23(3), 225-274.

Gokhale, A.A. (1995). Collaborative learning enhances critical thinking. *Journal of technology education*, 7(1).

Grace, C.W., Noeke., Okero, E., Mark, I.O., Keraro., & Fred, N. (2016). Secondary school biology teacher's perception of scientific creativity. *Journal of education and learning*, 5(1), 31-45.

Grunloud, N.E. (1981). Measurement and Evaluation in Teaching. New York: Macmillian Publishing Company.

Guico, T.M., & Dolor, G.(2013). Level of awareness and possible concerns of the marine faculty members on outcome based education. *Journal of International academic research for multi disciplinary*, 1(7), 159-167.

Guilford, J.P. (1956). The Structure of Intellect. Psychological Bulletin, 53, 267-293.

Guilford, J.P. (1967). Some Theoretical views of creativity. In H. Helsonand W. Bevan (Eds.)

Guilford, J. P. (1960). Intelligence: 1965 model. American Psychologist, 21(1), 20- 26.

Gupta, S. (2015). Influence of student's gender and stream of study on Scientific Attitude and Attitude towards Science. *International journal of Research Granthalaya*, (3) 12,195-202.

Gupta, S.P. (1996). Elementary Statistical Methods. New Delhi: Sultan Chand and Sons.

Guruprasad, P.R. (2009). Applying Bloom's Taxonomy to questioning techniques in the classroom. Teacher's net gazette. 6(7).

Halawi, L.A., Mc Carthy, R.V., & Pires, S. (2009). An Evaluation of E-Learning on the Basis of Bloom's Taxonomy: An Exploratory Study. *Journal of education for business*, 84(6), 374-380.

Handlesman,J. (2004). Scientific Thinking. WH Freeman publisher.

Haneeshia, D. (2001). A study on the scientific creativity of pupils in DPEP and non-DPEP schools in Kerala. Unpublished M. Ed Thesis, University of Kerala, Thiruvananthapuram.

Hassain, C. (2015). Assessment through the SOLO Taxonomy and how it can be used in the classroom. Unpublished Dissertation Bringingham university.

Hattie, J.A.C. & Brown, G.T.L. (2003). Cognitive processes in as TTle: the SOLO taxonomy. *As TTle technical report*, University of Auckland & Ministry of Education.

Havinghurst. R.F & Havinghrust, R.J. (1961). Educating gifted children. Chicago University of Chicago Press.

Hidayat, A. (2014). Students' metacognitive strategies in learning English. English education study program, Department of language and art faculty of teacher training and education, University of Bengkulu.

Hodson, D. & Reid, D. (1988). Science for all: motives, meanings and implications, School Science Review, 69, 653-661.

Hu,, Wu., & Adey, P. (2002). A scientific creativity test for secondary school students. *International journal of science education*, 2(4), 389- 403.

Hu, W., & Wu, B. (2013). Increasing student's creativity: the learn to think intervention programme. *Journal of creative behaviour*, 47(1) 3-21.

Jaleel, S., & Parameswaran, P. (2016). A study on the metacognitive awareness of secondary school students. *Universal journal of educational research*, 4(1), 165-172.

Jancirani, R., Dhevakrishnan, R., & Devi, S. (2012). A study on Scientific attitude of adolescence students in Namakkal District. *International e Journal*, 1(4), 1-8.

Jarvis, T., & Pell, A. (2004). Factors influencing elementary school children's attitudes towards science before, during, and after a visit to the UK National Space Center. *Journal of Research in Science Teaching*, 42, (1), 53- 83.

Jayaprabha, G. (2011). Metacognitive instruction and achievement in science classroom. *Journal of education and research*, 10(4), 16-24.

Jumani. R., Choudhary, N., Ajmal, M., Hassan, C. S., & Fahim, A., *Contemporary issues in education research*, 3(10), 39-44.

Juneau, E. (2016). Using Bloom's Taxonomy to foster critical thinking. Belhaven University faculty resources.

Kalra, R.M. (1995). Science Education - A Case for Humanizing It. *Journal of Indian Education*. 20 (5), 5-12.

Kamal, M. (2010). Assessing metacognitive awareness and learning strategies as positive predictors of success in a distance learning class. *University journal of social science institute*. 7(14), 123-134.

Kaur, M., Niwas, R., & Rai, V.K. (2015). A study of achievement in science in relation to sex, habitats and scientific attitude of higher secondary school students. *International journal of scientific research*, 4(7), 7-10

Keskin, Y., Keskin, S.C., & Kirtal, A. (2016). Examination of the Compatibility of the Questions Used by Social Studies Teachers in the Class with the Program Achievements According to the

SOLO Taxonomy. *Journal of education and training studies*, 4(4), 1-9.

Khan, S.A., & Khan, M. (2011). The development of scientific attitude on secondary school biology teaching. *Language in India Academic journal*, 12(5), 350-356.

Kiani, H.A.M. (2011). A study to evaluate the examination system at grade V in Punjab using SOLO Taxonomy. Unpublished doctoral dissertation. Foundation university college of liberal arts and science. Rawalpindi

Kind, P.M. (2007). Creativity in science education: perspectives and challenges for developing school science. *Studies in science education*, 43(1), 1-37

Kleitman, S. & Gibson, J. (2011). Metacognitive beliefs, self-confidence and primary learning environment of sixth grade. *Learning and Individual Differences*, 21(6), 728-735.

Koul, L. (1997). Methodology of educational research. New Delhi: Vikas Publications Pvt . Ltd.

students. Learning and Individual Differences, 21, 728-735.

Koutselini, M. (1995). Metacognition: Conceptual instruction, Nea Pedia, 74, 48-5.

Krathwohl, D.R. (2002). A revision of Bloom's Taxonomy: An overview. Theory into practice, 41(4), 212-18.

Kristeal, W.H. (2010). The effects of implementing Bloom's Taxonomy and utilizing the Virgina standards of learning curriculum framework to develop Mathematics lessons for Elementary students. Ph.D Thesis. Liberty University.

Kumar, A., & Chahar, M.S. (2016). Creativity in relation to students' perceived classroom goal structure and academic self-efficacy. *International education and research journal*, 2(12), 11-14.

Lakshmi, N.U. & Anjuli, S. (2010). A study on the contribution of scientific attitude and scientific aptitude to develop environmentally sensitive practices. Indian Educational Review. 46(1).

Laskey, M.L., & Hetzel, C.J. (2010). Self-regulated Learning, Metacognition, and Soft Skills: The 21st Century Learner, ERIC Database ED 511589.

Lawson, A.E. (1982). The reality of general cognitive operations. *Science education journal*, 66(2), 229-241.

Lawson, A. E., Alkhoury, S., Benford, R., Clark, B.R. & Falconer, K. A. (2010). What Kinds of Scientific Concepts Exist? Concept Construction and Intellectual Development in College Biology. *Journal of Research in Science Teaching*, 37(9), 996-1018.

Lederman, N.G. (1992). Student's and Teacher's conceptions of the nature of science: A review of the research. *Journal of research in science teaching*, 29(4), 331-359.

Lederman, N.G. (2000). Research on nature of science: reflections on the past, anticipations of the future. Asia pacific forum of science learning and teaching , 7(1), 1-7

Lee, Y.S. (2007). An approach to identify effective learning outcomes for a training programme. Ph.D. Thesis.

Lin, C., Hu, W., Adey, P., & Shen, J. (2003). The influence of CASE on scientific creativity. Research in science education, 33(2), 43-62.

Lucander, H., Bondemark, L., Brown, G., & Kruisson, K. (2010). The structure of observed learning outcome (SOLO) taxonomy: A model to promote dental student's learning. European journal of dental education, 14(3), 145-150.

Mackinnon, D.W. (1962). The nature and nurture of creative talent. *American Psychologist, 17*(7), 484-495.

Majumdar, S.K. (1973). Scientific creativity. New Delhi: N.C.E.R.T,

Mangal, S.K. (1995). Educational Psychology. Jalandhar: Prakash Brothers Educational Publishers.

Marzano, R. J. (2001). Designing a New Taxonomy of Educational Objectives. Thousand Oaks, CA: Corwin Press.

Maslow, A. (1963). The Creative Attitude .*The Structurist* ,3, 4-10

Mc Bain, R. (2011). How students can think? A study of student's cognitive levels using Bloom's Taxonomy in social studies. Retrieved from ERIC Data base, ED 524386.

Mc Cormack, A. J., & Yager, R. E. (1989). A New Taxonomy of Science Education. *Science Teacher*, 56(2), 47-48.

Mc Cormack, A. J., & Yager, R. E. (1989). Assessing Teaching/ Learning Successes in Multiple Domains of Science and Science Education. Science Education, 73(1), 45-58.

Mc Neil., & Rita, C. (2011). A programme evaluation model: Using Bloom's Taxonomy to identify outcome indicators in outcome based programme evaluation. *Journal of adult education*, 40 (2), 24-29.

Meador, K. S. (2003). Thinking Creatively about Science Suggestions for Primary Teachers, *Gifted Child Today*, 26(1), 25-29.

Melear, C.T. (1995). Creativity & inventiveness in science: A reflective course for teachers and other majors. *Journal of science teacher education*, (4) 5, 35-43.

Millar, R. (1989). Beyond 2000: Science education for the future. London, School of Education, King's College London

Meyer, A.A. (2012). Teaching for creativity. *The science teacher*, 79(5), 54-56.

.Minogue, J., & Jones, G. (2009). Measuring the impact of Haptic feedback using the SOLO Taxonomy. *International journal of Science Education*, 31(10), 1359-1378.

Miranda, M.A. (2008). Pedagogical Content Knowledge and Engineering and Technology Teacher Education: Issues for thought. *Journal of the Japanese Society of Technology Education* 50 (1) 17-26.

Misra, K.S. (1986). Effect of home and school environment on scientific creativity. Agra: National Psychology Corporation.

Misra, K.S. (1986). Effect of school and home environment on scientific creativity. Kanpur: Sangyanalaya.

Munakata, M., & Vaidya, A. (2013). Fostering creativity through personalized education. *Problems, resources, and issues in mathematics undergraduate studies*, 23(9), 764- 775.

Munby, H. (1983).Thirty studies involving the "scientific attitude inventory": What confidence can we have in this instrument? *Journal of research in science teaching*, 20(2), 141-162.

Moore, R. W., Leigh, R., & Foy, H. (1997). The scientific attitude inventory: A revision (SAI II) *Journal of research in science teaching*. 34(4), 327-336.

Nair, S. (2012). Effectiveness of learning styles and metacognition upon the learning of Malayalam language at secondary level. Unpublished Ph D Dissertation. Mahatma Gandhi University, Kottayam.

Nambikkai, C.D. (2014). Attitude towards science of secondary school students in Puducherry region. *Indian journal of applied research*, 4(8), 76-81.

Nehru,J.(1947). Special convocation in University of Allahabad. Nehru's Speeches, Preisdent's Secretariat library.

Nelson, T.O., & Narens L.N. (1994). Why investigate metacognition? In J. Metcalfe and P. Shimamura (Eds), Metacognition: Knowing about knowing Cambridge, Massachusetts: The MIT Press.

Osborne, J., Simson, S. & Collins, S. (2003). Attitude towards Science: A Review of the Literature and its Implications. *International Journal of Science Education*, 25(9), 1049 – 1079.

Patil, C. (2005). Correlational study of Scientific Attitude between IX standard students and their parents. M Ed dissertation SNDT University, Pune.

Patil, G.V. (2011). Comparative study of Scientific Attitude about secondary and higher secondary level students. *International refereed research journal*, 7(9) 56-61.

Piaget, J. (1972). The principles of genetic epistemology. London: Routledge & Kegan Paul.

Pillai, S.K.P. (2012). An analytical study on scientific attitude of higher secondary school students in Virudha Nagar District. *International journal of teacher education research*, 1(4) 22- 38

Pintrich, P.R. (2005). Assessing Academic Self-Regulated Learning: New York, US: Spring Science plus Business Media.

Power, A. & Yager, R.E. (1992). The status of science- technology- society reform efforts around the world. International council of association for science education ICASE Year book.

Pradhan, P.K. (2015). A comparative study of scientific attitude among students of English and Odia medium school at secondary level. *Global journal of Engineering, Science and Social Science studies*, 1(2).

Purti, U.H., & Mardiana, M. (2017). How to analyse a student's thinking levels based on SOLO taxonomy. *Journal of physics: Conference series*.

Rahman, F., Jumani, N.B., Chisti, H.S., & Abbasi, F. (2010). Impact Of Metacognitive Awareness On Performance Of Students In Chemistry. *Contemporary Issues In Education Research*, 3(2), 39-44.

Rajasree, S. (2014). Effectiveness of Mc Cormack and Yager's Taxonomy i teaching physics at secondary level. Unpublished Ph D Dissertation, Mahatma Gandhi University, Kottayam.

Raven, J. C. (1941). Standardisation of Progressive Matrices, 1938. British Journal of Medical Psychology, XIX(1), 137-150.

Rao, D.B. (1990). A Comparative Study of Scientific Attitude, Scientific Aptitude and Achievement in Biology at Secondary School

Level. Fifth Survey of Educational Research, New Delhi: NCERT, Vol.II.

Rao, D.B. (2003). Scientific Attitude. Discovery publishing house, New Delhi, 91-93.

Rani, K.D. (2003). Educational aspirations and scientific attitude. Discovery publishing house, New Delhi, 94-96.

Rao, P. (2005).Teachers objective in science. *International journal of Science and Education*, 8, 54-78.

Reading, C. (2004). Student descriptions of variations while working with weather data. Statistics Education Research Journal, 3(2), 84-105.

Renumol, V.G., & Jayaprakash, S. (2006). Classification of cognitive difficulties of students to learn computer programming. Technical report.

Rhodes, M. (1961). An analysis of creativity. Phi Delta Kappan, 42: 305-310.

Rodney, A.B. (2007). Teaching introductory Organic Chemistry: Blooming beyond a simple Taxonomy. *Journal of Chemical Education*, 80(7), 779-84.

Rupani, C.M. & Bhutto, M.I. (2011). Evaluation of existing Teaching learning process on Bloom's Taxonomy. *International Journal of Academic Research in Business and Social Sciences*, 1(3), 49-58.

Safdar, M. & Shah, I. (2014). Construction and validation of an instrument to measure the scientific attitude of the students and attitude gain by the application of meaningful learning model of

David Ausabel in teaching Physics. *Asian journal of education and e learning*, 2(1), 35-42.

Sansanwal, D.N. & Sharma, D. (2003). Scientific creativity as a function of intelligence, self confidence, sex and standard. Research Gate.

Savickiene, I. (2010). Conception of learning outcomes in the Bloom's Taxonomy affective domain. *The quality of higher education journal*, 7, 37-59.

Shabaya, J. (2005). The role of preservice teachers in developing metacognitive awareness strategies in an urban language arts writing high school classroom. *College teaching methods and styles journal*, 1(3), 49-57.

Sharma, K.N. (1971).Creativity as a function of intelligence. *Psychological studies*, 17(1), 64-67.

Sharma,V.P. & Shukla, J.P. (2007). Verbal test of scientific creativity. Agra, National Psychological Corporation.

Sharma, R.C. (1960). Modern Science Teaching. New Delhi: Danpat Rai and Sons.

Sharp, C. (2001). Developing young children's creativity through the arts: what does research have to offer? Paper presented to an Invitational Seminar, Chadwick Street Recreation Centre, London.

Schraw, G. & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*, 19(5), 460-475.

Shulman, L. S. (1986). Those Who Understand: Knowledge Growth in Teaching. *Educational Researcher*, 15(2), 4-14.

Siddiqui, S. (2011).A comparative study of creativity among boys and girls of class VII. *Indian educational review*, 49(2), 5-14.

Simonton. J., & Keith, D. (2003). Scientific creativity as a constrained scholastic behaviour: The integration of product, person and process perspectives. *Psychological Bulletin*, 12(4), 475-494.

Simpson, E.J. (1972). The Classification of Educational Objectives in the Psychomotor Domain. Washington, DC: Gryphon House.

Simpson, R. M. (1922), Creative imagination. *American Journal of Psychology*, 33, 234-43.

Singh, R. & Singh, R. (2017). A Correlational study of scientific attitude and scientific interest of class IX students. *International journal of Indian psychology*, 3(9), 40-43.

Sivakumar, D. (2014). Metacognitive Awareness of secondary teacher education students in relation to their attitude towards teaching. *Edutracks*, 13(7), 41-45.

Smith, W.T., & Colby, A.S. (2010). Teaching for deep learning. The clearing house. *A journal Educational Strategies, Issues and ideas*, 80(5), 205-210.

Sony, F.C. (2014). Effect of metacognitive interaction in enhancing achievement in economics among secondary school students. *Frontiers in education and research*, 3(2), 27-29.

Sophie, M. (2015). Deep level learning through SOLO Taxonomy. Linked in.

Spencer, H. (1972). What Knowledge is most worth In John Martin Rich (ed.), *Readings in the philosophy of education*, Belmont, Calif, Wadsworth Pub. Co.

SriAstutik, S.S.B.LN. (2017). Developing Scientific creativity test to improve scientific creativity skills for secondry school students. *The international journal of social sciences and humanities invension*, 4(9), 3970-3974.

Srivastava, N.N. (1980) : A Study of Scientific Attitude and its measurement. Ph.D. Thesis, Patna University.

Srivastava, S. (2013). A study of relationship between Scientific Attitude and environmental awareness among secondary school students, 8(4),1-7.

Srivastava, S. (2014) Achievement in science as predictors of student's attitude. *European academic research*, 2(2), 2879-2893.

Stein, M.I. (1953).Creativity and culture . *Journal of Psychology*, 36, 311-322.

Stephen, K. (2013). Introduction to curriculum design in gifted education. Source books International.

Sultana, F. (2010). An Initial Study of a Method for Instructing Educators about the Revised Taxonomy. Retrieved from ERIC Database, ED 523761.

Taylor, C.W. (1964) : Creativity : Progress and Potential, New York, McGraw Hill Inc..

Taylor, S. (1999). Better learning through better thinking: Developing students' metacognitive abilities. *Journal of College Reading and Learning*, 30(1), 35-52.

Thurston, L.L. (1938). Primary mental abilities. Psychometric Monograph, No. 1

Tierney, S. (2013). Redesigning classroom: Using SOLO to increase challenge. Leading learner blog.

Torrance, E. P. (1995). Education and creative potential. Minneapolis: University of Minnesota

Torrance, E.P. (1969). Motivating and guiding creative reading. In T. Clymer (Ed.), Reading 360. Lexington, MA: Ginn.

Ugur, H., Constantinescu, P.M., & Stevens, M.J. (2015). Self awareness and professional growth; theory and application of Bloom's taxonomy. *Eurasian Journal of Educational Research*, (60), 89-110.

Unsworth, K., (2001). Unpacking creativity. Academy of management review, 26 (2), 289-297.

Vaidy, A.N. (1971). The impact of science Teaching, Oxford & IBH Publishing Co. New Delhi.

Veal, W.R. (1999). Pedagogical Content Knowledge Taxonomies. Unpublished Ph D Dissertation, The University of North Carolina-Chapel Hill.

Vinacke, W.E. (1951). The psychology of thinking. Mc Graw Hill.

Vygotsky, L. (1962) Thought and Language, Cambridge: MIT Press.

Wallas, G. (1926). The art of thought. London: Jonathan Cape.

Wiggins, G., & Mc Tighe, J. (1998). *Understanding by design* .Alexandria, VA: Association for Supervision and Curriculum Development.

Wilson, N.S., & Bai, H. (2010). The relationships and impact of teachers' metacognitive knowledge and pedagogical understandings of metacognition. *International weekly journal of science*, 5(3), 269–288.

Wiswanathan, U. & Murthy, S. (2015). Raising students' cognitive levels, extending level of textbook questions: Can we do both? Proceedings of epiSTEME- 4, Homi Bhabha Centre for Science Education, Mumbai, 189-193.

Wong, B.C. (2012). Metacognitive awareness procrastination and academic performance of university students in Hong Kong. Unpublished Ph D Theses, Leicester University. United Kingdom.

Yager, O. S., & Akcay, H. (2009). Comparing Science Learning Among 4th-, 5th-, and 6th-Grade Students: STS Versus Textbook-Based Instruction. *Journal of Elementary Science Education*, 21(2), 15-24.

Yager, R.E. (2007). How are we stacking up. *IOWA Science teaching journal*, 34 (3), 19-25

Yager, R.E. & Faheen, S.M. (2016). Improving student attitudes regarding their science experiences in upper elementary grade levels. *International journal of education*, 4(1), 35-42.

Yamamoto, K. (1964). Role of Creative Thinking and Intelligence in High School achievement. *Psychological Reports*, 14, 783-789.

Yawalkar, V. (1985). Development of some personality correlates of scientific creativity. Ph. D. thesis, Nagpur University, Nagpur.

Young, A. & Fry, J.D. (2008). Metacognitive awareness and academic achievement in college students. *Journal of scholarship of teaching and learning*, 8(2), 1-10.

Zohar, A., & David, A.B. (2010) Contribution of metacognitive strategies to science inquiry learning. *International journal of science education*, 31(12), 1657-1682

Electronic Web sites

CBSE (2013). Central Board of Secondary Education. Retrieved from http://en.wiki pedia.org/wiki/CentralBoardofSecondaryEducation and from http://school country.com/ on March, 2013.

Green, J., Camilli, G., & Elmore, P. (2006). Handbook of Complementary Methods in Education Research. New Jersey: Lawrence Erlbaum Associates, Inc. Retrieved from http://www.education.com/ reference/article/quasi experimental-research.

http://www.unmc. edu/com/ documents/ blooms-taxonomy-lo.pdf

http://trove.nla.gov.au/work/153214468?q=subject%3A%22SOLO+taxo no my%22&c=book&versionId=166973644

http://www.ieee.org/

http:// www.bloom.taxonomy.com

http://www.ucd.ie/t4cms/taxonomies3.pdf

http://pamhook.com/wiki/

http://en.wikipedia.org/wiki/

http:// mhrd.gov.in/rashtriyamadhyamik_shiksha_abhiyan

http://planipolis.iiep.
unesco.org/upload/India/IndiaSchemesecondaryeducation.pdf

http://www.unicef.org/eapro/EALASbook.pdf

National Research Council. (1996). National Science Education Standards. Washington, DC: The National Academies Press. https://doi.org/10.17226/4962.

Saxena, S.P. (1994). Creativity and Science Education. Retrieved from http//www.education.nic.in/ed 50 years/q6J/ BJ/ 6JBJ0401.htm,

APPENDICES

APPENDIX –I A

SCIENTIFIC ATTITUDE SCALE (DRAFT)
(English Version)

Each of the following statements expresses a feeling which particular people have towards science. You have to express on a five point scale, the extent of agreement between the feeling expressed in each statement and your own feeling. The five points are

1. Strongly Agree SA
2. Agree A
3. Undecided U
4. Disagree D
5. Strongly Agree SD

You have to put a tick mark (✓) against columns of each statement, which best indicates how closely you agree or disagree. The only correct responses are those that are true for you.

No	Statements	SA	A	U	D	SD
1	I believe that scientific theories are subject to change					
2	It is often said that science can provide answers to anything we want to know					
3	It is better to believe those superstitions which are difficult to prove					
4	I will accept an idea only when everybody agrees with it					
5	I would like to find clarifications wherever I feel doubts about scientific facts					
6	I will not modify my result if it is not in agreement with the established laws					
7	Scientists are doing aimless things					
8	I believe in superstitions which my parents follow					
9	It is mere waste of time, searching for evidences from all sources before arriving at a conclusion					
10	I like to participate in science quiz					
11	I never believe in ghosts					
12	I like to read science books					
13	I will never accept my friend’s opinion if it is against my opinion					
14	I like to watch science related programmes in T V					
15	It is impossible to prove that superstitions are					

	false					
16	I like to do science projects					
17	I cannot change superstitions because it is part of our culture and rituals					
18	I prefer to seek an expert opinion rather than proving it through an experiment					
19	I will rethink my ideas with respect to other’s criticism					
20	It is not necessary to collect all details before proving an experiment					
21	I like to copy a project from internet rather than doing it					
22	I like to know my future through astronomers					
23	I like to copy results from my friend’s notebook					
24	It is not good to ask an opinion from a person who is academically lower than me					
25	It is good to go for clarification before approving an idea					
26	I like to talk to experts in science					
27	It is sin to reject some facts which is not scientifically proved ,but established by religions					
28	I believe that universe runs by supernatural force					
29	Scientists possess personal bias and prejudice during their scientific works					
30	I want to become a scientist in future					
31	I believe certain superstitions as true even though science is against it					
32	Scientific laws and theories are speculations of scientists					
33	I believe in ghosts					
34	A good human being may become a good scientist					
35	I will try to prove a fact through an experiment than seeking an expert opinion					
36	Science learning is meaningless					
37	I like to read science fictions					
38	I always have curiosity to learn more about Mars					
39	It is good to quote rather than copy the work of scientists					
40	I don’t watch science related programmes on T V					
41	It is not at all interesting to find secrets of nature					

42	I like to read stories of ghosts					
43	I like to learn science through rote learning					
44	I believe in rebirth					
45	I think my imagination fosters my creativity					
46	I believe objective observation and intellectual honesty is essential for scientific studies					
47	I like to change my opinion about a scientific fact only on the basis of sufficient evidence					
48	I always like to do scientific experiments					
49	I find it interesting to search reasons behind natural phenomena					
50	I like to show my scientific work to everyone for discussion and criticism					
51	I like to repeat an experiment to check whether the result is same or not					
52	I think my senses as well as scientific knowledge will help me to know the nature around me					
53	While doing an experiment my aim is to get a result which is commonly approved by my teacher					
54	I always listen to others ideas					
55	I always like to appreciate the hard work and dedication of scientists					
56	I like to read stories of great inventions					
57	I usually notice all the minute details of a phenomena					
58	I like to reveal the limitations of my scientific work					
59	I like to know the work of Nobel Laureates in science					
60	I like to collect pictures of scientists					
61	I like to read biographies of great scientists					
62	I try to chat with scientists through internet					
63	I usually watch Discovery and National Geographic channels than sports channel					
64	It is interesting to clarify doubts related to science					

APPENDIX – I B

SCIENTIFIC ATTITUDE SCALE - DRAFT
(Malayalam Version)

വിദ്യാർത്ഥിയുടെ പേര് :

സ്കൂളിന്റെ പേര് :

ക്ലാസ്സ് നമ്പർ :

ക്ലാസ്സ് :

താഴെകൊടുത്തിരിക്കുന്ന ഓരോ പ്രസ്താവനയും ഒരു വ്യക്തിക്ക് ശാസ്ത്ര ത്തോടുള്ള മനോഭാവത്തെ സൂചിപ്പിക്കുന്നു. അതിനോടുള്ള നിങ്ങളുടെ പ്രതികരണം രേഖപ്പെടുത്തുന്നതിന് അഞ്ച് സൂചകങ്ങൾ നൽകിയിട്ടുണ്ട്.

1. പൂർണ്ണമായി യോജിക്കുന്നു SA
2. യോജിക്കുന്നു A
3. അഭിപ്രായമില്ല U
4. വിജോയിക്കുന്നു D
5. ശക്തമായി വിയോജിക്കുന്നു SD

ഓരോ പ്രസ്താവനയോടുമുള്ള നിങ്ങളുടെ പ്രതികരണം അതതുകോളങ്ങളിൽ ടിക്ക് (✓) മാർക്ക് ഉപയോഗിച്ച് രേഖപ്പെടുത്തുക.

നമ്പർ	***പ്രസ്താവനകൾ***	**SA**	**A**	**U**	**D**	**SD**
1.	ശാസ്ത്രസിദ്ധാന്തങ്ങൾ മാറ്റമില്ലാത്തവയാണെന്നാണ് എന്റെ വിശ്വാസം					
2.	നമുക്കറിയാൻ ആവശ്യമുള്ള കാര്യങ്ങൾക്കെല്ലാം ഉത്തരം നൽകാൻ സയൻസിനു കഴിയുമെന്നാണ് പലപ്പോഴും പറയപ്പെടാറുള്ളത്					
3.	തെളിയിക്കപ്പെടാൻ സാധ്യതയില്ലാത്ത അന്ധവിശ്വാസങ്ങൾ വിശ്വസിക്കുകയാണ് നല്ലത്					
4.	ഏതൊരു ആശയത്തോടാണോ എല്ലാവരും യോജിക്കുന്നത് ആ ആശയം മാത്രമേ ഞാൻ സ്വീകരിക്കുകയുള്ളു					

5.	ശാസ്ത്രവസ്തുതകളെക്കുറിച്ചുള്ള സംശയ ങ്ങൾക്ക് വിശദീകരണം തേടുന്നത് എനിക്ക് ഇഷ്ടമാണ്					
6.	എന്റെ പരീക്ഷണഫലങ്ങൾ ശാസ്ത്രത്തിലെ അംഗീകൃത നിയമങ്ങളോട് വിയോജിക്കുന്നവ യാണെങ്കിലും ഞാൻ അതിൽ മാറ്റം വരുത്തില്ല					
7.	ശാസ്ത്രജ്ഞന്മാർ ലക്ഷ്യശൂന്യമായ കാര്യങ്ങ ളാണ് ചെയ്യുന്നത്					
8.	എന്റെ രക്ഷിതാക്കൾ അനുഗമിക്കുന്ന അന്ധവി ശ്വാസങ്ങളെ ഞാനും വിശ്വസിക്കുന്നു					
9.	അവസാന തീരുമാനത്തിലെത്തുന്നതിനു മുമ്പായി എല്ലാ തലത്തിലുമുള്ള തെളിവുകൾ ശേഖരിക്കുന്നത് വെറുതെ സമയം പാഴാക്ക ലാണ്					
10.	ശാസ്ത്ര പ്രശ്നോത്തരികളിൽ പങ്കെടുക്കാൻ എനിക്കിഷ്ടമാണ്					
11.	പ്രേതത്തിൽ എനിക്ക് വിശ്വാസം ഇല്ല					
12.	ശാസ്ത്രപുസ്തകങ്ങൾ വായിക്കാൻ എനിക്ക് ഇഷ്ടമാണ്					
13.	എന്റെ സുഹൃത്തിന്റെ അഭിപ്രായം എന്റെ ചിന്താ ഗതിയോട് വിയോജിക്കുന്നതാണെങ്കിൽ ഞാൻ ഒരിക്കലും അത് സ്വീകരിക്കില്ല					
14.	ടി.വിയിലെ ശാസ്ത്രസംബന്ധമായ പരിപാടികൾ കാണാൻ എനിക്ക് ഇഷ്ടമാണ്					
15.	അന്ധവിശ്വാസങ്ങൾ തെറ്റാണെന്ന് ഒരിക്കലും തെളിയിക്കാൻ പറ്റില്ല					
16.	ശാസ്ത്ര പ്രൊജക്ടുകൾ ചെയ്യാൻ എനിക്ക് ഇഷ്ടമാണ്					
17.	അന്ധവിശ്വാസങ്ങളെ എനിക്ക് മാറ്റാൻ പറ്റില്ല. എന്തുകൊണ്ടെന്നാൽ അവ നമ്മുടെ സംസ്കാര ത്തിന്റെയും ആചാരങ്ങളുടെയും ഭാഗമാണ്					
18.	പരീക്ഷണത്തിലൂടെ ഒരു വസ്തുത തെളിയിക്കു ന്നതിനേക്കാൾ വിദഗ്ദാഭിപ്രായം തേടുന്നതാണ് ഞാൻ തിരഞ്ഞെടുക്കുക					
19.	മറ്റുള്ളവരുടെ വിമർശനങ്ങൾക്കനുസൃതമായി എന്റെ ആശയങ്ങളെപ്പറ്റി ഞാൻ പുനർവിചി ന്തനം നടത്തും					

20.	ശാസ്ത്രപരീക്ഷണം തെളിയിക്കപ്പെടുന്നതിനു മുമ്പായി എല്ലാ വിശദാംശങ്ങളും ശേഖരി ക്കേണ്ട ആവശ്യമില്ല					
21.	പ്രൊജകട് ചെയ്യുന്നതിനേക്കാൾഇന്റർനെറ്റിൽ നിന്നും പകർത്തുന്നതാണ് എനിക്കിഷ്ടം					
22.	ജ്യോതിഷന്മാരിൽ നിന്നും ഭാവിയെക്കുറിച്ചറി യാൻ എനിക്കിഷ്ടമാണ്					
23.	സുഹൃത്തിന്റെ നോട്ടുബുക്കിൽ നിന്നും റിസൽട്ടുകൾ പകർത്താൻ ഞാൻ ഇഷ്ടപ്പെ ടുന്നു					
24.	വിദ്യാഭ്യാസപരമായി എന്നേക്കാൾ താഴ്ന്നു നിൽക്കുന്ന ഒരാളോട് അഭിപ്രായം ചോദിക്കു ന്നത് ശരിയായ കാര്യമല്ല					
25.	ഒരു ആശയം സ്വീകരിക്കുന്നതിനു മുമ്പായി അതിന്റെ വിശദാംശങ്ങൾ തേടുന്നത് നല്ലതാണ്					
26.	ശാസ്ത്രത്തിലെ വിദഗ്ദന്മാരോട് സംസാരി ക്കുന്നത് എനിക്കിഷ്ടമാണ്					
27.	ശാസ്ത്രീയമായി തെളിയിക്കപ്പെട്ടിട്ടില്ലാത്തതും എന്നാൽ മതപരമായി അംഗീകരിക്കപ്പെട്ടിട്ടുള്ള തുമായ വസ്തുതകൾ നിഷേധിക്കുന്നത് പാപ മാണ്					
28.	പ്രകൃത്യാതീതമായ ശക്തിയാണ് പ്രപഞ്ചത്തെ നിലനിർത്തുന്നത്					
29.	വ്യക്തിപരമായ പക്ഷപാതത്തോടെയും, മുൻവിധിയോടെയും ആണ് ശാസ്ത്രകാരന്മാർ അവരുടെ ശാസ്ത്രപ്രവർത്തനങ്ങൾ നടത്താറു ള്ളത്					
30.	ഭാവിയിൽ ഒരു ശാസ്ത്രജ്ഞനാവാൻ ഞാൻ ആഗ്രഹിക്കുന്നു					
31.	സയൻസ് എതിർക്കുന്നുണ്ടെങ്കിലും ചില അന്ധ വിശ്വാസങ്ങൾ ശരിയാണെന്ന് ഞാൻ വിശ്വസി ക്കുന്നു					
32.	ശാസ്ത്രനിയമങ്ങളും സിദ്ധാന്തങ്ങളും ശാസ്ത്ര ജ്ഞന്മാരുടെ അനുമാനങ്ങളാണ്					
33.	പ്രേതം, ഭൂതം എന്നിവയിൽ എനിക്ക് വിശ്വാസം ഉണ്ട്					
34.	ഒരു നല്ല മനുഷ്യന് ഒരു നല്ല ശാസ്ത്രജ്ഞനാ വാൻ കഴിഞ്ഞേക്കാം					

35.	ഒരു വസ്തുതയെപ്പറ്റി വിദഗ്ദാഭിപ്രായം തേടുന്ന തിനേക്കാൾ പരീക്ഷണത്തിലൂടെ തെളിയിക്കാനാണ് ഞാൻ ശ്രമിക്കുക					
36.	ശാസ്ത്രപഠനം അർത്ഥശൂന്യമാണ്					
37.	ശാസ്ത്രസംബന്ധമായ കല്പിതകഥകൾ വായിക്കാൻ എനിക്കിഷ്ടമാണ്					
38.	ചൊവ്വാ ഗ്രഹത്തെപ്പറ്റി അറിയുവാൻ എനിക്കെപ്പോഴും ജിജ്ഞാസ ഉണ്ട്					
39.	ശാസ്ത്രജ്ഞന്മാരുടെ പ്രവർത്തനങ്ങൾ പകർത്തുന്നതിനേക്കാൾ ഉദ്ധരിക്കുന്നതാണ് നല്ലത്					
40.	ടി.വിയിലെ ശാസ്ത്രസംബന്ധമായ പരിപാടികൾ ഞാൻ കാണാറില്ല					
41.	പ്രകൃതിരഹസ്യങ്ങൾ കണ്ടെത്തുന്നത് ഒട്ടും താത്പര്യമുളവാക്കുന്ന കാര്യമല്ല					
42.	പ്രേതകഥകൾ വായിക്കാൻ എനിക്കിഷ്ടമാണ്					
43.	ശാസ്ത്രവിഷയങ്ങൾ കാണാതെ പഠിക്കാനാണ് എനിക്കിഷ്ടം					
44.	പുനർജന്മത്തിൽ ഞാൻ വിശ്വസിക്കുന്നു					
45.	എന്റെ ഭാവനശേഷി എന്റെ സർഗ്ഗശക്തിയെ വളർത്താൻ സഹായിക്കുന്നുണ്ടെന്നു തോന്നുന്നു					
46	വസ്തുനിഷ്ഠമായ നിരീക്ഷണവും ബൗദ്ധികമായ സത്യസന്ധതയും ശാസ്ത്രപഠനങ്ങൾക്ക് അത്യാവശ്യമാണെന്ന് ഞാൻ വിശ്വസിക്കുന്നു					
47	ആവശ്യമായ തെളിവുകളുടെ അടിസ്ഥാനത്തിൽ മാത്രമേ ഒരു ശാസ്ത്ര വസ്തുതയെ പറ്റിയുള്ള എന്റെ ചിന്താഗതി ഞാൻ മാറ്റുകയുള്ളൂ					
48	ശാസ്ത്രപരീക്ഷണങ്ങൾ ചെയ്യാൻ എനിക്ക് ഇഷ്ടമാണ്					
49	പ്രകൃതി പ്രതിഭാസങ്ങൾക്ക് പിന്നിലുള്ള കാരണങ്ങൾ കണ്ടെത്താൻ എനിക്കിഷ്ടമാണ്					
50	മറ്റുള്ളവരുടെ ചർച്ചകൾക്കും നിരൂപണങ്ങൾക്കു വേണ്ടി എന്റെ ശാസ്ത്രപ്രവർത്തനങ്ങൾ അവതരിപ്പിക്കാൻ എനിക്കിഷ്ടമാണ്					
51	കിട്ടുന്ന നിഗമനങ്ങൾ ഒന്നുതന്നെയാണോ എന്നറിയാൻ ഞാൻ പല ആവർത്തി പരീക്ഷണങ്ങൾ ചെയ്യാൻ ഇഷ്ടപ്പെടുന്നു					

52	എന്റെ ഇന്ദ്രിയങ്ങളും ശാസ്ത്രപരമായ അറിവുകളും ചുറ്റുമുള്ള പ്രകൃതിയെ പറ്റി അറിയാൻ സഹായിക്കുന്നു					
53	ശാസ്ത്ര പരീക്ഷണങ്ങൾ ചെയ്യുമ്പോൾ ഞാൻ, ടീച്ചർ സാധാരണയായി സമ്മതിക്കുന്ന നിഗമനത്തിലേക്ക് എന്റെ പരീക്ഷണഫലത്തെ കൊണ്ടെത്തിക്കാനാണ് ശ്രമിക്കാറുള്ളത്					
54	ഞാൻ മറ്റുള്ളവരുടെ അഭിപ്രായങ്ങൾക്ക് എല്ലായ്പ്പോഴും ശ്രദ്ധകൊടുക്കാറുണ്ട്					
55	ശാസ്ത്രജ്ഞന്മാരുടെ കഠിനാധ്വാനത്തെയും അർപ്പണ ബോധത്തെയും എപ്പോഴും ഞാൻ അഭിനന്ദിക്കാറുണ്ട്					
56	മഹത്തായ കണ്ടുപിടുത്തങ്ങളെ കുറിച്ചുള്ള കഥകൾ വായിക്കാൻ എനിക്കിഷ്ടമാണ്					
57	ഞാൻ സാധാരണയായി ഒരു പ്രതിഭാസത്തിന്റെ എല്ലാ സൂക്ഷ്മമായ വിശദാംശങ്ങളെപറ്റിയും ശ്രദ്ധിക്കാറുണ്ട്					
58	എന്റെ ശാസ്ത്ര പ്രവർത്തനങ്ങളുടെ പോരായ്മകൾ തുറന്നുപറയാൻ ഞാൻ ഇഷ്ടപ്പെടുന്നു					
59	നോബൽ സമ്മാന ജേതാക്കളുടെ പ്രവർത്തനങ്ങളെക്കുറിച്ചറിയുവാൻ എനിക്കിഷ്ടമാണ്					
60	ശാസ്ത്രജ്ഞന്മാരുടെ ചിത്രങ്ങൾ ശേഖരിക്കുവാൻ എനിക്കിഷ്ടമാണ്					
61	പ്രഗത്ഭരായ ശാസ്ത്രജ്ഞന്മാരുടെ ജീവചരിത്രം വായിക്കാൻ എനിക്കിഷ്ടമാണ്					
62	ഇന്റെർനെറ്റിലൂടെ ശാസ്ത്രജ്ഞന്മാരോട് സംഭാഷണത്തിലേർപ്പെടാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്					
63	സ്പോർട്സ് ചാനലിനേക്കാളും, ഡിസ്ക്കവറി ചാനലും നാഷണൽ ജിയോഗ്രാഫിക് ചാനലും ആണ് സാധാരണയായി ഞാൻ കാണാറുള്ളത്					
64	ശാസ്ത്രസംബന്ധമായ സംശയ നിവാരണം രസകരമാണ്					

APPENDIX – II A
SCIENTIFIC ATTITUDE SCALE (FINAL)
(English Version)

Each of the following statements expresses a feeling which particular people have towards science. You have to express on a five point scale, the extent of agreement between the feeling expressed in each statement and your own feeling. The five points are

1. Strongly Agree SA
2. Agree A
3. Undecided U
4. Disagree D
5. Strongly Agree SD

You have to put a tick mark (✓) against columns of each statement, which best indicates how closely you agree or disagree. The only correct responses are those that are true for you.

No	Statements	SA	A	U	D	SD
1	I believe that scientific theories are subject to change					
2	It is better to believe those superstitions which are difficult to prove					
3	I would like to find clarifications wherever I feel doubts about scientific facts					
4	Scientists are doing aimless things					
5	I believe in superstitions which my parents follow					
6	It is mere waste of time, searching for evidences from all sources before arriving at a conclusion					
7	I like to participate in science quiz					
8	I like to read science books					
9	I will never accept my friend's opinion if it is against my opinion					
10	I like to watch science related programmes in T V					
11	It is impossible to prove that superstitions are false					
12	I like to do science projects					
13	It is not necessary to collect all details before proving an experiment					

14	I like to copy a project from internet rather than doing it					
15	I like to know my future through astronomers					
16	I like to copy results from my friend’s notebook					
17	It is not good to ask an opinion from a person who is academically lower than me					
18	It is good to go for clarification before approving an idea					
19	I like to talk to experts in science					
20	I want to become a scientist in future					
21	I believe certain superstitions as true even though science is against it					
22	I believe in ghosts					
23	Science learning is meaningless					
24	I like to read science fictions					
25	I always have curiosity to learn more about Mars					
26	I don’t watch science related programmes on T V					
27	It is not at all interesting to find secrets of nature					
28	I believe in rebirth					
29	I believe objective observation and intellectual honesty is essential for scientific studies					
30	I like to change my opinion about a scientific fact only on the basis of sufficient evidence					
31	I always like to do scientific experiments					
32	I find it interesting to search reasons behind natural phenomena					
33	I like to show my scientific work to everyone for discussion and criticism					
34	I like to repeat an experiment to check whether the result is same or not					
35	I think my senses as well as scientific knowledge will help me to know the nature around me					
36	I always like to appreciate the hard work and dedication of scientists					
37	I like to read stories of great inventions					
38	I like to reveal the limitations of my scientific work					

39	I like to know the work of Nobel Laureates in science					
40	I like to collect pictures of scientists					
41	I like to read biographies of great scientists					
42	I usually watch Discovery and National Geographic channels than sports channel					

APPENDIX – II B
SCIENTIFIC ATTITUDE SCALE - FINAL
(Malayalam Version)

വിദ്യാർത്ഥിയുടെ പേര് :

സ്കൂളിന്റെ പേര് :

ക്ലാസ്സ് നമ്പർ :

ക്ലാസ്സ് :

താഴെകൊടുത്തിരിക്കുന്ന ഓരോ പ്രസ്താവനയും ഒരു വ്യക്തിക്ക് ശാസ്ത്രത്തോടുള്ള മനോഭാവത്തെ സൂചിപ്പിക്കുന്നു. അതിനോടുള്ള നിങ്ങളുടെ പ്രതികരണം രേഖപ്പെടുത്തുന്നതിന് അഞ്ച് സൂചകങ്ങൾ നൽകിയിട്ടുണ്ട്.

1. പൂർണ്ണമായി യോജിക്കുന്നു SA
2. യോജിക്കുന്നു A
3. അഭിപ്രായമില്ല U
4. വിജോയിക്കുന്നു D
5. ശക്തമായി വിയോജിക്കുന്നു SD

ഓരോ പ്രസ്താവനയോടുമുള്ള നിങ്ങളുടെ പ്രതികരണം അതതുകോളങ്ങളിൽ ടിക്ക് (✓) മാർക്ക് ഉപയോഗിച്ച് രേഖപ്പെടുത്തുക.

നമ്പർ	*പ്രസ്താവനകൾ*	SA	A	U	D	SD
1.	ശാസ്ത്രസിദ്ധാന്തങ്ങൾ മാറ്റമില്ലാത്തവയാണെന്നാണ് എന്റെ വിശ്വാസം					
2.	തെളിയിക്കപ്പെടാൻ സാധ്യതയില്ലാത്ത അന്ധവിശ്വാസങ്ങൾ വിശ്വസിക്കുകയാണ് നല്ലത്					
3	ശാസ്ത്രവസ്തുതകളെക്കുറിച്ചുള്ള സംശയങ്ങൾക്ക് വിശദീകരണം തേടുന്നത് എനിക്ക് ഇഷ്ടമാണ്					
4	ശാസ്ത്രജ്ഞന്മാർ ലക്ഷ്യശൂന്യമായ കാര്യങ്ങളാണ് ചെയ്യുന്നത്					
5	എന്റെ രക്ഷിതാക്കൾ അനുഗമിക്കുന്ന അന്ധവിശ്വാസങ്ങളെ ഞാനും വിശ്വസിക്കുന്നു					

6	അവസാന തീരുമാനത്തിലെത്തുന്നതിനു മുമ്പായി എല്ലാ തലത്തിലുമുള്ള തെളിവുകൾ ശേഖരിക്കുന്നത് വെറുതെ സമയം പാഴാക്കലാണ്					
7	ശാസ്ത്ര പ്രശ്നോത്തരികളിൽ പങ്കെടുക്കാൻ എനിക്കിഷ്ടമാണ്					
8	ശാസ്ത്രപുസ്തകങ്ങൾ വായിക്കാൻ എനിക്ക് ഇഷ്ടമാണ്					
9	എന്റെ സുഹൃത്തിന്റെ അഭിപ്രായം എന്റെ ചിന്താഗതിയോട് വിയോജിക്കുന്നതാണെങ്കിൽ ഞാൻ ഒരിക്കലും അത് സ്വീകരിക്കില്ല					
10	ടി.വിയിലെ ശാസ്ത്രസംബന്ധമായ പരിപാടികൾ കാണാൻ എനിക്ക് ഇഷ്ടമാണ്					
11	അന്ധവിശ്വാസങ്ങൾ തെറ്റാണെന്ന് ഒരിക്കലും തെളിയിക്കാൻ പറ്റില്ല					
12	ശാസ്ത്ര പ്രൊജക്ടുകൾ ചെയ്യാൻ എനിക്ക് ഇഷ്ടമാണ്					
13	ശാസ്ത്രപരീക്ഷണം തെളിയിക്കപ്പെടുന്നതിനു മുമ്പായി എല്ലാ വിശദാംശങ്ങളും ശേഖരിക്കേണ്ട ആവശ്യമില്ല					
14	പ്രൊജകട് ചെയ്യുന്നതിനേക്കാൾ ഇന്റർനെറ്റിൽ നിന്നും പകർത്തുന്നതാണ് എനിക്കിഷ്ടം					
15	ജ്യോതിഷന്മാരിൽ നിന്നും ഭാവിയെക്കുറിച്ചറിയാൻ എനിക്കിഷ്ടമാണ്					
16	സുഹൃത്തിന്റെ നോട്ടുബുക്കിൽ നിന്നും റിസൽട്ടുകൾ പകർത്താൻ ഞാൻ ഇഷ്ടപ്പെടുന്നു					
17	വിദ്യാഭ്യാസപരമായി എന്നേക്കാൾ താഴ്ന്നുനിൽക്കുന്ന ഒരാളോട് അഭിപ്രായം ചോദിക്കുന്നത് ശരിയായ കാര്യമല്ല					
18	ഒരു ആശയം സ്വീകരിക്കുന്നതിനു മുമ്പായി അതിന്റെ വിശദാംശങ്ങൾ തേടുന്നത് നല്ലതാണ്					
19	ശാസ്ത്രത്തിലെ വിദഗ്ദന്മാരോട് സംസാരിക്കുന്നത് എനിക്കിഷ്ടമാണ്					
20	ഭാവിയിൽ ഒരു ശാസ്ത്രജ്ഞനാവാൻ ഞാൻ ആഗ്രഹിക്കുന്നു					
21	സയൻസ് എതിർക്കുന്നുണ്ടെങ്കിലും ചില അന്ധവിശ്വാസങ്ങൾ ശരിയാണെന്ന് ഞാൻ വിശ്വസിക്കുന്നു					
22	പ്രേതം, ഭൂതം എന്നിവയിൽ എനിക്ക് വിശ്വാസം ഉണ്ട്					
23	ശാസ്ത്രപഠനം അർത്ഥശൂന്യമാണ്					
24	ശാസ്ത്രസംബന്ധമായ കല്പിതകഥകൾ വായിക്കാൻ എനിക്കിഷ്ടമാണ്					
25	ചൊവ്വാ ഗ്രഹത്തെപ്പറ്റി അറിയുവാൻ എനിക്കെപ്പോഴും ജിജ്ഞാസ ഉണ്ട്					

26	ടി.വിയിലെ ശാസ്ത്രസംബന്ധമായ പരിപാടികൾ ഞാൻ കാണാറില്ല					
27	പ്രകൃതിരഹസ്യങ്ങൾ കണ്ടെത്തുന്നത് ഒട്ടും താത്പര്യ മുളവാക്കുന്ന കാര്യമല്ല					
28	പുനർജന്മത്തിൽ ഞാൻ വിശ്വസിക്കുന്നു					
29	വസ്തുനിഷ്ഠമായ നിരീക്ഷണവും ബൗദ്ധികമായ സത്യസന്ധതയും ശാസ്ത്രപഠനങ്ങൾക്ക് അത്യാവശ്യ മാണെന്ന് ഞാൻ വിശ്വസിക്കുന്നു					
30	ആവശ്യമായ തെളിവുകളുടെ അടിസ്ഥാനത്തിൽ മാത്രമേ ഒരു ശാസ്ത്ര വസ്തുതയെ പറ്റിയുള്ള എന്റെ ചിന്താഗതി ഞാൻ മാറ്റുകയുള്ളൂ					
31	ശാസ്ത്രപരീക്ഷണങ്ങൾ ചെയ്യാൻ എനിക്ക് ഇഷ്ടമാണ്					
32	പ്രകൃതി പ്രതിഭാസങ്ങൾക്ക് പിന്നിലുള്ള കാരണങ്ങൾ കണ്ടെത്താൻ എനിക്കിഷ്ടമാണ്					
33	മറ്റുള്ളവരുടെ ചർച്ചകൾക്കും നിരൂപണങ്ങൾക്കു വേണ്ടി എന്റെ ശാസ്ത്രപ്രവർത്തനങ്ങൾ അവതരിപ്പി ക്കാൻ എനിക്കിഷ്ടമാണ്					
34	കിട്ടുന്ന നിഗമനങ്ങൾ ഒന്നുതന്നെയാണോ എന്നറിയാൻ ഞാൻ പല ആവർത്തി പരീക്ഷണങ്ങൾ ചെയ്യാൻ ഇഷ്ടപ്പെടുന്നു					
35	എന്റെ ഇന്ദ്രിയങ്ങളും ശാസ്ത്രപരമായ അറിവുകളും ചുറ്റുമുള്ള പ്രകൃതിയെ പറ്റി അറിയാൻ സഹായി ക്കുന്നു					
36	ശാസ്ത്രജ്ഞന്മാരുടെ കഠിനാധ്വാനത്തെയും അർപ്പണ ബോധത്തെയും എപ്പോഴും ഞാൻ അഭിനന്ദിക്കാറുണ്ട്					
37	മഹത്തായ കണ്ടുപിടുത്തങ്ങളെ കുറിച്ചുള്ള കഥകൾ വായിക്കാൻ എനിക്കിഷ്ടമാണ്					
38	എന്റെ ശാസ്ത്ര പ്രവർത്തനങ്ങളുടെ പോരായ്മകൾ തുറന്നുപറയാൻ ഞാൻ ഇഷ്ടപ്പെടുന്നു					
39	നോബൽ സമ്മാന ജേതാക്കളുടെ പ്രവർത്തനങ്ങളെ ക്കുറിച്ചറിയുവാൻ എനിക്കിഷ്ടമാണ്					
40	ശാസ്ത്രജ്ഞന്മാരുടെ ചിത്രങ്ങൾ ശേഖരിക്കുവാൻ എനിക്കിഷ്ടമാണ്					
41	പ്രഗത്ഭരായ ശാസ്ത്രജ്ഞന്മാരുടെ ജീവചരിത്രം വായി ക്കാൻ എനിക്കിഷ്ടമാണ്					
42	സ്പോർട്സ് ചാനലിനേക്കാളും, ഡിസ്ക്കവറി ചാനലും നാഷണൽ ജിയോഗ്രാഫിക് ചാനലും ആണ് സാധാരണയായി ഞാൻ കാണാറുള്ളത്					

APPENDIX – III A

SCIENTIFIC CREATIVE TEST

(English Version)

Today I would like to demonstrate a very important ability – Scientific Creativity. You have 7 different tasks. Each task investigates different scientific skills, giving you the opportunity to excel at what you are best at! These tasks will enable you to use creativity explore new ideas and solve problems. Please try to complete all the tasks in 50 nor 60 minutes. If you have questions about the tasks, please raise your hand and ask examiner. Please write your school, year, class, name, sex and today's date on the answer sheet before you begin.

Item -1

Please write down as many as possible scientific uses as you can for a piece of glass.

For example, make a test tube.

Item -2

If you can take a space ship to travel in the outer space and go to a planet, what scientific questions do you want to research? Please list as many as you can. For example, are there any living things on the planet.

Item -3

Please think up as many possible improvements as you can to a regular bicycle, making it more interesting, more useful and more beautiful.

For example, make the tyres reflective, so they can be seen in the darks.

Item -4

Suppose there was no gravity, describe what the world be like?

For example, human beings would be floating.

Item -5

Please use as many possible methods as you can to divide a square on to four equal pieces (same shape)

Item -6

There are two kinds of lenses. How can you test which is better? Please write down as many possible methods as you can and the instruments, principles and simple procedure.

Item – 7

Please design as apple picking machine. Draw a picture, point out the name and function of each part.

APPENDIX – III B

SCIENTIFIC CREATIVITY TEST
(Malayalam Version)

ഇന്നു നിങ്ങളുടെ മുമ്പിൽ ഞാൻ അവതരിപ്പിക്കുന്നത് ഒരു പ്രധാന കഴിവായ സയൻസ് ക്രീയേറ്റിവിറ്റിആണ്. നിങ്ങൾക്ക് 7 വ്യത്യസ്ത പ്രവർത്തികൾ തരുന്നു. ഓരോ പ്രവർത്തിയും വ്യത്യസ്തതരം പ്രായോഗികശേഷി പരീക്ഷിക്കുന്നു.എല്ലാപ്രവർത്തികളും ഒരുമണിക്കൂറിനുള്ളിൽ തീർക്കാൻ ശ്രമിക്കുക. എന്തെങ്കിലും സംശയം ഉണ്ടെങ്കിൽദയവായിചോദിക്കുക. ഉത്തരം എഴുതാൻ തുടങ്ങുന്നതിനു മുൻപ് നിങ്ങളുടെ പേരും, സ്കൂളും, ക്ലാസ്സും, തീയതി, സെക്സ് എന്നിവ ഉത്തരക്കടലാസ്സിന്റെ മുകളിലായിഎഴുതുക.

<u>Item-1</u>

ഒരു കഷണം ഗ്ലാസ്സിന്റെ ശാസ്ത്രിയ ഉപയോഗങ്ങൾ എന്തെല്ലാമെന്ന് കഴിയുന്നിടത്തോളം എഴുതുക

ഉദാ: ടെസ്റ്റൂബ് ഉണ്ടാക്കാൻ ഉപയോഗിക്കുന്നു.

<u>Item-2</u>

ഒരു ബഹിരാകാശവാഹനത്തിൽ കയറി ബഹിരാകാശത്തുകൂടി സഞ്ചരിക്കുവാനും ഒരു ഗ്രഹത്തിൽ പോകാനും കഴിഞ്ഞാൽ എന്തൊക്കെ ശാസ്ത്രീയചോദ്യങ്ങളാണ് നിങ്ങൾ അന്വേഷിക്കാൻ ആഗ്രഹിക്കുന്നത്.

ഉദാ: ഗ്രഹത്തിൽ ജീവനുള്ളവസ്തുക്കൾ ഉണ്ടോ?

<u>Item-3</u>

ഒരു സാധാരണ ബൈസൈക്കിളിനെ കൂടുതൽ രസകരവും, ഉപകാരപ്രദവും, മനോഹരവും ആക്കാൻ വേണ്ടി അതിന് എന്തോക്കെ മാറ്റം വരുത്താൻ കഴിയുമെന്ന് നിങ്ങളാൽ കഴിയുന്ന വിധം എഴുതുക.

ഉദാ: ടയറുകൾ രാത്രിയിലും തിളങ്ങുതാക്കാം.

Item-4

ഗുരുത്വാകർഷണമില്ലാത്ത ലോകത്തെക്കുറിച്ച് വിശദീകരിക്കുക.

ഉദാ: എല്ലാ ജീവജാലങ്ങൾക്കും പറന്നു നടക്കാം

Item-5

ഒരു സമചതുരത്തിനെ നാലുതുല്യ ഭാഗങ്ങളായി വിഭജിക്കാൻ കഴിയുന്ന ഏതെല്ലാം സാധ്യമായ മാർഗ്ഗങ്ങളുണ്ടെന്ന് കണ്ടെത്തി ഉത്തരക്കടലാസ്സിൽ വരയ്ക്കുക.

Item-6

രണ്ടു തരത്തിലുള്ള ലെൻസുകൾ ഉണ്ട്. ഏതാണ് ഏറ്റവും നല്ലത് എന്ന് എങ്ങനെ പരീക്ഷിക്കാം നിങ്ങളാൽ കഴിയുന്നിടത്തോളം മാർഗ്ഗങ്ങൾ എഴുതുക.

Item-7

ഒരു ആപ്പിൾ പിക്കിംഗ് മിഷ്യന്റെ ഡിസൈൻ തയ്യാറാക്കുക. പടം വരച്ച് ഭാഗങ്ങൾ അടയാളപ്പെടുത്തി ഓരോ ഭാഗത്തിന്റെയും ധർമ്മമെന്തെന്ന് എഴുതുക.

APPENDIX – IV A

METACOGNITIVE AWARENESS INVENTORY - DRAFT

(English Version)

Each of the following statements expresses an awareness about the learning process, which particular people have. You have to express on a five point scale, the extent of agreement between the feeling expressed in each statement and your own feeling. The five points are

1. Always A
2. Very often VO
3. Sometimes S
4. Rarely R
5. Never N

You have to put a tick mark (✓) against columns of each statement, which best indicates how closely you agree or disagree. The only correct responses are those that are true for you.

No	Statements	A	VO	S	R	N
1	I think twice about a problem before taking a decision					
2	I compare previously learned things before learning a new content					
3	According to the nature of the content I use different learning methods					
4	I always follow a strict time table for the studies					
5	I usually try to complete my learning assignments within the time schedule					
6	I often try to recollect the main idea of the content after learning					
7	I usually test myself that whether I am getting my goals					
8	I go through several alternatives of problem before answering it					
9	I understand my intellectual strength and weakness					

10	I always internalise an idea of what I have to learn before I start my learning					
11	I always try to know how well I did in a test					
12	Before beginning a task I frame specific goal in my mind					
13	I always concentrate more when I receive important information					
14	I know which information should get more importance during the learning process					
15	I organise information according to its importance before learning it					
16	I apply each strategy with a specific purpose while learning					
17	I learn best when I have familiarity with the topic					
18	I know teacher’s expectations about my learning					
19	I can remember information very well					
20	I always have control over how well I learn					
21	I periodically review important topics for better understanding					
22	I always check my knowledge about a topic before beginning to learn it					
23	I usually summarise the content after learning it					
24	I seek other’s help when there is difficulty in understanding content					
25	I motivate myself when there is a need					
26	I know my usual learning strategies					
27	I know which strategy is suitable for me to learn a specific content					
28	I usually overcome my weakness by using my own strategies					
29	I give importance to the meaning and significance of the content					
30	By using my own examples I meaningfully process the information					

31	I am able to judge my own understanding					
32	I usually check whether I have attained the goal after finishing my learning					
33	For better memory and retention I take help of pictures and diagrams					
34	I often take intervals between my learning to check my understanding					
35	I like to translate new information into my own words					
36	When I fail to understand I change my learning strategy					
37	Careful reading of instruction in the beginning helps my learning					
38	I always link the new content to my previously learned content					
39	I will recheck my assumption when get confused					
40	I accomplish my goal by carefully organising the time					
41	I learn more when I am interested in the topic					
42	I often break a difficult and lengthy content in to smaller parts					
43	I always try to get an overall meaning rather than significant details					
44	I will try to learn again if the new information is not clear to me					
45	When I get confused I stop and reread the topic					
46	I am efficient in finding and rectifying my own weaknesses					
47	I always try to improve myself					
48	I consider my failures as milestones towards success					
49	I used to write short notes while studying a massive content					
50	I often use certain memory tricks to remember points which are difficult to memorise					

51	I always try to find out the reason behind my failures, so that I can improve next time by rectifying it					
52	I usually develop a deeper understanding of the content than applying rote learning					
53	Self motivation increases my interest in learning					
54	I usually try to apply learned material in daily life situations					
55	I often ask my seniors and bright students of the class about their study habits and try to adopt it wherever necessary					
56	I discuss the learning material with my class mates because it clarifies my assumptions					
57	I take more time for learning things which are difficult for my understanding					
58	I workout previous years question papers to check my understanding					
59	I always revise learned portions daily, weekly and monthly					
60	I know which study environment is good for me					
61	I always try to avoid those things which causes distractions to my study					
62	I like to read reference books					
63	I like to search internet for further information					
64	Tests help for my own improvement					
65	I try to get back on track when I lose concentration.					
66	I underline or circle information in the text to remember it.					
67	I decide what to study closely and what to ignore.					
68	I analyze and evaluate the information presented in the text.					
69	I try to use more than one way for learning something					

APPENDIX – IV B

META COGNITIVE AWARENESS INVENTORY- DRAFT

(Malayalam Version)

വിദ്യാർത്ഥിയുടെ പേര് :

സ്കൂളിന്റെ പേര് :

ക്ലാസ്സ് നമ്പർ :

ക്ലാസ്സ് :

താഴെ കൊടുത്തിരിക്കുന്ന ഓരോ പ്രസ്താവനയും ഓരോ വ്യക്തിക്കും അവരവരുടെ പഠനപ്രക്രിയയെ പറ്റിയുള്ള അറിവ് സൂചിപ്പിക്കുന്നു. അതിനോടുള്ള നിങ്ങളുടെ പ്രതിക രണം രേഖപ്പെടുത്തുന്നതിന് അഞ്ച് സൂചകങ്ങൾ നൽകിയിട്ടുണ്ട്.

1. എല്ലായ്പ്പോഴും A
2. പലപ്പോഴും VO
3. ചിലപ്പോൾ S
4. വിരളമായി R
5. ഒരിക്കലുമില്ല N

ഓരോ പ്രസ്താവനയോടുമുള്ള നിങ്ങളുടെ പ്രതികരണം അതതുകോളങ്ങളിൽടിക്ക് (✓) മാർക്ക് ഉപയോഗിച്ച്രേഖപ്പെടുത്തുക.

നമ്പർ	*പ്രസ്താവനകൾ*	A	VO	S	R	N
1.	ഒരു പ്രശ്നത്തെപറ്റി വീണ്ടും വീണ്ടും ആലോചിച്ച തിനു ശേഷം മാത്രമേ ഞാൻ തീരുമാനത്തിലെത്താറുള്ളൂ					
2.	ഞാൻ മുമ്പ് പഠിച്ച അറിവുകളുമായി താരതമ്യം ചെയ്താണ് പുതിയ പാഠഭാഗം പഠിക്കാറുള്ളത്					
3.	പാഠ്യവിഷയത്തിന്റെ പ്രത്യേകതയ്ക്കനുസരിച്ച് വിവിധ പഠനമാർഗ്ഗങ്ങൾ ഞാൻ അവലംബിക്കാറുണ്ട്					
4.	എല്ലായ്പ്പോഴും ഒരു കൃത്യമായ ടൈംടേബിളനുസരി ച്ചാണ് ഞാൻ പഠനം നടത്താറുള്ളത്					
5.	കൃത്യമായ സമയത്തു തന്നെ അസൈൻമെന്റുകൾ പൂർത്തിയാക്കാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്					
6.	ഒരു പാഠ്യഭാഗം പഠിച്ചതിനുശേഷം അതിന്റെ പ്രധാന ആശയംകൂടെക്കൂടെ ഓർത്തുനോക്കാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്					
7.	ഉദ്ദേശിച്ച ലക്ഷ്യത്തിൽ എത്തുന്നുണ്ടോ എന്ന് ഞാൻ പതിവായി പരിശോധിക്കാറുണ്ട്					

8.	ഒരു പ്രശ്നം നിർദ്ധാരണം ചെയ്യാനുള്ള പല മാർഗ്ഗങ്ങളെക്കുറിച്ച് ഞാൻ ആലോചിക്കാറുണ്ട്					
9.	എന്റെ ബൗദ്ധികമായ കഴിവുകളും കുറവുകളും ഞാൻ മനസ്സിലാക്കുന്നു					
10.	പഠനത്തിന്റെ തുടക്കത്തിൽ എന്താണ് പഠിക്കേണ്ടതെന്നതിനെപ്പറ്റി ഒരു ധാരണ ഉണ്ടാക്കാൻ എല്ലായ്പോഴും ഞാൻ ശ്രമിക്കാറുണ്ട്					
11.	പരീക്ഷ എത്രമാത്രം നന്നായി എഴുതി എന്നറിയാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്					
12.	ഒരു പ്രവർത്തി തുടങ്ങുന്നതിനു മുമ്പായി വ്യക്തമായ ലക്ഷ്യങ്ങൾ ഞാൻ വെയ്ക്കാറുണ്ട്					
13.	പ്രധാനപ്പെട്ട അറിവുനേടുന്ന സമയത്ത് ഞാൻ കൂടുതൽ ശ്രദ്ധ അതിനു വേണ്ടി കൊടുക്കാറുണ്ട്					
14.	പഠനപ്രക്രിയയിൽ ഏത് അറിവിനാണ് കൂടുതൽ പ്രാധാന്യം കൊടുക്കേണ്ടതെന്ന് എനിക്കറിയാം					
15.	പഠിക്കുന്നതിനുമുമ്പായി ഞാൻ അറിവുകളെ അതിന്റെ പ്രാധാന്യമനുസരിച്ച് തരംതിരിക്കാറുണ്ട്					
16.	നിശ്ചിതമായ ലക്ഷ്യത്തോടെയാണ് പഠിക്കുമ്പോൾ ഓരോ തന്ത്രങ്ങളും ഞാൻ പ്രയോഗിക്കാറുണ്ട്					
17.	സുപരിചിതമായ വിഷയങ്ങൾ എനിക്ക് നന്നായി പഠിക്കുവാൻ സാധിക്കാറുണ്ട്					
18.	എന്റെ പഠനത്തെക്കുറിച്ച് ടീച്ചർക്കുള്ള പ്രതീക്ഷകൾ എനിക്കറിയാം					
19.	എനിക്ക് വിവരങ്ങൾ നന്നായി ഓർത്തുവെയ്ക്കാൻ കഴിയാറുണ്ട്					
20.	നന്നായി പഠിക്കുന്ന കാര്യത്തിൽ എനിക്കു സ്വയം നിയന്ത്രണം ഉണ്ട്					
21.	പ്രധാനപ്പെട്ട ഭാഗങ്ങൾ പുനരവലോകനം ചെയ്യാൻ എനിക്കിഷ്ടമാണ്					
22.	ഒരുവിഷയം പഠിക്കുന്നതിനു മുമ്പായി അതിനെക്കുറിച്ചുള്ള അറിവ് ഞാൻ എല്ലായ്പോഴും പരിശോധിക്കാറുണ്ട്					
23.	ഒരുകാര്യം പഠിച്ചതിനു ശേഷം ഞാൻ അത്സംക്ഷിപ്തരൂപത്തിലാക്കാറുണ്ട്					
24.	പഠനഭാഗം മനസ്സിലാകാതെ വരുമ്പോൾ മറ്റുള്ളവരുടെ സഹായം ഞാൻ തേടാറുണ്ട്					

25.	അവശ്യഘട്ടങ്ങളിൽ ഞാൻ സ്വയം പ്രചോദനം ഉൾക്കൊള്ളാറുണ്ട്					
26.	സ്ഥിരമായി ഞാൻ ഉപയോഗിക്കുന്ന പഠനതന്ത്രങ്ങളെപ്പറ്റി എനിക്ക് അറിവുണ്ട്					
27.	ഒരു പ്രത്യേകം പഠനഭാഗം പഠിക്കുന്നതിനായി ഏത് പഠനമാർഗ്ഗമാണ് എനിക്ക് അനുയോജ്യമെന്ന് എനിക്ക് അറിയാം					
28.	പഠനസംബന്ധമായ എന്റെ ബലഹീനതകൾ തരണം ചെയ്യാൻ സാധാരണ എന്റേതായ തന്ത്രങ്ങൾ ഞാൻ ഉപയോഗിക്കാറുണ്ട്					
29.	പാഠഭാഗത്തിന്റെ അർത്ഥ (വ്യാപ്തിയിലും)ത്തിനും പൊരുളിനുമാണ് ഞാൻ പ്രാധാന്യം കൊടുക്കുന്നത്					
30.	എന്റേതായ ഉദാഹരണങ്ങളിലൂടെ വിവരങ്ങളെ അർത്ഥപൂർണ്ണമായി ഞാൻ പാകപ്പെടുത്താറുണ്ട്					
31.	എന്റെ ധാരണയെ വിലയിരുത്താനുള്ള കഴിവ് എനിക്കുണ്ട്					
32.	പഠനത്തിനു –ശേഷം ഉദ്ദേശിച്ച ലക്ഷ്യത്തിലെത്തിയോ എന്ന് ഞാൻ പരിശോധിക്കാറുണ്ട്					
33.	പഠനത്തിനിടയ്ക്ക് ഇടവേളകൾ എടുത്ത് മനസ്സിലാക്കിയ കാര്യങ്ങളെപ്പറ്റി ഞാൻ അവലോകനം നടത്താറുണ്ട്					
34.	അറിവ് ഓർത്തിരിക്കുന്നതിനും അത് നിലനിർത്തുന്നതിനും വേണ്ടി ചിത്രങ്ങളുടെയും ഡയഗ്രങ്ങളുടെയും സഹായം ഞാൻ സാധാരണയായി തേടാറുണ്ട്					
35.	പുതിയ ആശയങ്ങളെ എന്റേതായ രീതിയിലേക്ക് മാറ്റാൻ ശ്രമിക്കാറുണ്ട്					
36.	കാര്യങ്ങൾ മനസ്സിലാകാതെ വരുമ്പോൾ ഞാൻ പഠന തന്ത്രം മാറ്റാറുണ്ട്					
37.	തുടക്കത്തിൽ കൊടുക്കുന്ന നിർദ്ദേശങ്ങൾ ശ്രദ്ധയോടെ വായിക്കുന്നത് എന്റെ പഠനത്തെ സഹായിക്കാറുണ്ട്					
38.	പുതിയതായി പഠിക്കുന്ന പാഠഭാഗം മുമ്പ് പഠിച്ച പാഠഭാഗവുമായി എല്ലായ്പോഴും ഞാൻ ബന്ധപ്പെടുത്താറുണ്ട്					
39.	ഏതെങ്കിലും തരത്തിലുള്ള ആശയകുഴപ്പം നേരിടുമ്പോൾ എന്റെ ധാരണ ശരിയാണോ എന്ന് ഞാൻ പുനരവലോകനം ചെയ്യാറുണ്ട്					
40.	ലക്ഷ്യപ്രാപ്തിക്കു വേണ്ടി സമയത്തെ ഞാൻ ശ്രദ്ധയോടെ ക്രമീകരിക്കാറുണ്ട്					

41.	എനിക്ക് താല്പര്യമുള്ള കാര്യങ്ങൾ ഞാൻ കൂടുതൽ പഠിക്കാറുണ്ട്					
42.	ബുദ്ധിമുട്ടുള്ളതും കൂടുതലുള്ളതുമായ പാഠഭാഗത്തെ ചെറിയ ഭാഗങ്ങളാക്കി പഠിക്കാനാണ് എനിക്കിഷ്ടം					
43.	കൃത്യമായ വിശദാംശങ്ങളെക്കാളും മൊത്തമായ ഒരു ധാരണ കിട്ടാനാണ് ഞാൻ ശ്രമിക്കാറുള്ളത്					
44.	പുതിയ അറിവ് എനിക്ക് വ്യക്തമാകാത്തപ്പോൾ വീണ്ടും വീണ്ടും ഞാൻ അത് പഠിക്കാറുണ്ട്					
45.	അറിവ് പൂർണ്ണമായി ഉൾക്കൊള്ളാൻ കഴിയാതെവരുമ്പോൾ നിർത്തിയിട്ട് ഞാൻ വീണ്ടും വീണ്ടും വായിക്കാറുണ്ട്					
46.	എന്റെ ബലഹീനതകൾ കണ്ടെത്താനും അത് തിരുത്താനും എനിക്കു് കഴിവുണ്ട്					
47.	ഗ്വയം മെച്ചപ്പെടാൻ (മെച്ചപ്പെടുത്താൻ) എല്ലായ്പോഴും ഞാൻ ശ്രമിക്കാറുണ്ട്					
48.	എന്റെ പരാജയങ്ങളെ വിജയത്തിലേക്കുള്ള ചവിട്ടുപടികളായിട്ടാണ് ഞാൻ കാണാറുള്ളത്					
49.	ബൃഹത്തായ പാഠഭാഗം പഠിക്കുമ്പോൾ ലഘുലേഖകൾ കുറിച്ചുവെയ്ക്കുന്ന ശീലം എനിക്കുണ്ട്					
50.	ഓർത്തെടുക്കാൻ ബുദ്ധിമുട്ടുള്ള കാര്യങ്ങൾക്ക് പലപ്പോഴും ഞാൻ ഓർക്കാനുള്ള ചില കുറുക്കുവഴികൾ പ്രയോഗിക്കാറുണ്ട്					
51.	എനിക്ക് പറ്റുന്ന വീഴ്ചകളുടെ കാരണം കണ്ടുപിടിച്ച് അടുത്തപ്രാവശ്യം അതുണ്ടാവാതെയിരിക്കാൻ ഞാൻ എല്ലായ്പോഴും ശ്രമിക്കാറുണ്ട്.					
52.	ഞാൻ സാധാരണയായി കാണാതെ പഠിക്കാതെ ആഴത്തിലുള്ള ധാരണ ഉണ്ടാക്കാനാണ് ്ശ്രമിക്കാറുള്ളത്					
53.	സ്വയം നടത്തുന്ന പ്രചോദനം പഠിക്കാനുള്ള എന്റെ ആഗ്രഹത്തെ വർദ്ധിപ്പിക്കാറുണ്ട്					
54.	പഠിച്ച ഭാഗങ്ങൾ സാധാരണയായി ഞാൻ നിത്യജീവിതത്തിൽ പ്രയോഗത്തിൽ വരുത്താറുണ്ട്					
55.	ഇടയ്ക്കിടെ ഞാൻ മുതിർന്ന കുട്ടികളോടും പഠനത്തിൽ മുൻപന്തിയിൽ നിൽക്കുന്ന കുട്ടികളോടും അവരുടെ പഠനശീലങ്ങളെക്കുറിച്ചു ചോദിക്കുകയും അവശ്യാനുസരണം ഉപയോഗിക്കാറും ഉണ്ട്					
56.	പാഠഭാഗങ്ങൾ ഞാൻ എന്റെ സുഹൃത്തുക്കളുമായി ഞാൻ ചർച്ച ചെയ്യാറുണ്ട് അത് എന്റെ അനുമാനങ്ങൾക്ക് കൂടുതൽ വ്യക്തത നൽകാറുണ്ട്.					

57.	എനിക്ക് മനസ്സിലാക്കാൻ ബുദ്ധിമുട്ടുള്ള പാഠഭാഗങ്ങൾക്ക് കൂടുതൽ സമയം ഞാൻ കൊടുക്കാറുണ്ട്					
58.	മുൻകാല ചോദ്യപേപ്പറുകൾക്ക് ഉത്തരം കണ്ടെത്തി ഞാൻ എന്റെ ധാരണയെപ്പറ്റി പരിശോധിക്കാറുണ്ട്					
59.	പഠിച്ച ഭാഗങ്ങൾ ഞാൻ ദിവസേന, ആഴ്ചതോറും, മാസംതോറും എന്ന രീതിയിൽ റിവിഷൻ നടത്താറുണ്ട്					
60.	എനിക്ക് അനുയോജ്യമായ പഠനാന്തരീക്ഷം ഏതെന്ന് എനിക്കറിയാം					
61.	എന്റെ പഠനത്തിനു തടസ്സം സൃഷ്ടിക്കുന്ന കാര്യങ്ങളെ എപ്പോഴും ഞാൻ ഒഴിവാക്കാൻ ശ്രമിക്കാറുണ്ട്					
62.	റഫറൻസ് ഗ്രന്ഥങ്ങൾ വായിക്കാൻ എനിക്കിഷ്ടമാണ്					
63.	കൂടുതൽ അറിവുനേടാൻ ഇന്റർനെറ്റ് നോക്കാൻ എനിക്കിഷ്ടമാണ്					
64.	പരീക്ഷകൾ എന്നെ മെച്ചപ്പെടുത്താൻ സഹായിക്കുന്നു					
65.	ഏകാഗ്രത നഷ്ടപ്പെടുമ്പോൾ അത് വീണ്ടെടുക്കാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്					
66.	വിവരങ്ങൾ ഓർത്തിരിക്കാൻ വേണ്ടി പാഠപുസ്തകത്തിൽ അടിവരയിടുകയോ വൃത്തംവരയ്ക്കുകയോ ചെയ്യാറുണ്ട്					
67.	എന്തു പഠിക്കണം എന്ത് ഒഴിവാക്കണം എന്നതിനെപ്പറ്റി ഞാൻ തീരുമാനം എടുക്കാറുണ്ട്					
68.	പാഠപുസ്തകത്തിലെ വിവരങ്ങൾ ഞാൻ പരിശോധിക്കുകയും വിലയിരുത്തുകയും ചെയ്യാറുണ്ട്					
69.	ഒന്നിൽ കൂടുതൽ വഴികളുപയോഗിച്ച് ഞാൻ പഠിക്കാൻ ശ്രമിക്കാറുണ്ട്					

APPENDIX –V A

METACOGNITIVE AWARENESS INVENTORY (FINAL)

(English Version)

Each of the following statements expresses an awareness about the learning process, which particular people have. You have to express on a five point scale, the extent of agreement between the feeling expressed in each statement and your own feeling. The five points are

1. Always A
2. Very often VO
3. Sometimes S
4. Rarely R
5. Never N

You have to put a tick mark (✓) against columns of each statement, which best indicates how closely you agree or disagree. The only correct responses are those that are true for you.

No	Statements	A	VO	S	R	N
1	I think twice about a problem before taking a decision					
2	I compare previously learned things before learning a new content					
3	I always follow a strict time table for the studies					
4	I usually try to complete my learning assignments within the time schedule					
5	I often try to recollect the main idea of the content after learning					
6	I usually test myself that whether I am getting my goals					
7	I go through several alternatives of problem before answering it					
8	I understand my intellectual strength and weakness					
9	I always internalise an idea of what I have to learn before I start my learning					

10	I always try to know how well I did in a test					
11	Before beginning a task I frame specific goal in my mind					
12	I always concentrate more when I receive important information					
13	I know which information should get more importance during the learning process					
14	I organise information according to its importance before learning it					
15	I apply each strategy with a specific purpose while learning					
16	I learn best when I have familiarity with the topic					
17	I know teacher’s expectations about my learning					
18	I can remember information very well					
19	I always have control over how well I learn					
20	I periodically review important topics for better understanding					
21	I always check my knowledge about a topic before beginning to learn it					
22	I usually summarise the content after learning it					
23	I motivate myself when there is a need					
24	I know my usual learning strategies					
25	I know which strategy is suitable for me to learn a specific content					
26	I usually overcome my weakness by using my own strategies					
27	I give importance to the meaning and significance of the content					
28	By using my own examples I meaningfully process the information					
29	I am able to judge my own understanding					
30	I usually check whether I have attained the goal after finishing my learning					

31	For better memory and retention I take help of pictures and diagrams					
32	I often take intervals between my learning to check my understanding					
33	I like to translate new information into my own words					
34	When I fail to understand I change my learning strategy					
35	Careful reading of instruction in the beginning helps my learning					
36	I always link the new content to my previously learned content					
37	I will recheck my assumption when get confused					
38	I accomplish my goal by carefully organising the time					
39	I learn more when I am interested in the topic					
40	I often break a difficult and lengthy content in to smaller parts					
41	I always try to get an overall meaning rather than significant details					
42	I will try to learn again if the new information is not clear to me					
43	When I get confused I stop and reread the topic					
44	I am efficient in finding and rectifying my own weaknesses					
45	I always try to improve myself					
46	I consider my failures as milestones towards success					
47	I used to write short notes while studying a massive content					
48	I often use certain memory tricks to remember points which are difficult to memorise					
49	I always try to find out the reason behind my failures, so that I can improve next time by rectifying it					

50	I usually develop a deeper understanding of the content than applying rote learning					
51	Self motivation increases my interest in learning					
52	I usually try to apply learned material in daily life situations					
53	I often ask my seniors and bright students of the class about their study habits and try to adopt it wherever necessary					
54	I discuss the learning material with my class mates because it clarifies my assumptions					
55	I take more time for learning things which are difficult for my understanding					
56	I workout previous years question papers to check my understanding					
57	I always revise learned portions daily, weekly and monthly					
58	I know which study environment is good for me					
59	I always try to avoid those things which causes distractions to my study					
60	I like to read reference books					
61	I like to search internet for further information					
62	I try to get back on track when I lose concentration.					
63	I underline or circle information in the text to remember it.					
64	I decide what to study closely and what to ignore.					
65	I analyze and evaluate the information presented in the text.					
66	I try to use more than one way for learning something					

APPENDIX –V B

META COGNITIVE AWARENESS INVENTORY – FINAL

(Malayalam Version)

വിദ്യാർത്ഥിയുടെ പേര് :

സ്കൂളിന്റെ പേര് :

ക്ലാസ്സ് നമ്പർ :

ക്ലാസ്സ് :

താഴെകൊടുത്തിരിക്കുന്ന ഓരോ പ്രസ്താവനയും ഓരോ വ്യക്തിക്കും അവരവരുടെ പഠനപ്രക്രിയയെ പറ്റിയുള്ള അറിവ് സൂചിപ്പിക്കുന്നു. അതിനോടുള്ള നിങ്ങളുടെ പ്രതികരണം രേഖപ്പെടുത്തുന്നതിന് അഞ്ച് സൂചകങ്ങൾ നൽകിയിട്ടുണ്ട്.

1. എല്ലായ്പ്പോഴും A
2. പലപ്പോഴും VO
3. ചിലപ്പോൾ S
4. വിരളമായി R
5. ഒരിക്കലുമില്ല N

ഓരോ പ്രസ്താവനയോടുമുള്ള നിങ്ങളുടെ പ്രതികരണം അതതുകോളങ്ങളിൽ ടിക്ക് (✓) മാർക്ക് ഉപയോഗിച്ച് രേഖപ്പെടുത്തുക.

നമ്പർ	*പ്രസ്താവനകൾ*	SA	A	U	D	SD
1.	ഒരു പ്രശ്നത്തെപറ്റി വീണ്ടും വീണ്ടും ആലോചിച്ചതിനു ശേഷം മാത്രമേ ഞാൻ തീരുമാനത്തിലെത്താറുള്ളൂ					
2.	ഞാൻ മുമ്പ് പഠിച്ച അറിവുകളുമായി താരതമ്യം ചെയ്താണ് പുതിയ പാഠഭാഗം പഠിക്കാറുള്ളത്					
3.	എല്ലായ്പ്പോഴും ഒരു കൃത്യമായ ടൈംടേബിളനുസരിച്ചാണ് ഞാൻ പഠനം നടത്താറുള്ളത്					
4.	കൃത്യമായ സമയത്തുതന്നെ അസൈൻമെന്റുകൾ പൂർത്തിയാക്കാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്					
5.	ഒരു പാഠ്യഭാഗം പഠിച്ചതിനുശേഷം അതിന്റെ പ്രധാന ആശയം കൂടെക്കൂടെ ഓർത്തുനോക്കാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്					

6.	ഉദ്ദേശിച്ച ലക്ഷ്യത്തിൽ എത്തുന്നുണ്ടോ എന്ന് ഞാൻ പതിവായി പരിശോധിക്കാറുണ്ട്					
7.	ഒരു പ്രശ്നം നിർദ്ധാരണം ചെയ്യാനുള്ള പല മാർഗ്ഗങ്ങളെക്കുറിച്ച് ഞാൻ ആലോചിക്കാറുണ്ട്					
8.	എന്റെ ബൗദ്ധികമായ കഴിവുകളും കുറവുകളും ഞാൻ മനസ്സിലാക്കുന്നു					
9.	പഠനത്തിന്റെ തുടക്കത്തിൽ എന്താണ് പഠിക്കേണ്ടതെന്നതിനെപ്പറ്റി ഒരു ധാരണ ഉണ്ടാക്കാൻ എല്ലായ്പോഴും ഞാൻ ശ്രമിക്കാറുണ്ട്					
10.	പരീക്ഷ എത്രമാത്രം നന്നായി എഴുതി എന്നറിയാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്					
11.	ഒരു പ്രവർത്തി തുടങ്ങുന്നതിനു മുമ്പായി വ്യക്തമായ ലക്ഷ്യങ്ങൾ ഞാൻ വെയ്ക്കാറുണ്ട്					
12.	പ്രധാനപ്പെട്ട അറിവുനേടുന്ന സമയത്ത് ഞാൻ കൂടുതൽ ശ്രദ്ധ അതിനുവേണ്ടി കൊടുക്കാറുണ്ട്					
13.	പഠനപ്രക്രിയയിൽ ഏത് അറിവിനാണ് കൂടുതൽ പ്രാധാന്യം കൊടുക്കേണ്ടതെന്ന് എനിക്കറിയാം					
14.	പഠിക്കുന്നതിനുമുമ്പായി ഞാൻ അറിവുകളെ അതിന്റെ പ്രാധാന്യമനുസരിച്ച് തരം തിരിക്കാറുണ്ട്					
15.	നിശ്ചിതമായ ലക്ഷ്യത്തോടെയാണ് പഠിക്കുമ്പോൾ ഓരോ തന്ത്രങ്ങളും ഞാൻ പ്രയോഗിക്കാറുണ്ട്					
16.	സുപരിചിതമായ വിഷയങ്ങൾ എനിക്ക് നന്നായി പഠിക്കുവാൻ സാധിക്കാറുണ്ട്					
17.	എന്റെ പഠനത്തെക്കുറിച്ച് ടീച്ചർക്കുള്ള പ്രതീക്ഷകൾ എനിക്കറിയാം					
18.	എനിക്ക് വിവരങ്ങൾ നന്നായി ഓർത്തുവെയ്ക്കാൻ കഴിയാറുണ്ട്					
19.	നന്നായി പഠിക്കുന്ന കാര്യത്തിൽ എനിക്കു സ്വയം നിയന്ത്രണം ഉണ്ട്					
20.	പ്രധാനപ്പെട്ട ഭാഗങ്ങൾ പുനരവലോകനം ചെയ്യാൻ എനിക്കിഷ്ടമാണ്					
21.	ഒരു വിഷയം പഠിക്കുന്നതിനുമുമ്പായി അതിനെക്കുറിച്ചുള്ള അറിവ് ഞാൻ എല്ലായ്പോഴും പരിശോധിക്കാറുണ്ട്					

22.	ഒരു കാര്യം പഠിച്ചതിനുശേഷം ഞാൻ അത് സംക്ഷിപ്തരൂപത്തിലാക്കാറുണ്ട്					
23.	അവശ്യഘട്ടങ്ങളിൽ ഞാൻ സ്വയം പ്രചോദനം ഉൾക്കൊള്ളാറുണ്ട്					
24.	സ്ഥിരമായി ഞാൻ ഉപയോഗിക്കുന്ന പഠനതന്ത്രങ്ങളെപ്പറ്റി എനിക്ക് അറിവുണ്ട്					
25.	ഒരു പ്രത്യേകം പഠനഭാഗം പഠിക്കുന്നതിനായി ഏത് പഠനമാർഗ്ഗമാണ് എനിക്ക് അനുയോജ്യമെന്ന് എനിക്ക് അറിയാം					
26.	പഠനസംബന്ധമായ എന്റെ ബലഹീനതകൾ തരണം ചെയ്യാൻ സാധാരണ എന്റേതായ തന്ത്രങ്ങൾ ഞാൻ ഉപയോഗിക്കാറുണ്ട്					
27.	പാഠഭാഗത്തിന്റെ അർത്ഥത്തിനും പൊരുളിനുമാണ് ഞാൻ പ്രാധാന്യം കൊടുക്കുന്നത്					
28.	എന്റേതായ ഉദാഹരണങ്ങളിലൂടെ വിവരങ്ങളെ അർത്ഥപൂർണ്ണമായി ഞാൻ പാകപ്പെടുത്താറുണ്ട്					
29.	എന്റെ ധാരണയെ വിലയിരുത്താനുള്ള കഴിവ് എനിക്കുണ്ട്					
30.	പഠനത്തിനുശേഷം ഉദ്ദേശിച്ച ലക്ഷ്യത്തിലെത്തിയോ എന്ന് ഞാൻ പരിശോധിക്കാറുണ്ട്					
31.	പഠനത്തിനിടയ്ക്ക് ഇടവേളകൾ എടുത്ത് മനസ്സിലാക്കിയ കാര്യങ്ങളെപ്പറ്റി ഞാൻ അവലോകനം നടത്താറുണ്ട്					
32.	അറിവ് ഓർത്തിരിക്കുന്നതിനും അത് നിലനിർത്തുന്നതിനുംവേണ്ടി ചിത്രങ്ങളുടെയും ഡയഗ്രങ്ങളുടെയും സഹായം ഞാൻ സാധാരണയായി തേടാറുണ്ട്					
33.	പുതിയ ആശയങ്ങളെ എന്റേതായ രീതിയിലേക്ക് മാറ്റാൻ ശ്രമിക്കാറുണ്ട്					
34.	കാര്യങ്ങൾ മനസ്സിലാകാതെ വരുമ്പോൾ ഞാൻ പഠനതന്ത്രം മാറ്റാറുണ്ട്					
35.	തുടക്കത്തിൽ കൊടുക്കുന്ന നിർദ്ദേശങ്ങൾ ശ്രദ്ധയോടെ വായിക്കുന്നത് എന്റെ പഠനത്തെ സഹായിക്കാറുണ്ട്					

36.	പുതിയതായി പഠിക്കുന്ന പാഠഭാഗം മുമ്പ് പഠിച്ച പാഠ ഭാഗവുമായി എല്ലായ്പോഴും ഞാൻ ബന്ധപ്പെടുത്താറുണ്ട്					
37.	ഏതെങ്കിലും തരത്തിലുള്ള ആശയകുഴപ്പം നേരിടുമ്പോൾ എന്റെ ധാരണ ശരിയാണോ എന്ന് ഞാൻ പുനരവലോകനം ചെയ്യാറുണ്ട്					
38.	ലക്ഷ്യപ്രാപ്തിക്കുവേണ്ടി സമയത്തെ ഞാൻ ശ്രദ്ധയോടെ ക്രമീകരിക്കാറുണ്ട്					
39.	എനിക്ക് താല്പര്യമുള്ള കാര്യങ്ങൾ ഞാൻ കൂടുതൽ പഠിക്കാറുണ്ട്					
40.	ബുദ്ധിമുട്ടുള്ളതും കൂടുതലുള്ളതുമായ പാഠഭാഗത്തെ ചെറിയ ഭാഗങ്ങളാക്കി പഠിക്കാനാണ് എനിക്കിഷ്ടം					
41.	കൃത്യമായ വിശദാംശങ്ങളെക്കാളും മൊത്തമായ ഒരു ധാരണ കിട്ടാനാണ് ഞാൻ ശ്രമിക്കാറുള്ളത്					
42.	പുതിയ അറിവ് എനിക്ക് വ്യക്തമാകാത്തപ്പോൾ വീണ്ടും വീണ്ടും ഞാൻ അത് പഠിക്കാറുണ്ട്					
43.	അറിവ് പൂർണ്ണമായി ഉൾക്കൊള്ളാൻ കഴിയാതെ വരുമ്പോൾ നിർത്തിയിട്ട് ഞാൻ വീണ്ടും വീണ്ടും വായിക്കാറുണ്ട്					
44.	എന്റെ ബലഹീനതകൾ കണ്ടെത്താനും അത് തിരുത്താനും എനിക്ക് കഴിവുണ്ട്					
45.	സ്വയം മെച്ചപ്പെടാൻ (മെച്ചപ്പെടുത്താൻ) എല്ലായ്പോഴും ഞാൻ ശ്രമിക്കാറുണ്ട്					
46.	എന്റെ പരാജയങ്ങളെ വിജയത്തിലേക്കുള്ള ചവിട്ടുപടികളായിട്ടാണ് ഞാൻ കാണാറുള്ളത്					
47.	ബൃഹത്തായ പാഠഭാഗം പഠിക്കുമ്പോൾ ലഘുലേഖകൾ കുറിച്ചുവെയ്ക്കുന്ന ശീലം എനിക്കുണ്ട്					
48.	ഓർത്തെടുക്കാൻ ബുദ്ധിമുട്ടുള്ള കാര്യങ്ങൾക്ക് പലപ്പോഴും ഞാൻ ഓർക്കാനുള്ള ചില കുറുക്കുവഴികൾ പ്രയോഗിക്കാറുണ്ട്					
49.	എനിക്ക് പറ്റുന്ന വീഴ്ചകളുടെ കാരണം കണ്ടുപിടിച്ച് അടുത്തപ്രാവശ്യം അതുണ്ടാവാതെയിരിക്കാൻ ഞാൻ എല്ലായ്പോഴും ശ്രമിക്കാറുണ്ട്.					
50.	ഞാൻ സാധാരണയായി കാണാതെ പഠിക്കാതെ ആഴത്തിലുള്ള ധാരണ ഉണ്ടാക്കാനാണ് ശ്രമിക്കാറുള്ളത്					

51.	സ്വയം നടത്തുന്ന പ്രചോദനം പഠിക്കാനുള്ള എന്റെ ആഗ്രഹത്തെ വർദ്ധിപ്പിക്കാറുണ്ട്					
52.	പഠിച്ച ഭാഗങ്ങൾ സാധാരണയായി ഞാൻ നിത്യജീവിതത്തിൽ പ്രയോഗത്തിൽ വരുത്താറുണ്ട്					
53.	ഇടയ്ക്കിടെ ഞാൻ മുതിർന്ന കുട്ടികളോടും പഠനത്തിൽ മുൻപന്തിയിൽ നിൽക്കുന്ന കുട്ടികളോടും അവരുടെ പഠനശീലങ്ങളെക്കുറിച്ചു ചോദിക്കുകയും അവശ്യാനുസരണം ഉപയോഗിക്കാറും ഉണ്ട്					
54.	പാഠഭാഗങ്ങൾ ഞാൻ എന്റെ സുഹൃത്തുക്കളുമായി ഞാൻ ചർച്ച ചെയ്യാറുണ്ട് അത് എന്റെ അനുമാനങ്ങൾക്ക് കൂടുതൽ വ്യക്തത നൽകാറുണ്ട്.					
55.	എനിക്ക് മനസ്സിലാക്കാൻ ബുദ്ധിമുട്ടുള്ള പാഠഭാഗങ്ങൾക്ക് കൂടുതൽ സമയം ഞാൻ കൊടുക്കാറുണ്ട്					
56.	മുൻകാല ചോദ്യപേപ്പറുകൾക്ക് ഉത്തരം കണ്ടെത്തി ഞാൻ എന്റെ ധാരണയെപ്പറ്റി പരിശോധിക്കാറുണ്ട്					
57.	പഠിച്ച ഭാഗങ്ങൾ ഞാൻ ദിവസേന, ആഴ്ചതോറും, മാസംതോറും എന്ന രീതിയിൽ റിവിഷൻ നടത്താറുണ്ട്					
58.	എനിക്ക് അനുയോജ്യമായ പഠനാന്തരീക്ഷം ഏതെന്ന് എനിക്കറിയാം					
59.	എന്റെ പഠനത്തിനു തടസ്സം സൃഷ്ടിക്കുന്ന കാര്യങ്ങളെ എപ്പോഴും ഞാൻ ഒഴിവാക്കാൻ ശ്രമിക്കാറുണ്ട്					
60.	റഫറൻസ് ഗ്രന്ഥങ്ങൾ വായിക്കാൻ എനിക്കിഷ്ടമാണ്					
61.	കൂടുതൽ അറിവുനേടാൻ ഇന്റർനെറ്റ് നോക്കാൻ എനിക്കിഷ്ടമാണ്					
62.	ഏകാഗ്രത നഷ്ടപ്പെടുമ്പോൾ അത് വീണ്ടെടുക്കാൻ ഞാൻ ശ്രമിക്കാറുണ്ട്					
63.	വിവരങ്ങൾ ഓർത്തിരിക്കാൻ വേണ്ടി പാഠപുസ്തകത്തിൽ അടിവരയിടുകയോ വൃത്തം വരയ്ക്കുകയോ ചെയ്യാറുണ്ട്					
64.	എന്തു പഠിക്കണം എന്ത് ഒഴിവാക്കണം എന്നതിനെപ്പറ്റി ഞാൻ തീരുമാനം എടുക്കാറുണ്ട്					
65.	പാഠപുസ്തകത്തിലെ വിവരങ്ങൾ ഞാൻ പരിശോധിക്കുകയും വിലയിരുത്തുകയും ചെയ്യാറുണ്ട്					
66.	ഒന്നിൽ കൂടുതൽ വഴികളുപയോഗിച്ച് ഞാൻ പഠിക്കാൻ ശ്രമിക്കാറുണ്ട്					

APPENDIX -VI A

LESSON TRANSCRIPT BASED ON

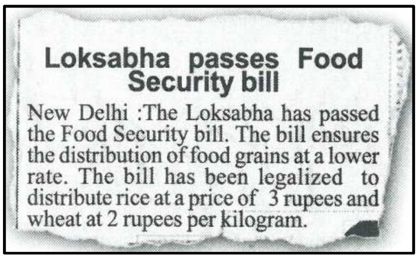
SOLO TAXONOMY 1

(English Version)

Name of the teacher	: Ravati N			
Name of the school	: N.S.S. Boy's High school,Perunnai	Std	: VIII	
Subject	: Biology	Duration	: 35 min	
Unit	: Let's regain our fields	Date	:	
Topic	: Food safety and crises in agriculture			

Content Overview :	Food safety
Content Analysis :	
Terms:	Food security, scarcity of food
Facts :	• Food security is the condition that ensures sufficient food for everyone. • Food security is necessary for a healthy and better society. • Increasing population, lack of knowledge, lack of fertile soil are the reasons for scarcity of food. • Scientific way of agriculture can solve the problems of food scarcity. • Food scarcity is the insufficiency in amount of food or shortage of food materials. • Food scarcity leads to poverty and malnutrition. • Population, food availability, food access and food use are the factors determining food security. • Population growth is the risk factor for food security.
Concepts:	
Major Concept :	**Food Security:** Food security is the situation that ensures sufficient food for everyone to lead a healthy life.

Learning Objectives	
Pre structural:	Pupils are unaware of food security, food scarcity and relationship between available land for cultivation, rice production and population.
Uni structural:	Understands food scarcity, problems related to scarcity of food and verifies relationship between available land for cultivation, rice production and population.
Multistructural:	Analyses food security bill, makes inferences by observing chart showing yearwise description of the relationship between available land for cultivation, rice production and population.
Relational:	Defines food security and identifies effects of food scarcity
Extended Abstract:	Suggests ways to ensure food and to regain fields.
Learning materials:	• Paper cuttings showing food security bill. • Chart showing year wise analysis of rice production, available land for cultivation, and population growth
Pre requisites:	• Food is necessary for a healthy and better living. • Food is obtained through agriculture. • Rice is one of among the main crop cultivated in Kerala. • Unavailability of food leads to malnutrition.

Content	Level of SOLO taxonomy	Evaluation
Introduction:	Teacher asks students about the condition of agriculture near their house. Students respond to the question by describing the pathetic condition of agriculture in their area. Teacher by stressing the need to cherish agriculture moves to the topic <u>food safety and crises in agriculture</u> (BB)	
Food security: and food scarcity:	**Pre structural:** Pupils are unaware of food security and food related issue. They don't know how to define food security and how to solve problems related to food scarcity.	
	Uni structural Teacher shows some pictures related to food scarcity. Students gets some knowledge about the problems related to scarcity of food	Defines food security. Understands FoodSecurity Bill. Suggest measures to ensure food security in the country.
	Multi structural Teacher shows a paper cutting describing food security bill passed by Loksabha.  **Loksabha passes Food Security bill** New Delhi :The Loksabha has passed the Food Security bill. The bill ensures the distribution of food grains at a lower rate. The bill has been legalized to distribute rice at a price of 3 rupees and wheat at 2 rupees per kilogram. Students realize that Government of India took an initiative to distribute food grains at lower rate for ensuring food to poor people.	

Content	Level of SOLO taxonomy	Evaluation
	Relational Teacher asks the students to form a definition for food security and gives necessary help. Students form a definition that food security is the situation, which ensures sufficient food for everyone, to lead a healthy life. **Extended Abstract** Teacher directs the students to suggest some ways to ensure food security in our country. Students give some suggestion to ensure food security in our country like the following. • Adopting scientific methods in agriculture • Ensuring food to all by law • Decreasing cost of production. • Ensuring Government incentives for farming. • Providing training in better agricultural practices etc.	
Relationship between area for cultivation, production of rice and population in different years.	**Pre structural** Students don't know the relationship between area for cultivation, production of rice and population growth in different years. **Uni structural** Teacher shows a chart depicting relationship between area available for cultivation, production of rice and population rate in different years	Compares and contrasts information given on the table. Suggest measures to regain the lost fields.

<table>
<tr><th>Content</th><th>Level of SOLO taxonomy</th><th>Evaluation</th></tr>
<tr><td></td><td>
CHART
<table>
<tr><th rowspan="2">Year</th><th colspan="2">Rice Production</th><th rowspan="2">Population in crores</th></tr>
<tr><th>Land for cultivation in lakh hectors</th><th>Production in lakh tones</th></tr>
<tr><td>1971</td><td>8.75</td><td>13.65</td><td>2.13</td></tr>
<tr><td>1991</td><td>5.5</td><td>10.6</td><td>2.91</td></tr>
<tr><td>2011</td><td>2.08</td><td>5.69</td><td>3.34</td></tr>
</table>
Students observe the chart and notices details written under each heading.
Multi structural
Teacher asks students to write the inferences evolved from the chart in their note book.
Students write their inference; as year goes up area available for cultivation of rice and its production also decreases but there is an increase in population.
Relational
Teacher directs students to discuss the effects of food scarcity in groups and report it in the class.
Students reports the following points

Increase in poverty rate
Dependence on other states for rice
Increasing price
Decrease in land available for cultivation

Extended abstract
Teacher asks students to suggest some ways to regain the fields.
Students say that by creating a culture of love towards agriculture we can regain the cultivable land.
</td><td></td></tr>
</table>

Review questions:

What is meant by food security?

What is meant by food scarcity?

State the need and significance of food security?

Follow up activity:

Collect information regarding the bill on food security passed by LokSabha

APPENDIX- VI B

LESSON PLAN TRANSCRIPT BASED ON SOLO TAXONOMY I

(Malayalam Version)

Name of the teacher : രേവതി എൻ

Name of the school : എൻ.എസ്.എസ്,ബോയ്സ് ഹൈസ്കൂൾ, പെരുന്ന Std : VIII

Duration : 35min

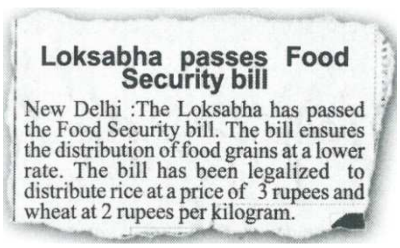
Subject : ജീവശാസ്ത്രം Date :

Unit : വീണ്ടെടുക്കാംവിളനിലങ്ങൾ

Topic : ഭക്ഷ്യസുരക്ഷ

Content Overview	ഭക്ഷ്യസുരക്ഷ
Content Analysis	
Terms:	ഭക്ഷ്യസുരക്ഷ, ഭക്ഷണദൗർലഭ്യം
Facts:	• എല്ലാവർക്കും ആവശ്യാനുസരണം ഭക്ഷണം ലഭ്യമാകുന്ന സാഹചര്യമാണ് ഭക്ഷ്യസുരക്ഷ. • ആരോഗ്യപൂർണമായ ഒരു നല്ല സമൂഹത്തിന് ഭക്ഷ്യസുരക്ഷ അത്യന്താപേഷിതമാണ്. • ജനസംഖ്യാവർദ്ധനവ്, അറിവില്ലായ്മ, വളക്കൂറുള്ള മണ്ണിന്റെ ലഭ്യതകുറവ്, കാലാവസ്ഥാവ്യതിയാനം, കീടങ്ങളുടെ ആക്രമണം എന്നിവ ഭക്ഷ്യദൗർലഭ്യതയ്ക്കു കാരണമാകുന്നു. • ശാസ്ത്രീയമായ കൃഷിരീതികളിലൂടെ ഭക്ഷ്യസുരക്ഷയുടെ പ്രശ്നങ്ങൾ പരിഹരിക്കാനാവും • ആവശ്യമായ അളവിൽ ഭക്ഷണം ലഭ്യമാകാതിരിക്കുക, ഭക്ഷണ പദാർത്ഥങ്ങളുടെ കുറവ് എന്നിവ ഭക്ഷ്യദൗർലഭ്യതയിലേക്ക് നയിക്കുന്നു. • ഭക്ഷ്യദൗർലഭ്യത ദാരിദ്ര്യത്തിനും, പോഷകാഹാരകുറവിനും കാരണമാകുന്നു. • ജനസംഖ്യ, ഭക്ഷ്യലഭ്യത, ഭക്ഷ്യഅഭിഗമ്യത, ഭക്ഷ്യോപയോഗം എന്നിവ ആണ് ഭക്ഷ്യദൗർലഭ്യതയെ നിർണയിക്കുന്ന ഘടകങ്ങൾ • ജനസംഖ്യാ വർദ്ധനവ് ഭക്ഷ്യസുരക്ഷയ്ക്ക് ഒരു വെല്ലുവിളിയാണ്.

Concepts	
Major concept:	***ഭക്ഷ്യസുരക്ഷ***:ഏവർക്കും ആരോഗ്യപരമായ ജീവിതം നയിക്കുന്നതിനു വേണ്ട ഭക്ഷണം ആവശ്യാനുസരണം ലഭ്യമാകുന്ന സാഹചര്യമാണ് ഭക്ഷ്യസുരക്ഷ.
Learning Objectives	
Pre structural :	Pupil are unaware of food security, food scarcity and relationship between available land for cultivation, rice production and population.
Uni structural:	Understands food scarcity,problems related to scarcity of food and verifies relationship between available land for cultivation, rice production and population.
Multistructural:	Analyses food security bill, make inferences by observing chart showing year wise description of the relationship between available land for cultivation, rice production and
Relational:	Defines food security and identifies effects of food scarcity
Extended Abstract:	Suggests ways to ensure food and to regain fields.
Pre requisites:	• ആരോഗ്യപരമായ നല്ലജീവിതം നയിക്കാൻ ഭക്ഷണം ആവശ്യമാണ്. • കൃഷിയിലൂടെ ഭക്ഷണം ലഭ്യമാകുന്നു. • കേരളത്തിലെ പ്രധാന കാർഷികവിളകളിൽ ഒന്നാണ് നെല്ല്. • ഭക്ഷണത്തിന്റെ ലഭ്യതക്കുറവ് അപപോഷണത്തിലേക്ക് നയിക്കുന്നു.
Learning materials:	• ഭക്ഷ്യസുരക്ഷാ ബില്ലിനെ പറ്റിയുള്ള പത്രവാർത്തകൾ • നെല്ലുൽപാദനം, കൃഷിയിടത്തിന്റെ വിസ്തൃതി, ജനസംഖ്യ എന്നിവയുടെ വാർഷിക വിശകലനം അടങ്ങിയ ചാർട്ട്.

Content	Learning Activity	Response/ Evaluation
	Introduction ടീച്ചർ കുട്ടികളോട് അവരുടെ വീടിനു ചുറ്റുപാടുള്ള കൃഷിയുടെ അവസ്ഥയെപറ്റി ചോദിക്കുന്നു.കുട്ടികൾ അവരുടെ വീടിനടുത്തുള്ള കൃഷിയുടെ ശോചനീയമായ അവസ്ഥയെപറ്റി പറയുന്നു.കൃഷിയെ അഭിവൃദ്ധിപ്പെടുത്തേണ്ടതിന്റെ ആവശ്യകതയ്ക്ക് ഊന്നൽ കൊടുത്തു കൊണ്ട് ഭക്ഷ്യസുരക്ഷയും കാർഷികമേഖലയിലെ പ്രതിസന്ധികളും എന്ന പാഠഭാഗത്തേയ്ക്ക് കടക്കുന്നു.	
ഭക്ഷ്യ സുരക്ഷ ഭക്ഷ്യ ദൗർലഭ്യത	**<u>Pre structural</u>** കുട്ടികൾക്ക് ഭക്ഷ്യസുരക്ഷയെ പറ്റിയും അനുബന്ധ പ്രശ്നങ്ങളെപറ്റിയും അറിയില്ല. അവർക്ക് ഭക്ഷ്യസുരക്ഷ നിർവ്വചിക്കാനും ഭക്ഷ്യദൗർലഭ്യതയെകൊണ്ടുള്ള പ്രശ്നങ്ങൾ പരിഹരിക്കാനുള്ള മാർഗ്ഗങ്ങളെക്കുറിച്ചും അറിയില്ല. **<u>Uni structural</u>** ഭക്ഷ്യദൗർലഭ്യതയെ കാണിക്കുന്ന ചിത്രങ്ങൾ ടീച്ചർ കാണിക്കുന്നു കുട്ടികൾക്ക് ഭക്ഷ്യദൗർലഭ്യതയെ കുറിച്ചുള്ള ഒരു ഏകദേശധാരണ കിട്ടുന്നു. **<u>Multistructural</u>** ടീച്ചർ ഭക്ഷ്യ സുരക്ഷാബില്ലിനെ കുറിച്ചുള്ളപത്ര വാർത്ത കാണിക്കുന്നു.  **Loksabha passes Food Security bill** New Delhi :The Loksabha has passed the Food Security bill. The bill ensures the distribution of food grains at a lower rate. The bill has been legalized to distribute rice at a price of 3 rupees and wheat at 2 rupees per kilogram. പാവപ്പെട്ടവർക്ക് കുറഞ്ഞനിരക്കിൽ ഭക്ഷ്യധാന്യങ്ങൾ ലഭ്യമാക്കുന്നതിനുള്ള ഇന്ത്യഗവൺമെന്റിന്റെ ഒരു തുടക്കമാണ് ഭക്ഷ്യസുരക്ഷാബിൽ എന്ന് കുട്ടികൾ മനസ്സിലാക്കുന്നു. **Relational** ടീച്ചർ കുട്ടികളോട് ഭക്ഷ്യസുരക്ഷയ്ക്ക് ഒരു നിർവ്വചനം രൂപീകരിക്കാൻ നിർദ്ദേശിക്കുകയും	ഭക്ഷ്യസുരക്ഷ നിർവ്വചിക്കുന്നു ഭക്ഷ്യസുരക്ഷാബില്ല് എന്തൊണന്നു മനസ്സിലാക്കുന്നു

Content	Learning Activity	Response/ Evaluation
	അതിനാവശ്യമായ സഹായം ചെയ്യുകയും ചെയ്യുന്നു. ആരോഗ്യകരമായ ജീവിതം നയിക്കുന്നതിനുവേണ്ടി ഭക്ഷണം ആവശ്യാനുസരണം ലഭ്യമാക്കുന്ന സാഹചര്യ മാണ് ഭക്ഷ്യസുരക്ഷ എന്ന് കുട്ടികൾ നിർവ്വചിക്കുന്നു. **Extended Abstract** നമ്മുടെ രാജ്യത്ത് ഭക്ഷ്യസുരക്ഷ ഉറപ്പാക്കുന്നതിനായി ചിലമാർഗ്ഗങ്ങൾ നിർദ്ദേശിക്കുവാൻ ടീച്ചർ ആവശ്യപ്പെടു ന്നു. കുട്ടികൾ താഴെകൊടുത്തിരിക്കുന്നതു പോലെയുള്ള നിർദ്ദേശങ്ങൾ മുന്നോട്ടുവയ്ക്കുന്നു. • ശാസ്ത്രീയമായ കൃഷിരീതികൾ സ്വീകരിക്കുക. • നിയമം വഴി എല്ലാവർക്കും ഭക്ഷണം ഉറപ്പാക്കുക. • ഉൽപാദനച്ചെലവ് കുറയ്ക്കുക. • കൃഷിചെയ്യുന്നതിനാവശ്യമായ ഗവൺമെന്റു തലത്തിലുള്ള പ്രോത്സാഹനം ഉറപ്പാക്കുക. • നല്ല കൃഷിരീതികളെക്കുറിച്ചടുള്ള പരിശീലന ക്ലാസ്സു കൾ സംഘടിപ്പിക്കുക.	
കൃഷിയിട ത്തിന്റെ വിസ്തൃതി, നെല്ലുൽപാദനം എന്നിവ തമ്മിലുള്ള ബന്ധം	**Pre structural** കുട്ടികൾക്ക് കൃഷിയിടത്തിന്റെ വിസ്തൃതി, നെല്ലുൽപാദനം, എന്നിവ തമ്മിലുള്ള ബന്ധം അറിയില്ല. **Unistructural** ടീച്ചർ കൃഷിയിടത്തിന്റെ വിസ്തൃതി, നെല്ലുൽപ്പാദനം, എന്നിവ തമ്മിലുള്ള ബന്ധം എന്നിവ കാണിക്കുന്ന ചാർട്ട് കുട്ടികൾക്ക് മുമ്പിൽ പ്രദർശിപ്പിക്കുന്നു	പട്ടികയായി ചാർട്ടിൽ കൊ ടുക്കുന്ന വിവ രങ്ങൾ താര തമ്യം ചെയ്യു ന്നു. കൃഷിയിടങ്ങൾ വീണ്ടെടുക്കു ന്നതിനുള്ള മാർഗ്ഗങ്ങൾ മുന്നോട്ടുവ യ്ക്കുന്നു.

Content	Learning Activity	Response/ Evaluation
	ചാർട്ട്	

വർഷം	നെല്ലുൽപാദനം		ജനസംഖ്യ (കോടി)
	കൃഷിയിടത്തിന്റെ വിസ്തൃതി	ഉൽപാദനം (ലക്ഷം ടണ്ണിൽ)	
1971	8.75	13.65	2.13
1991	5.5	10.6	2.91
2011	2.08	5.69	3.34

Multistructural

ചാർട്ട് നിരീക്ഷിച്ച് പട്ടികയിലെ വിവരങ്ങൾക്കനുസരിച്ച് നിഗമനങ്ങൾ രൂപീകരിച്ച് നോട്ടുബുക്കിൽ രേഖപ്പെടുത്തുവാൻ ആവശ്യപ്പെടുന്നു.

വർഷം മുന്നോട്ടു പോകുന്തോറും കൃഷിയിടത്തിന്റെ ആകെ വിസ്തൃതി, നെല്ലുപൽാദനം, എന്നിവ കുറയുകയും പക്ഷെ ജനസംഖ്യ കൂടുകയും ചെയ്യുന്നു എന്ന് കുട്ടികൾ നിഗമനത്തിലെത്തിചേരുന്നു.

Relational

ഭക്ഷ്യദൗർലഭ്യതയുടെ പ്രഭാവം കൊണ്ട് എന്തുണ്ടാകുന്നു എന്ന് ഗ്രൂപ്പിൽ ചർച്ച ചെയ്ത് ക്ലാസ്സിൽ അവതരിപ്പിക്കാൻ ടീച്ചർ കുട്ടികളോട് ആവശ്യപ്പെടുന്നു.
കുട്ടിതാഴെ പറയുന്ന വസ്തുതകൾ അവതരിപ്പിക്കുന്നു.

- ദാരിദ്ര്യം വർധിക്കുന്നു.
- അരിക്കു വേണ്ടി മറ്റ് സംസ്ഥാനങ്ങളെ ആശ്രയിക്കേണ്ടി വരുന്നു.
- വിലകൂടുന്നു.
- കൃഷിയിടത്തിന്റെ ആകെ വിസ്തൃതി കുറയുന്നു.

Extended Abstract

വിളനിലങ്ങൾ വീണ്ടെടുക്കാനാവശ്യമായ ചില മാർഗ്ഗങ്ങൾ മുന്നോട്ടു വയ്ക്കാൻ ടീച്ചർ കുട്ടികളോട് ആവശ്യപ്പെടുന്നു.

കൃഷിയോടുള്ള സ്നേഹം ഒരു സംസ്കാരമായി മാറ്റിയാൽ നഷ്ടപ്പെട്ട കൃഷിയിടങ്ങൾ നമുക്ക് വീണ്ടെടുക്കാൻ പറ്റുമെന്ന് കുട്ടികൾ പറയുന്നു.

Review

- ഭക്ഷ്യ സുരക്ഷ എന്നാൽഎന്ത്?
- ഭക്ഷ്യ സുരക്ഷയുടെ ആവശ്യകത എന്ത്?
- ഭക്ഷ്യ സുരക്ഷബില്ലിനെ കുറിച്ച് കൂടുതൽ വിവരങ്ങൾ ശേഖരിക്കുക.

Follow up Activity

ലോകസഭ പാസാക്കിയ ഭക്ഷ്യസുരക്ഷ ബില്ലിനെ കുറിച്ച് കൂടുതൽ വിവരങ്ങൾ ശേഖരിക്കുക

APPENDIX -VII A

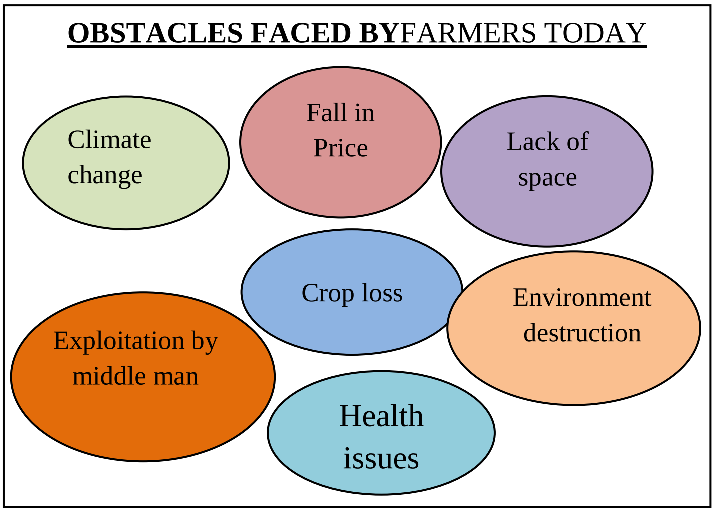
LESSON TRANSCRIPT BASED ON SOLO TAXONOMY 2

(English Version)

Name of the teacher	: Ravati N			
Name of the school	: N.S.S. Boy's High School,Perunnai		Std	: VIII
Subject	: Biology		Duration	: 35 min
Unit	: Let's regain our fields		Date	:
Topic	: Crises in the Agricultural sector			

Content over view:	Crises in the agricultural sector, soil fertility, pH of the soil and soil testing.
Content Analysis	
Terms :	Crises in the agricultural sector, essential element, pH of the soil.
Facts :	• Problems in agriculture can be solved by scientific approach. • Elements required for the proper growth of plants are known as essential elements. • Essential elements are made naturally available in the soil through decomposition by micro organism • Climate change, fall in price, cost of production etc. are some obstacles faced by farmers. • pH is an important factor that influence the growth of plants. • Presence of elements in the soil and the pH value can be identified by soil testing. • Organisms like bacteria, fungi, algae, termite, earth worm etc. can help to increase soil fertility.
Concept	
Major concept:	Crises in agriculture: Farmers face many obstacles like, climate change, fall in price, cost of production, crop loss,

	lack of space, exploitation by middle man which leads to crises in agriculture
Instructional objectives	
Pre structural:	Pupil is unaware of the obstacles faced by farmers, essential elements, and soil testing.
Uni structural:	Students list factors responsible for crisis in agriculture and gives more examples for essential elements present in the soil.
Multi structural:	Pupil recognizes all the factors responsible for crisis in agriculture and notes essential elements present in the soil.
Relational:	Students combine and analyses factors responsible for crisis in agriculture and tries to suggest measures to the problems. Students recognizes the significance of pH in the soil.
Extended Abstract:	Children suggests various ways to solve the crisis in agriculture and reports how bio fertilizers are better than chemical fertilizers
Pre requisites :	Problems faced by farmers Climate change adversely affects agriculture. Agriculture land is decreasing Chemical fertilizers destroy quality of the soil.
Learning Material:	Chart showing problems in the agricultural sector Chart on soil testing

Content	Levels of SOLO Taxonomy	Evaluation
Crisis in agriculture sector	**Introduction** Teacher tells a story about few farmers who complained about their loss in agriculture to their king. They said they had to face many challenges to get a better yield. King understood the difficulties of farmers and put many policies to solve those problems for ensuring food to all people in this country. After saying this story teacher moves to the topic crises in agriculture (BB). **Pre structural** Children don't know how to describe crisis in agricultural sector. **Uni structural** Teacher asks students to list some factors responsible for crisis in agriculture. Students list some factors like drought, storm, plant diseases etc. **Multistructural** Teacher shows a chart showing main reasons behind crisis in agriculture. **CHART**  	Explains obstacles faced by farmers. Suggests measures to solve current problems in agriculture.

<table>
<tr><th>Content</th><th>Levels of SOLO Taxonomy</th><th>Evaluation</th></tr>
<tr><td></td><td>Students recognize the factors behind crises in agriculture and note it in their note book.

Relational

Teacher asks students to combine the factors responsible for crisis in the agricultural sector and describe how it affects agriculture.

Students points out how exploitation of middle man, climate change, fall in price, cost of production, and crop loss lack of space, environmental destruction and health issues affect agriculture.

Extended Abstract

Teacher asks students suggest some ways to solve the crisis in agriculture.

Pupil suggests many ways to come out of the problems related to crisis in agriculture and reports it in the class.</td><td></td></tr>
<tr><td>Fertile soil as the basis of food security</td><td>Pre structural
Pupil are unaware about the essential element and testing of soil
Uni structural
Teacher asks students to write few names of elements present in the soil, which help in plant growth
Pupil writes Nitrogen, carbon, Hydrogen etc.
Multistructural
Teacher displays chart about essential elements necessary for the growth of plant.
CHART
Soil Testing
• Essential elements are required for proper growth of plants
• Carbon, Hydrogen, Nitrogen and Phosphorous and examples
• pH of the soil influences the growth of pants
• Presence of elements in the soil and pH can be identified by soil testing</td><td>Defines essential elements.
Lists essential elements.
Suggests measures to regain fertility of the soil.</td></tr>
</table>

Content	Levels of SOLO Taxonomy	Evaluation
	Pupil observes chart and notes essential element necessary for proper plant growth. **Relational** Teacher explains how pH of the soil affects plant growth and microorganisms decompose the essential elements to make them available for the plants. Teacher asks students how one could know the presence of essential elements in the soil. Students recognize the significance of pH in the soil and its effect on plant growth. They say that, it is by testing of soil, we can find out the presence of elements and pH in the soil. **Extended Abstract** Teacher asks the students to discuss on how composition of the soil affects growth of crops and why it is said that natural fertilizers are better than chemical fertilizers. Pupils after discussion reports that there are many organisms present in the soil like bacteria, fungi, algae, termites, earthworm which help in decomposition of essential elements and increases soil fertility. All those natural organisms are destroyed by use of chemical fertilizers which destroy the natural soil texture and microorganisms present in the soil.	

Review of Questions:

- What are essential elements?
- What is the importance of the soil testing?
- What is the significance of pH in soil fertility?

Follow up activity: Visit an agriculture office and collect information about soil testing

APPENDIX - VII B

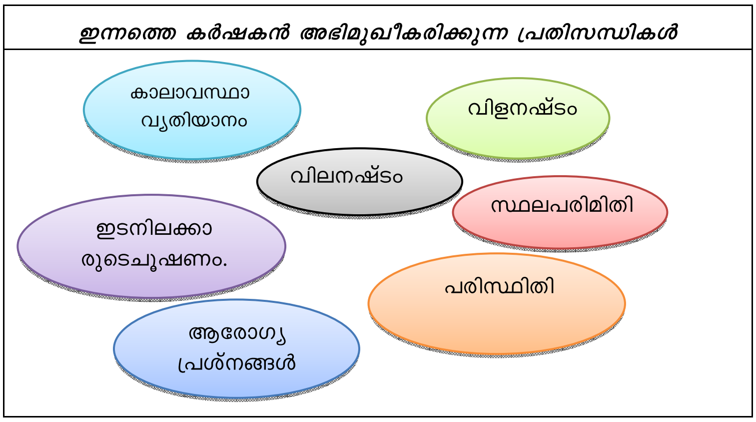
LESSON PLAN TRANSCRIPT BASED ON SOLO TAXONOMY II

(Malayalam Version)

Name of the teacher	: രേവതി എൻ		
Name of the school	: എൻ.എസ്.എസ്,ബോയ്സ്	Std :	VIII
	ഹൈസ്കൂൾ, പെരുന്ന	Duration :	35min
Subject	: ജീവശാസ്ത്രം	Date :	
Unit	: വീണ്ടെടുക്കാം വിളനിലങ്ങൾ		
Topic	: കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ		

Content Overview:	കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ, മണ്ണിന്റെ ഫലപൂഷ്ടി, മണ്ണിന്റെ pH മണ്ണുപരിശോധന.
Content Analysis Terms:	കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ, അവശ്യമൂലകങ്ങൾ, മണ്ണിന്റെ pH
Facts:	• ശാസ്ത്രീയ സമീപനത്തിലൂടെ കാർഷിക മേഖലയുടെ പ്രശ്നങ്ങൾ പരിഹരിക്കാനാകും • സസ്യങ്ങളുടെ ത്വരിതമായ വളർച്ചയ്ക്കാവശ്യമായ മൂലകങ്ങളെ അവശ്യമൂലകങ്ങൾ എന്നു പറയുന്നു. • സൂക്ഷമജീവികളുടെ വിഘടിപ്പിക്കൽ പ്രവർത്തനം മൂലം അവശ്യമൂലകങ്ങൾ മണ്ണിൽ പ്രകൃതിദത്തമായി ലഭ്യമാണ്. • സസ്യങ്ങളുടെ വളർച്ചയെ സ്വാധീനിക്കുന്ന ഒരു പ്രധാന ഘടകം ആണ് മണ്ണിന്റെ pH • മണ്ണുപരിശോധനയിലൂടെ മണ്ണിലെ മൂലകങ്ങളുടെ സാന്നിധ്യവും, pH മൂല്യവും തിരിച്ചറിയാം. • ബാക്ടീരിയകൾ, കുമിളുകൾ, ആൽഗകൾ, ചിതൽ, മണ്ണിര തുടങ്ങിയ ജീവിവർഗ്ഗങ്ങൾ മണ്ണിന്റെ ഫലപൂഷ്ടി വർദ്ധിപ്പിക്കുവാൻ സഹായിക്കുന്നുണ്ട്.

Concepts **Major concept:**	***<u>കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ</u>:*** കൃഷിക്കാർ അഭിമുഖീകരിക്കേണ്ടി വരുന്ന കാലാവസ്ഥാവ്യതിയാനം, വിലനഷ്ടം, ഉൽപാദനച്ചെലവ്, വിളനഷ്ടം, സ്ഥലപരിമിതി, ഇടനിലക്കാരുടെ ചൂഷണം എന്നീ പ്രതിബന്ധങ്ങൾ കാർഷിക മേഖലയിലെ പ്രതിസന്ധിക്കു കാരണമാകുന്നു.
Pre Structural :	Pupil are unaware of the obstacles faced by farmers, essential elements, and soil testing.
UniStructural :	Students list factors responsible for crisis in agriculture and gives more examples for essential elements present in the soil.
MultiStructural:	Pupil recognizes all the factors responsible for crisis in agriculture and notes essential elements present in the soil.
Relational:	Students combine and analyses factors responsible for crisis in agriculture and tries to suggest measures to the problems. Students recognize the significance of pH in the soil.
Extended Abstract:	Children suggests various ways to solve the crisis in agriculture and reports how bio fertilizers are better than chemical fertilizers
Pre Requisites:	• കർഷകൻ അഭിമുഖീകരിക്കുന്ന പ്രശ്നങ്ങൾ • കാലാവസ്ഥാവ്യതിയാനം കൃഷിയെ പ്രതികൂലമായി ബാധിക്കുന്നു. • കൃഷിയിടത്തിന്റെ അളവ് കുറഞ്ഞു കൊണ്ടിരിക്കുന്നു. • രാസവളങ്ങൾ മണ്ണിന്റെ മേന്മ തർക്കുന്നു.
Learning Materials:	• കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ കാണിക്കുന്ന ചാർട്ട്. • മണ്ണ് പരിശോധനയുടെ വിവരങ്ങൾ അടങ്ങിയ ചാർട്ട്

	Learning Activity	Response/ Evaluation
കാർഷിക മേഖലയിലെ പ്രതിസന്ധി കൾ	**Introduction** കൃഷിയിലുണ്ടായ നഷ്ടത്തെ കുറിച്ച് രാജാവിനോട് പരാതിപ്പെടാൻ എത്തിയ കുറച്ച് കർഷകരുടെ കഥ പറഞ്ഞു കൊണ്ട് ടീച്ചർ പാഠം തുടങ്ങുന്നു. നല്ല വിളവു കിട്ടാൻ വേണ്ടി അവർക്ക് പല വെല്ലുവിളികളും നേരിടേണ്ടി വന്നു എന്നവർ പറഞ്ഞു. കർഷർക്കുണ്ടായ ബുദ്ധിമുട്ട് മനസ്സിലാക്കി അവരുടെ പ്രശ്നങ്ങൾക്ക് പരിഹാരം കണ്ട് എല്ലാവർക്കും ഭക്ഷണം ഉറപ്പാക്കുന്നതിനായി ചില കാര്യപരിപാടികൾ നടപ്പാക്കി. കഥയ്ക്കു ശേഷം ടീച്ചർ കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ എന്ന പാഠഭാഗത്തേയ്ക്കു കടക്കുന്നു. **Pre Structural** കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ എന്തൊക്കെയാണെന്ന് വിശദീകരിക്കാൻ കുട്ടികൾക്കറിയില്ല. **Uni Structural** കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾക്കു കാരണമായ ഘടകങ്ങളെ പട്ടികപ്പെടുത്താൻ ടീച്ചർ കുട്ടികൾക്ക് നിർദേശം നൽകുന്നു വരൾച്ച, കൊടുങ്കാറ്റ്, വിളകൾക്കുണ്ടാകുന്ന രോഗങ്ങൾ എന്നിവയാണ് ഘടകങ്ങൾ എന്ന് കുട്ടികൾ പറയുന്നു. **Multi structural** കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ കാണിക്കുന്ന ചാർട്ട് ടീച്ചർ ക്ലാസ്സിൽ പ്രദർശിപ്പിക്കുന്നു. ***ചാർട്ട്***  	കൃഷിക്കാർ അഭിമുഖീകരിക്കുന്ന പ്രതിബന്ധങ്ങൾ വിശദീകരിക്കുന്നു. പ്രതിസന്ധികൾ തരണം ചെയ്യാനുള്ള മാർഗ്ഗങ്ങൾ മുന്നോട്ടു വയ്ക്കുന്നു

	Learning Activity	Response/ Evaluation
	Relational കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾക്ക് കാരണമായ ഘടകങ്ങളെ ഏകോപിപ്പിച്ച് അവ എങ്ങനെയാണ് കൃഷിയെ ബാധിക്കുന്നതെന്ന് വിശദീകരിക്കാൻ നിർദ്ദേശിക്കുന്നു. ഇടനിലക്കാരുടെ ചൂഷണം, കാലാവസ്ഥാവ്യതിയാനം, വിലനഷ്ടം, ഉൽപാദനച്ചെലവ്, സ്ഥലപരിമിതി, പരിസ്ഥിതിനാശം, ആരോഗ്യ പ്രശ്നങ്ങൾ എന്നിവ ആണ് കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾക്ക് കാരണം എന്ന് കുട്ടികൾ പറയുന്നു. **Extended Abstract** കാർഷികമേഖലയിലെ പ്രതിസന്ധി തരണം ചെയ്യാൻ ചില മാർഗ്ഗങ്ങൾ നിർദ്ദശിക്കാൻ ടീച്ചർ കുട്ടികളോടാവശ്യപ്പെടുന്നു. കുട്ടികൾ പല തരത്തിലുള്ള മാർഗ്ഗങ്ങൾ നിർദ്ദേശിക്കുകയും അവ ക്ലാസ്സിൽ അവതരിപ്പിക്കുകയും ചെയ്യുന്നു.	
വളക്കൂറുള്ള മണ്ണ് ഭക്ഷ്യ സുരക്ഷയ്ക്ക് ആധാരം	**Pre Structural** അവശ്യമൂലകങ്ങളെ പറ്റിയും മണ്ണ് പരിശോധനയെകുറിച്ചും കുട്ടികൾക്ക് അറിയില്ല. **Un Structural** മണ്ണിൽ അടങ്ങിയിട്ടുള്ള ചില മൂലകങ്ങളുടെ പേര് എഴുതാൻ കുട്ടികളോട് ടീച്ചർ ആവശ്യപ്പെടുന്നു. കുട്ടികൾ കാർബൺ, ഹൈഡ്രജൻ, നൈട്രജൻഎന്ന്എഴുതുന്നു. **Multi structural** അവശ്യമൂലകങ്ങളെ പറ്റിയുള്ള വിവരങ്ങൾ അടങ്ങിയ ചാർട്ട് ടീച്ചർ ക്ലാസ്സിൽ അവതരിപ്പിക്കുന്നു.	അവശ്യമൂലകങ്ങൾ എന്താണെന്ന് നിർവ്വചിക്കുന്നു. അവശ്യമൂലകങ്ങളുടെ ലിസ്റ്റ് തയ്യാറാക്കുന്നു മണ്ണിന്റെ ഫലപുഷ്ടി വീണ്ടെടുക്കാൻ മാർഗ്ഗങ്ങൾ നിർദ്ദേശിക്കുന്നു

	Learning Activity	Response/ Evaluation
	ചാർട്ട് ***മണ്ണുപരിശോധന*** ❖ സസ്യങ്ങളുടെ നല്ലരീതിയിലുളള വളർച്ചയ്ക്ക് അവശ്യമൂലകങ്ങൾ അത്യന്താപേക്ഷിതമാണ്. ❖ കാർബൺ, ഹൈഡ്രജൻ, നൈട്രജൻ, ഫോസ്ഫറസ്, എന്നിവ അവശ്യമൂലകങ്ങൾക്ക് ഉദാഹരണങ്ങളാണ്. ❖ മണ്ണിന്റെ pH ചെടിയുടെ വളർച്ചയെ സ്വാധീനിക്കുന്നു. ❖ മണ്ണു പരിശോധനയിലൂടെ മണ്ണിന്റെ pH മൂല്യം, വിവിധ മൂലകങ്ങളുടെ സാനിധ്യം എന്നിവ അറിയാം. ചാർട്ട് നിരീക്ഷിച്ചതിനു ശേഷം സസ്യങ്ങളുടെ വളർച്ചയ്ക്കാവശ്യമായ അവശ്യമൂലകങ്ങൾ ഏതൊക്കെയാണെന്ന് നോട്ടുബുക്കിൽ എഴുതുക. **Relational** മണ്ണിന്റെ pHമൂല്യം സസ്യവളർച്ചയെ എങ്ങനെ സ്വാധീനിക്കുന്നു എന്ന് ടീച്ചർ വിശദീകരിക്കുന്നു. സൂക്ഷ്മജീവികൾ അവശ്യമൂലകങ്ങളെ വിഘടിപ്പിച്ച് ചെടികൾക്ക് ലഭ്യമാക്കുന്നു. മണ്ണിലെ അവശ്യമൂലകങ്ങളുടെ സാന്നിദ്ധ്യം എങ്ങനെ നമുക്ക് തിരിച്ചറിയാം എന്ന് കുട്ടികളോട് ടീച്ചർ ചോദിക്കുന്നു. ചെടിയുടെ വളർച്ചയെ മണ്ണിന്റെ pHഎങ്ങനെ സ്വാധീനിക്കുന്നു എന്ന് ടീച്ചർ കുട്ടികളോട് വിശദീകരിക്കുന്നു. മണ്ണുപരിശോധനയിലൂടെ അവശ്യമൂലകങ്ങളുടെ സാന്നിദ്ധ്യം അറിയാൻ കഴിയും. **Extended Abstract** മണ്ണിന്റെ ഘടന വിളകളുടെ വളർച്ചയെ എങ്ങനെ സ്വാധീനിക്കുന്നു എന്നും, ജൈവവളങ്ങൾ രാസവളങ്ങളെക്കാൾ നല്ലതാണെന്ന് എന്തുകൊണ്ടാണ് പറയുന്നതെന്നും ചർച്ച ചെയ്യാൻ കുട്ടികളോട് ആവശ്യപ്പെടുന്നു. ചർച്ചയ്ക്ക് ശേഷം കുട്ടികൾ മണ്ണിലെ ബാക്ടീരിയകൾ കുമിളകൾ, ആൽഗകൾ, ചിതൽ, മണ്ണിര തുടങ്ങിയ ജീവികൾ അവശ്യമൂലങ്ങളുടെ വിഘടനത്തിനു സഹായിക്കുന്നുണ്ടെന്നും അങ്ങനെ മണ്ണിന്റെ ഫലപൂഷ്ടി മെച്ചപ്പെടുത്തുന്നുണ്ടെന്നും പറയുന്നു. രാസവളപ്രയോഗംമൂലം ഈ ജീവികൾ ഒക്കെ നശിച്ചു പ്രകൃതിദത്തമായ മണ്ണിന്റെ ഘടനമാറ്റുകയും ചെയ്യുന്നു.	

Review

- എന്താണ് അവശ്യമൂലകങ്ങൾ?
- മണ്ണു പരിശോധനയുടെ പ്രാധാന്യംഎന്ത് ?
- മണ്ണിന്റെ ഫലപുഷ്ടി pHമൂല്യവുമായി എങ്ങനെ ബന്ധപ്പെട്ടിരിക്കുന്നു.

Follow up Activity

കൃഷിഓഫീസ് സന്ദർശിച്ച് മണ്ണുപരിശോധനയെ പറ്റിയുള്ള വിവരങ്ങൾ ശേഖരിക്കുക.

APPENDIX - VIII A

LESSON TRANSCRIPT BASED ON REVISED BLOOM'S TAXONOMY-I

(English Version)

Name of the teacher : Ravati.N

Name of the school : N.S.S. Boy's High school, Perunnai Std : VIII

Subject : Biology Duration : 35 min

Unit : Let's regain our fields Date :

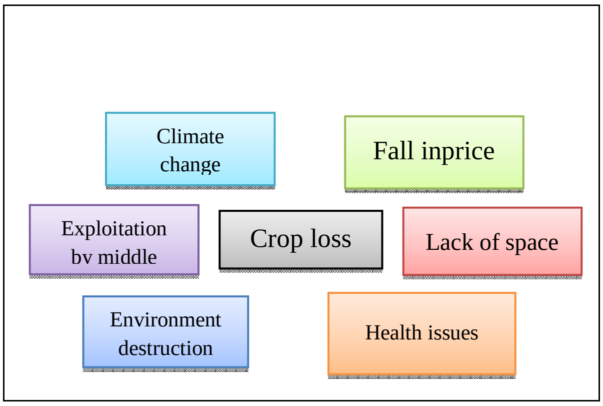
Topic : Crises in the Agricultural sector

Content over view:	Crises in the agricultural sector, soil fertility, pH of the soil and soil testing.
Content Analysis:	
Terms :	Crises in the agricultural sector, essential element, pH of the soil.
Facts :	Problems in agriculture can be solved by scientific approach. • Elements required for the proper growth of plants are known as essential elements. • Essential elements are made naturally available in the soil through decomposition by micro organism • Climate change, fall in price, cost of production etc are some obstacles faced by farmers. • pH is an important factor that influence the growth of plants. • Presence of elements in the soil and the pH value can be identified by soil testing. • Organisms like bacteria, fungi, algae, termite, earth worm etc. can help to increase soil fertility.

Concept	
Major concept :	Crises in agriculture: Farmers face many obstacles like, climate change, fall in price, cost of production, crop loss, lack of space, and exploitation by middle man which leads to crises in agriculture.
Instructional Objectives	
Remembering :	Pupil remembers, Fertile soil is essential for agriculture. Problems related to agriculture. Nutrients present in the soil. Scientific methods can solve problems associated with agriculture
Understanding :	Pupil understands, Influence of pH on plant growth. Soil testing to identity fertility of the soil. Significance of essential elements for the proper growth of the plant. Use of scientific methods to solve crises in agriculture.
Applying :	Pupil applies knowledge in, Testing fertility of the soil. Practicing scientific methods in agriculture. Applying manure according to the deficiency of nutrients in the soil. Making bio fertilizers like vermicompost.
Analysing :	Pupil analyses, Presence of essential elements in the soil. Manures which contain essential elements. Effect of pH on plant growth. Various scientific methods and its applicability.

Evaluating :	Pupil evaluates, Quality of soil. Problems faced by agriculture sector. Present methods of agriculture.
Creating :	Pupils creates, Making vermicompost. Testing soil with pH paper and determining its quality. Making a collague showing the obstacles faced by farmers. Visiting an agriculture office and collecting information about soil testing. Proposes new solutions for the problems faced by farmers.
Previous Knowledge :	Climate change adversely affects agriculture. Agriculture land is decreasing. Chemical fertilizers destroy quality of the soil.
Learning Materials :	Picture of agricultural land. Chart showing factors affecting crises in agriculture. Roots of leguminous plants.

Content	Objective/specification	Learning Experiences	Evaluation
Preparation		Teacher shows some pictures of agricultural land which are flourished by numerous crops with full of greenery. After the beautiful sights, teacher shows some pictures of barren agricultural lands and asks students to note the differences between the two pictures. After summarizing student's responses teacher moves to the topic crises in agricultural sector (BB).	
Presentation Crises in the agricultural sector	Remembering/ recalls favourable times in agriculture, recognizes differences in past and present agriculture. Understanding/ interprets chart, expresses factors causing crises in agriculture.	Teacher shows a chart showing different factors affecting agriculture. Teacher explains how climate change, exploitation by middle man, fall in price, cost of production, crop loss, lack of space, environmental destruction and health issues affect agriculture.	What are the factors causing crises in agriculture?

Content	Objective/specification	Learning Experiences	Evaluation
	Applying/ locates problem in agriculture sector expresses ideas to solve these problems	**CHART** 	
Essential elements	Understanding /cites examples of essential elements, defines essential elements. Applying/ arrives at a generalization that essential elements are necessary for plant growth. Understanding/ sees relationship between pH of the soil and plant growth. Analysis/locates parts of leguminous root	Teacher explains that elements required for the proper growth of plants are known as <u>essential elements</u> (BB). <u>Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorous, Potassium, Sulphur</u> (BB) are examples of essential elements in the soil. Teacher shows roots of leguminous plants to identity the presence of microorganisms and its effect on plant growth.	What are essential elements? Give examples
pH of the soil		Teacher explains that pH of the soil affect soil fertility. It can be tested in a laboratory.Optimum pH value is necessary for plant growth. Alkaline and acidic soil hinders plant growth. Teacher shows some pH papers used as pH indicators.	What is the effect of pH on plant growth?

Review Questions

1. What are the obstacles faced by farmers
2. Why soil testing is important in agriculture
3. What are essential elements
4. Give examples of essential elements.

Assignment: Write an assignment on essential elements.

APPENDIX- VIII B

LESSON PLAN TRANSCRIPT BASED ON BLOOM'S TAXONOMY 1
(Malayalam Version)

Name of the teacher : രേവതി എൻ

Name of the school : എൻ.എസ്.എസ്, ബോയ്സ് ഹൈസ്കൂൾ, പെരുന്ന Std : VIII

Duration : 35min

Subject : ജീവശാസ്ത്രം Date :

Unit : വീണ്ടെടുക്കാം വിളനിലങ്ങൾ

Topic : ഭക്ഷ്യ സുരക്ഷ

Content Overview	ഭക്ഷ്യസുരക്ഷ
Content Analysis:	
Terms:	ഭക്ഷ്യസുരക്ഷ, ഭക്ഷണ ദൗർലഭ്യം
Facts:	• എല്ലാവർക്കും ആവശ്യാനുസരണം ഭക്ഷണം ലഭ്യമാകുന്ന സാഹചര്യമാണ് ഭക്ഷ്യസുരക്ഷ. • ആരോഗ്യപൂർണമായ ഒരു നല്ല സമൂഹത്തിന് ഭക്ഷ്യസുരക്ഷ അത്യന്താപേഷിതമാണ്. • ജനസംഖ്യാവർദ്ധനവ്, അറിവില്ലായ്മ, വളക്കൂറുള്ള മണ്ണിന്റെ ലഭ്യതകുറവ്, കാലാവസ്ഥാ വ്യതിയാനം, കീടങ്ങളുടെ ആക്രമണം എന്നിവ ഭക്ഷ്യദൗർലഭ്യതയ്ക്കു കാരണമാകുന്നു. • ശാസ്ത്രീയമായ കൃഷിരീതികളിലൂടെ ഭക്ഷ്യസുരക്ഷയുടെ പ്രശ്നങ്ങൾ പരിഹരിക്കാനാവും • ആവശ്യമായ അളവിൽ ഭക്ഷണം ലഭ്യമാകാതിരിക്കുക, ഭക്ഷണ പദാർത്ഥങ്ങളുടെ കുറവ് എന്നിവ ഭക്ഷ്യദൗർലഭ്യതയിലേക്ക് നയിക്കുന്നു. • ഭക്ഷ്യദൗർലഭ്യത ദാരിദ്രത്തിനും, പോഷകാഹാരക്കുറവിനും കാരണമാകുന്നു • ജനസംഖ്യ, ഭക്ഷ്യലഭ്യത, ഭക്ഷ്യഅഭിഗമ്യത ഭക്ഷ്യോപയോഗം എന്നിവ ആണ് ഭക്ഷ്യദൗർലഭ്യതയെ നിർണയിക്കുന്ന ഘടകങ്ങൾ • ജനസംഖ്യാ വർദ്ധനവ് ഭക്ഷ്യസുരക്ഷയ്ക്ക് ഒരു വെല്ലുവിളിയാണ്.

Concepts	
Major concept:	ഭക്ഷ്യസുരക്ഷ ഏവർക്കും ആരോഗ്യപരമായ ജീവിതം നയിക്കുന്നതിനു വേണ്ട ഭക്ഷണം ആവശ്യാനുസരണം ലഭ്യമാകുന്ന സാഹചര്യമാണ് ഭക്ഷ്യസുരക്ഷ.
Learning Objectives	
Knowledge Domain:	Pupil develops knowledge in the above mentioned terms and facts, Relationship between population growth, availability of agricultural land and rice production Population growth as a threat to food security. Ways to solve problems related to food security.
Process Domain:	Pupil develops process skills in, Observing news on food security bill in the newspaper. Drawing inferences from the newspaper report about the need and importance of food security. Discussion on food security of Kerala. Listing different factors causing food scarcity during group discussion.
Application Domain:	Pupil applies knowledge in, Sensitizing society about the importance of food security. Observing production of different crops. Using barren land for agriculture. Starting agriculture at home and school premises.
Attitude Domain:	Pupil develops positive attitude towards, The need to ensure food security in our country. Responsibility of every citizen to promote agriculture. To minimize the misuse of food. Practising scientific ways of doing agriculture.
Creativity Domain:	Pupil develops creativity in, Organizing a street play on the needs to ensure food security. Writing an article on the importance of food security. Creating an album on various methods of agriculture.

Pre requisites:	• ആരോഗ്യപരമായ നല്ലജീവിതം നയിക്കാൻ ഭക്ഷണം ആവശ്യമാണ്. • കൃഷിയിലൂടെ ഭക്ഷണം ലഭ്യമാകുന്നു. • കേരളത്തിലെ പ്രധാന കാർഷികവിളകളിൽ ഒന്നാണ് നെല്ല്. • ഭക്ഷണത്തിന്റെ ലഭ്യതക്കുറവ് അപപോഷണത്തിലേക്ക് നയിക്കുന്നു.
Learning materials:	• ഭക്ഷ്യ സുരക്ഷാബില്ലിനെ പറ്റിയുള്ള പത്രവാർത്തകൾ • നെല്ലുൽപ്പാദനത്തിന്റെ വാർഷിക കണക്ക് കാണിക്കുന്ന ചാർട്ട്. • കർഷകൻ അഭിമുഖീകരിക്കുന്ന പ്രതിസന്ധികൾ കാണിക്കുന്ന ചാർട്ട്.

Content	**Objectives/ specifications**	**Learning Experiences**	**Evaluation**
Preparation	Remembering/ മഹാബലിയുടെ കഥ ഓർത്തു കൊണ്ട് ഇന്നു നില നിൽക്കുന്ന ഭക്ഷ്യ ലഭ്യതയെ താരതമ്യം ചെയ്യുന്നു	പണ്ടു കാലത്ത് കേരളത്തിലെ രാജാവായിരുന്ന മഹാബലി യേയും അദ്ദേഹത്തിന്റെ ഭര ണത്തിന്റെയും കഥ പറഞ്ഞു കൊണ്ട് ടീച്ചർ തുടങ്ങുന്നു. അക്കാലത്ത് ഒന്നിനും ഒരു ബുദ്ധിമുട്ടും ഇല്ലായിരുന്നു. സ്വർഗ്ഗത്തിലെന്ന പോലെ എല്ലാം സമൃദ്ധമായ കാലഘട്ട മായിരുന്നു. ജനങ്ങൾക്ക് ആവ ശ്യമായ ഭക്ഷണവും ആരോ ഗ്യവും ഉണ്ടായിരുന്നു.	

Content	**Objectives/ specifications**	**Learning Experiences**	**Evaluation**
		ഇന്നത്തെ കേരളത്തിന്റെ ന്നത്തെ അവസ്ഥയും മഹാബലിയുടെ അവ സ്ഥയും മഹാബലി യുടെ ഭരണകാലത്തെ കേരളത്തിന്റെ അവസ്ഥ യുമായി താരതമ്യം ചെയ്യുക, എന്നിങ്ങനെ യുള്ള ചിലചോദ്യങ്ങൾ ടീച്ചർ ചോദിക്കുന്നു. കുട്ടികളുടെ ഉത്തര ങ്ങൾക്കു ശേഷം <u>ഭക്ഷ്യ സുരക്ഷയുടെ (BB)</u> ആവശ്യകതയെ കുറിച്ച് ടീച്ചർ ചർച്ച ചെയ്യുന്നു.	
Presentation ഭക്ഷ്യസുര ക്ഷാ ബിൽ	Understanding/ ഭക്ഷ്യസുരക്ഷാ ബിൽ വിശകലനം ചെയ്ത് പ്രധാന പ്പെട്ട ആശയങ്ങൾ വിശദീകരിക്കു ന്നു.	ലോകസഭയിൽ ഭക്ഷ്യ സുരക്ഷാബില്ലിന് അനു മതി നല്കി എന്ന പത്ര വാർത്ത ടീച്ചർ, കുട്ടി കൾക്ക് കാണിച്ചു കൊ ടുക്കുന്നു. കുറഞ്ഞ നി രക്കിൽ ഭക്ഷ്യധാന്യവി തരണം ഈ ബില്ലിൽ ഉറപ്പുനൽകുന്നു. മൂന്നുരൂപ നിരക്കിൽ അരിയും രണ്ടുരൂപ നിര ക്കിൽ ഗോതമ്പും വിത രണം ചെയ്യാൻ നിയമപ രമായി വ്യവസ്ഥ ചെയ്യു ന്നു.	ഭക്ഷ്യസുരക്ഷാ ബിൽ വിശദീകരി ക്കുക

<table>
<tr><th>Content</th><th>Objectives/ specifications</th><th>Learning Experiences</th><th>Evaluation</th></tr>
<tr><td>ഭക്ഷ്യ ദൗർലഭ്യ തയുടെ കാരണ ങ്ങൾ</td><td>Understanding/ ഭക്ഷ്യദൗർലഭ്യത യുടെ കാരണ ങ്ങൾ പട്ടികപ്പെടു ത്തുന്നു.
Understanding/ ഭക്ഷ്യദൗർലഭ്യത നിർവ്വചിക്കുന്നു.
Applying/ ഭക്ഷ്യദൗർലഭ്യ തയ്ക്കു പ്രതിവി ധികൾമുൻകൂട്ടി പറയുന്നു</td><td>ഭക്ഷ്യദൗർലഭ്യതയുടെ കാരണങ്ങൾ പറ യാൻ ടീച്ചർ കുട്ടികൾക്ക് നിർദ്ദേശം നൽകുന്നു. കുട്ടികളുടെ ഉത്തര ങ്ങൾക്കു ശേഷം ടീച്ചർ, <u>ഭക്ഷ്യദൗർലഭ്യ തയുടെ കാരണങ്ങൾ, ജനസംഖ്യാ അശാസ്ത്രീയമായ കൃഷിരീതികൾ, കാലാവസ്ഥാ വ്യതിയാനം,</u> (BB) എന്നിവ ആണെന്ന് വിശദമാക്കുന്നു.</td><td>ഭക്ഷ്യദൗർലഭ്യത യുടെ കാരണ ങ്ങൾ എന്തൊക്കെയാ ണ്?</td></tr>
<tr><td>ഭക്ഷ്യ സുരക്ഷ</td><td>Understanding/ ജനസംഖ്യ, നെല്ലുൽപ്പാദനം, കൃഷിയിട ത്തിന്റെ വിസ്തൃതി എന്നിവ തമ്മിലുള്ള ബന്ധം താര തമ്യം ചെയ്യുന്നു.
Applying/ഭക്ഷ്യ ദൗർലഭ്യതയി ലേക്കു നയി ക്കുന്ന കാരണ ങ്ങളെ സമർത്ഥിച്ചു കാണിക്കുന്നു.</td><td>കൃഷിയിടത്തിന്റെ വിസ്തൃതി, നെല്ലുൽപാദനം, ജനസംഖ്യ എന്നിവ കാണിക്കുന്ന ചാർട്ട് ടീച്ചർ ക്ലാസ്സിൽ പ്രദർശിപ്പിക്കുന്നു.
ചാർട്ട്
<table>
<tr><td>വർഷം</td><td colspan="2">നെല്ലുൽപാദനം</td><td>ജനസംഖ്യ (കോടി)</td></tr>
<tr><td></td><td>കൃഷിയിട ത്തിന്റെ വിസ്തൃതി</td><td>ഉൽപാ ദനം (ലക്ഷം) ടണ്ണിൽ)</td><td></td></tr>
<tr><td>1971</td><td>8.75</td><td>13.65</td><td>2.13</td></tr>
<tr><td>1991</td><td>5.5</td><td>10.6</td><td>2.91</td></tr>
<tr><td>2011</td><td>2.08</td><td>5.69</td><td>3.34</td></tr>
</table>
ടീച്ചർകുട്ടികളോട്താഴെകൊടുത്തിരി ക്കുന്ന ചോദ്യങ്ങൾക്ക്ചാർട്ട് നോക്കിഉത്തരംകണ്ടെത്താൻ പറയു ന്നു.</td><td>കൃഷിയിട ത്തിന്റെ വിസ്തൃ തി, നെല്ലുൽപാദ നം, ജനസംഖ്യ എന്നിവ തമ്മിലുള്ള ബന്ധം എന്ത്</td></tr>
</table>

Content	Objectives/ specifications	Learning Experiences	Evaluation
	Evaluating/ ഭക്ഷ്യദൗർലഭ്യത യുടെ കാരണങ്ങ ളോടുള്ള അനിഷ്ടം പ്രക ടിപ്പിക്കുന്നു.	***<u>സൂചകങ്ങൾ</u>*** • 1971 മുതൽ 2011 വരെകൃഷിയിട ത്തിന്റെ വിസ്തൃതിയിൽ ഉണ്ടായി ട്ടുള്ളമാറ്റം എന്താണ്? • ഈ കാലയളവിൽ നെല്ലുൽപ്പാദ നവും ജനസംഖ്യാവളർച്ചയും തമ്മി ലുള്ള ബന്ധത്തിൽ എന്തു പ്രവണ തയാണ് കാണാൻ കഴിയുന്നത്? • ഇതൊരു അഭിലക്ഷണിയമായ പ്രവ ണതയാണോ? ചോദ്യങ്ങൾക്കുശേഷം മുകളിൽ പറഞ്ഞ കാര്യങ്ങൾ എങ്ങിനെ ബന്ധ പ്പെട്ടിരിക്കുന്നു എന്ന് ടീച്ചർ വിശദീകരി ക്കുന്നു.	

Review Questions *:*

- ഭക്ഷ്യസുരക്ഷാബിൽ എന്നാലെന്ത്?
- ഭക്ഷ്യസുരക്ഷയ്ക്കു നിർവ്വചനം നൽകുക.
- ജനസംഖ്യാവർദ്ധനവ്, ഭക്ഷ്യദൗർലഭ്യതയ്ക്ക് കാരണമാകുന്നതെങ്ങനെയെന്ന് വിശദീകരിക്കുക.
- കൃഷിക്കാർ നേരിടുന്ന പ്രതിസന്ധികൾ ഏതൊക്കെയാണ്?

Assignment :

കൃഷിനാശത്തിന്റെ ചിത്രങ്ങൾ ശേഖരിച്ച് അത് തരണം ചെയ്യാനുള്ള മാർഗ്ഗങ്ങൾ നിർദ്ദേശിക്കുക.

APPENDIX - IX A

LESSON TRANSCRIPT BASED ON REVISED BLOOM'S TAXONOMY-1I

(English Version)

Name of the teacher : Ravati.N

Name of the school : N.S.S. Boy's High school, Perunnai Std : VIII

Subject : Biology Duration : 35 min

Unit : Let's regain our fields Date :

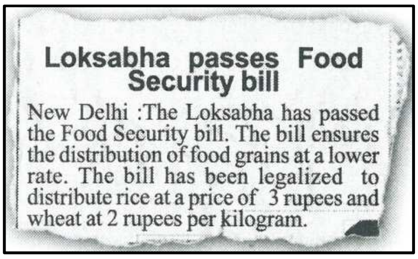
Topic : Food safety and crises in agriculture

Content Overview :	Food safety
Content Analysis :	
Terms:	• Food security, Scarcity of food
Facts :	• Food security is the condition that ensures sufficient food for everyone. • Food security is necessary for a healthy and better society. • Increasing population, lack of knowledge, lack of fertile soil are the reasons for scarcity of food. • Scientific way of agriculture can solve the problems of food scarcity. • Food scarcity is the insufficiency in amount of food / shortage of food materials. • Foods scarcity leads to poverty and malnutrition. • Population, food availability, food access and food use are the factors determining food security. • Food growth is the risk factor for food security.
Concepts:	
Major Concept :	**Food Security**: Food security is the situation that ensures sufficient food for everyone to lead a healthy life.

Instructional Objectives: **Remembering:**	Pupil remembers, Food security bill passed at Loksabha, Reasons of poverty. Population of India. Various crops cultivated in India. Factors affecting agriculture.
Understanding:	Pupil understands, Food security bill passed by Loksabha which ensures distribution of food grains at lower rate. Food security is the situation that ensures sufficient food for everyone. Scientific methods for ensuring food security. Poverty and malnutrition due to food security. Population growth as a threat to food security.
Applying :	Pupil applies knowledge in, Giving awareness about the importance of food security to the society Observing production rates of different crops. Using barren land for cultivation. Analysing laws on food security. Starting agriculture in school premises and at home.
Analyzing :	Pupil analyses, Problems related to food security. Problems faced by farmers. Factors responsible for food security in India. Effects of population growth on food security.

Evaluating :	Pupil evaluates, Scientific methods used to solve the problems in agriculture sector. Factors related to depletion of agricultural land. Effect of population on food security. Obstacles faced by farmers today.
Previous Knowledge :	Food is necessary for a healthy and better living. Food is obtained through agriculture. Rice is the main crop cultivated in Kerala. Unavailability of food leads to malnutrition.
Learning Materials :	Paper cuttings showing food security bill Chart showing year wise analysis of rice production Chart showing obstacles faced by farmers

Content	Objectives/Specifications	Learning Experiences	Evaluation
Preparation	Remembering story of Mahabali, student recognizes the present situation of food availability.	Teacher narrates the story of Mahabali, Raja of Kerala and his rule. There was no scarcity for anything. At that time Kerala was a country, which is prosperous similar to heaven. People are well fed and healthy. Teacher asks certain questions like; can you compare present situation in Kerala with the ancient one when Mahabali was the ruler? After the answers of students; teacher discusses about the need and importance of <u>food security.</u> (BB).	
<u>Presentation</u> Food Security Bill.	Understanding/verifies food security bill, describes main points of the bill.	Teacher: Shows the newspaper cutting which shows approval of <u>Food Security Bill</u>(BB) in Loksabha	Explain food security bill.

<table>
<tr>
<td>Reasons for scarcity of food.</td>
<td>Understanding /lists reasons for food scarcity.</td>
<td>.

Loksabha passes Food Security bill
New Delhi :The Loksabha has passed the Food Security bill. The bill ensures the distribution of food grains at a lower rate. The bill has been legalized to distribute rice at a price of 3 rupees and wheat at 2 rupees per kilogram.

The bill ensures the distribution of food grains at a lower rate. This bill has been legalized to distribute rice at a price 3 Rs. And wheat at 2 Rs. per kilogram.

Teacher: Asks students to tell reasons for food scarcity (BB).</td>
<td>What are the reasons for food scarcity?</td>
</tr>
<tr>
<th>Content</th>
<th>Objectives/Specifications</th>
<th>Learning Experiences</th>
<th>Evaluation</th>
</tr>
<tr>
<td>Food Security</td>
<td>Application / predicts solution for solving the problem of food scarcity.

Understanding/
Compares and contrasts relationship between population, area available for cultivation and rate of production of rice.

Applying / establishes relationship between factors leading to food scarcity.

Evaluating / expresses dislike towards causes behind food scarcity.</td>
<td>After gathering answers, teacher explains that uncontrolled population growth, unscientific agricultural methods, climate change (BB) etc. affects food scarcity.

Teacher displays a chart showing area of land for cultivation, production of rice and population

CHART
<table>
<tr><td rowspan="2">Year</td><td colspan="2">Rice production</td><td rowspan="2">Population (in crores)</td></tr>
<tr><td>Area of land for Cultivation (in lakh hectors)</td><td>Production (in lakh tonnes)</td></tr>
<tr><td>1971</td><td>8.75</td><td>13.65</td><td>2.13</td></tr>
<tr><td>1991</td><td>5.5</td><td>10.6</td><td>2.91</td></tr>
<tr><td>2011</td><td>2.08</td><td>5.69</td><td>3.34</td></tr>
</table>
Teacher asks students, following questions.</td>
<td>How population and area available for cultivation affects food scarcity?</td>
</tr>
</table>

Content	Objectives/Specifications	Learning Experiences	Evaluation
		• What happened to the area of agricultural fields from the year 1971 to 2011? • What tendency observed in rice production and population growth during the period. • Is the tendency desirable? Why? After the question answer session teacher explains how the factors are related.	

Review:

1. What is food security bill?
2. Define food security.
3. Explain how population growth affects food scarcity?
4. What are the obstacles faced by farmers?

Assignment:

Collect pictures showing agricultural loss and suggest ways to overcome it.

APPENDIX - IX B
LESSON PLAN TRANSCRIPT BASED ON
BLOOM'S TAXONOMY II
(Malayalam Version)

Name of the teacher : രേവതി എൻ

Name of the school : എൻ.എസ്.എസ്,ബോയ്സ് ഹൈസ്കൂൾ,പെരുന്ന Std : VIII

Duration : 35min

Subject : ജീവശാസ്ത്രം Date :

Unit : വീണ്ടെടുക്കാം വിളനിലങ്ങൾ

Topic : കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ

Content Overview	കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ, മണ്ണിന്റെ ഫലപൂഷ്ടി, മണ്ണിന്റെ pH, മണ്ണുപരിശോധന.
Content Analysis	
Terms:	കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ,അവശ്യമൂലകങ്ങൾ, മണ്ണിന്റെpH.
Facts:	• ശാസ്ത്രീയ സമീപനത്തിലൂടെ കാർഷികമേഖലയുടെ പ്രശ്നങ്ങൾ പരിഹരിക്കാനാകും • സസ്യങ്ങളുടെ ത്വരിതമായ വളർച്ചയ്ക്കാവശ്യമായ മൂലകങ്ങളെ അവശ്യമൂലകങ്ങൾ എന്നു പറയുന്നു. • സൂക്ഷ്മജീവികളുടെ വിഘടിപ്പിക്കൽ പ്രവർത്തനം മൂലം അവശ്യമൂലകങ്ങൾ മണ്ണിൽ പ്രകൃതിദത്തമായി ലഭ്യമാണ്. • കാലാവസ്ഥാ വ്യതിയാനം, വിലനഷ്ടം, ഉൽപ്പാദനച്ചെലവ്, എന്നിങ്ങനെ ഒരുപാട് പ്രതിസന്ധികൾ കർഷകർ നേരിടുന്നുണ്ട്. • സസ്യങ്ങളുടെ വളർച്ചയെ സ്വാധീനിക്കുന്ന ഒരു പ്രധാന ഘടകം ആണ് മണ്ണിന്റെ pH. • മണ്ണുപരിശോധനയിലൂടെ മണ്ണിലെമൂലകങ്ങളുടെ സാന്നിധ്യവും, pH മൂല്യവും തിരിച്ചറിയാം. • ബാക്ടീരിയകൾ, കുമിളുകൾ, ആൽഗകൾ, ചിതൽ, മണ്ണിര തുടങ്ങിയ ജീവിവർഗ്ഗങ്ങൾ മണ്ണിന്റെ ഫലപൂഷ്ടി, വർദ്ധിപ്പിക്കുവാൻ സഹായിക്കുന്നുണ്ട്.

Concepts	
Major concept:	***കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ :***കൃഷിക്കാർ അഭിമുഖീകരിക്കേണ്ടി വരുന്ന കാലാവസ്ഥാ വ്യതിയാനം, വിലനഷ്ടം, ഉൽപാദനച്ചെലവ്, വിളനഷ്ടം, സ്ഥലപരിമിതി, ഇടനിലക്കാരുടെ ചൂഷണം എന്നീ പ്രതിബന്ധങ്ങൾ കാർഷികമേഖലയിലെ പ്രതിസന്ധിക്ക് കാരണമാകുന്നു.
Instructional Objectives	
Remembering:	Pupil remembers, Fertile soil is essential for agriculture. Problems related to agriculture. Nutrients present in the soil. Scientific methods can solve problems associated with agriculture
Understanding:	Pupil understands, Influence of pH on plant growth. Soil testing to identity fertility of the soil. Significance of essential elements for the proper growth of the plant. Use of scientific methods to solve crises in agriculture.
Applying:	Pupil applies knowledge in, Testing fertility of the soil. Practicing scientific methods in agriculture. Applying manure according to the deficiency of nutrients in the soil. Making bio fertilizers like vermicompost.

Analysing:	Pupil analyses, Presence of essential elements in the soil. Manures which contain essential elements. Effect of pH on plant growth. Various scientific methods and its applicability.
Evaluating:	Pupil evaluates, Quality of soil. Problems faced by agriculture sector. Present methods of agriculture.
Creating:	Pupils creates, Making vermicompost. Testing soil with pH paper and determining its quality. Making a collague showing the obstacles faced by farmers. Visiting an agriculture office and collecting information about soil testing. Proposes new solutions for the problems faced by farmers.
Pre requisites:	• ആരോഗ്യപരമായ നല്ലജീവിതം നയിക്കാൻ ഭക്ഷണം ആവശ്യമാണ് • കൃഷിയിലൂടെ ഭക്ഷണം ലഭ്യമാകുന്നു • കേരളത്തിലെ പ്രധാന കാർഷികവിളകളിൽ ഒന്നാണ് നെല്ല് • ഭക്ഷണത്തിന്റെ ലഭ്യതക്കുറവ് അപപോഷണത്തിലേക്ക് നയിക്കുന്നു
Learning materials:	• കൃഷിയിടത്തിന്റെ ചിത്രം. • കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ കാണിക്കുന്ന ചാർട്ട്. • പയറുചെടിയുടെ വേരുകൾ

Content	Objectives/ specifications	Learning Experiences	Evaluation
Preparation		പച്ചനിറത്തിൽ തഴച്ചുവളർന്നു നിൽക്കുന്ന പലതരത്തിലുള്ള കൃഷികളുടെ ചിത്രങ്ങൾ ടീച്ചർ കുട്ടികൾക്ക് കാണിച്ചുകൊടുക്കുന്നു. ഭംഗിയുള്ള കാഴ്ചകൾക്കു ശേഷം തരിശായിട്ട് ഉപേക്ഷിച്ചിട്ടിരിക്കുന്ന കൃഷിയിടങ്ങളുടെ ചിത്രങ്ങളും ടീച്ചർ കാണിച്ചു കൊടുക്കുന്നു. ഈ രണ്ടുതരം ചിത്രങ്ങളും തമ്മിലുള്ള വ്യത്യാസം രേഖപ്പെടുത്തുവാൻ പറയുന്നു. കുട്ടികളുടെ അഭിപ്രായങ്ങൾ ചുരുക്കികൊണ്ട് ടീച്ചർ <u>കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ</u>(BB) എന്ന പാഠഭാഗത്തേയ്ക്ക് കടക്കുന്നു.	
Presentation കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ	Remembering/ കൃഷിക്കനുകൂലമായ സാഹചര്യങ്ങളെ കുട്ടികൾ ഓർത്തെടുക്കുന്നു. പണ്ടു കാലത്തെയും ഇപ്പോളത്തെയും കൃഷിയുടെ അവസ്ഥകൾ തമ്മിലുള്ള വ്യത്യാസം തിരിച്ചറിയുന്നു.	കൃഷിയെ പ്രതികൂലമായിബാധിക്കുന്ന വിവിധ ഘടകങ്ങൾ കാണിക്കുന്ന ചാർട്ട് അദ്ധ്യാപിക കുട്ടികൾക്ക് കാണിച്ചുകൊടുക്കുന്നു. കാലാവസ്ഥാ-വ്യതിയാനം, ഇടനിലക്കാരുടെ ചൂഷണം വിലനഷ്ടം, ഉൽപാദനച്ചെലവ്, വിളനഷ്ടം, സ്ഥലപരിമിതി, പരിസ്ഥിതിനാശം, ആരോഗ്യ പ്രശ്നങ്ങൾ എന്നിവ കൃഷിയെ ബാധിക്കുന്നു.	കാർഷികമേഖലയിലെ പ്രതിസന്ധികളുടെ കാരണങ്ങൾ ഏതൊക്കെ?

Content	Objectives/ specifications	Learning Experiences	Evaluation
	understanding/ ചാർട്ട് വ്യാഖ്യാനം ചെയ്തതിനു ശേഷം കാർഷിക മേഖലയിലെ പ്രതിസന്ധിക ളുടെ കാരണ ങ്ങൾ സ്പഷ്ടമാ ക്കുന്നു. Applying/കൃഷി അഭിമുഖീകരി ക്കുന്ന പ്രശ്ന ങ്ങൾ കണ്ടെത്തു കയും പരിഹാര മാർഗ്ഗങ്ങൾ വ്യക്തമാക്കു കയും ചെയ്യുന്നു.	***ചാർട്ട്*** ***ഇന്നത്തെ കർഷകൻ അഭിമുഖീകരിക്കുന്ന പ്രതിസന്ധികൾ*** കാലാവസ്ഥാ വ്യതിയാനം വിളനഷ്ടം വിലനഷ്ടം ഇടനിലക്കാ രുടെചൂഷണം. സ്ഥലപരിമിതി. പരിസ്ഥിതി നാശം. ആരോഗ്യ പ്രശ്നങ്ങൾ.	
അവശ്യമൂലക ങ്ങൾ	Understanding/ അവശ്യമൂലക ങ്ങൾക്ക് ഉദാഹര ണങ്ങൾ കണ്ടെ ത്തുന്നു. അവശ്യ മൂലകങ്ങളെ നിർവ്വചി ക്കുന്നുApplying/ സസ്യവളർച്ച യ്ക്ക്ആവശ്യമൂല കങ്ങൾ അത്യന്താ പേഷിതമാണെ ന്നുള്ളധാരണയി ലേക്ക്എത്തുന്നു.	സസ്യങ്ങളുടെ ശരിയായവളർച്ച യ്ക്കാവശ്യമായ മൂലകങ്ങളെ അവ ശ്യമൂലകങ്ങൾ (BB) എന്നാണ് പറയുന്നത്. കാർബൺ, ഹൈഡ്രജൻ, ഓക്സിജൻ,നൈട്ര ജൻ, ഫോസ്ഫറസ്, പൊട്ടാസ്യം, സൾഫർ എന്നിവ അവശ്യമൂലക ങ്ങൾക്ക് ഉദാഹരണങ്ങളാണ്. പയറുചെടിയുടെ വേര് കാണിച്ചു കൊണ്ട് അതിലെ സൂഷ്മജീവിക ളുടെ സാന്നിദ്ധ്യവും സസ്യവളർച്ച യിൽ അവയ്ക്കുള്ള പങ്കും വ്യക്ത മാക്കുന്നു.	എന്താണ് അവശ്യമൂല കങ്ങൾ? അവശ്യമൂല കങ്ങൾക്ക് ഉദാഹരണ ങ്ങൾ പറയുക

Content	Objectives/ specifications	Learning Experiences	Evaluation
മണ്ണിന്റെ pH മൂല്യം	Understanding/ മണ്ണിന്റെ pH മൂല്യവും സ സ്യവർച്ചയും തമ്മിലുള്ള ബന്ധം അറിയുന്നു. Analyzing / പയറു ചെടിയുടെ വിവിധ ഭാഗങ്ങൾ നിരീക്ഷിച്ച് കണ്ടെത്തുന്നു.	pH മൂല്യം മണ്ണിന്റെ ഫലപൂഷ്ടിയെ എങ്ങനെ സ്വാധീനിക്കുന്നു എന്ന് ടീച്ചർ വിശദീകരിക്കുന്നു.അനുകൂലമായ pH മൂല്യം (BB) സസ്യവളർച്ചയ്ക്ക് ആവശ്യമാണ്. മണ്ണിന്റെ ക്ഷാര സ്വഭാവവും അമ്ലഗുണവും സസ്യ വളർച്ചയെ ബാധിക്കുന്നു. pH സുചകങ്ങൾ pH പേപ്പറും ടീച്ചർ ക്ലാസ്സിൽ പ്രദർശിപ്പിക്കുന്നു.	സസ്യവളർച്ചയെ pH എങ്ങനെയാണ് ബാധിക്കുന്നത്

Review Questions :

- കൃഷിക്കാർ അഭിമുഖീകരിക്കുന്ന പ്രതിസന്ധികൾ ഏവ?
- മണ്ണു പരിശോധയ്ക്ക് കൃഷിയിലുള്ള പ്രധാന്യം എന്ത്?
- എന്താണ് അവശ്യമൂലകങ്ങൾ?
- അവശ്യമൂലകങ്ങൾക്ക് ഉദാഹരണം നൽകുക.

Follow up activity

അവശ്യമൂലകങ്ങളെ പറ്റി ഒരു അസൈൻമെന്റ് തയ്യാറാക്കുക

APPENDIX - X A

LESSON TRANSCRIPT BASED ON
Mc CORMACK AND YAGER'S TAXONOMY 1
(English Version)

Name of the teacher	: Ravati.N			
Name of the school	: N.S.S. Boy's High school, Perunnai	Std	: VIII	
Subject	: Biology	Duration	: 35 min	
Unit	: Let's regain our fields	Date :		
Topic	: Food safety and crises in agriculture			

Content Overview :	Food safety
Content Analysis :	
Terms:	Food security, Scarcity of food
Facts :	• Food security is the condition that ensures sufficient food for everyone. • Food security is necessary for a healthy and better society. • Increasing population, lack of knowledge, lack of fertile soil etc. are the reasons for scarcity of food. • Scientific way of agriculture can solve the problems of food scarcity. • Food scarcity is the insufficiency in amount of food / shortage of food materials. • Food scarcity leads to poverty and malnutrition. • Population, food availability, food access and food use are the factors determining food security. • Population growth is the risk factor for food security.
Concepts:	
Major Concept	**Food Security:** Food security is the situation that ensures sufficient food for everyone to lead a healthy life.
Learning Objectives:	Pupil develops knowledge in the above mentioned terms and facts, Relationship between population growth, availability of agricultural land and rice production Population growth as a threat to food security. Ways to solve problems related to food security.

Process Domain:	Pupil develops process skills in, Observing news on food security bill in the newspaper. Drawing inferences from the newspaper report about the need and importance of food security. Discussion on food security of Kerala. Listing different factors causing food scarcity during group discussion.
Application Domain:	Pupil applies knowledge in, Sensitizing society about the importance of food security. Observing production of different crops. Using barren land for agriculture. Starting agriculture at home and school premises.
Attitude Domain:	Pupil develops positive attitude towards, The need to ensure food security in our country. Responsibility of every citizen to promote agriculture. To minimize the misuse of food. Practising scientific ways of doing agriculture.
Creativity Domain:	Pupil develops creativity in, Organizing a street play on the needs to ensure food security. Writing an article on the importance of food security. Creating an album on various methods of agriculture.
Learning strategy:	Group discussion Observation
Pre requisites:	Food is necessary for a healthy and better living. Food is obtained through agriculture. Rice is one among the main crop cultivated in Kerala. Unavailability of food leads to malnutrition.
Learning Materials:	VIII Standard Basic Science text book for analysing rate of rice production, availability of land for cultivation and population. Power point presentation showing pictures of food scarcity

<table>
<tr><th>Learning Activity</th><th>Evaluation</th></tr>
<tr><td>
Introduction
Pupil listens to the story of a farmer called Ramu and his love towards agriculture. The name of his house is “Haritham”, which shows his love to nature. Fifty acres of land owned by him had traditional fencing with plants. There are many varieties of vegetables, fruits, tubers, coconut etc. Teacher explains the beautiful sight of his farm and asks students certain questions like, what will happen if there are no such persons like Ramu. After collecting answers from students, teacher moves on to the topic <u>Food Safety</u> (BB).
Activity 1
Students observe the illustration and newspaper report given on the page number 35 of the VIII standard Basic Science text book. She directs the children to discuss the matter in groups with the help of the indicators given in activity cards and to write their inferences in the science diary.
Indicators

Reasons for scarcity of food
Role of science in solving the problems in agriculture
Relevance of food security

Consolidation
The leader of each group read out their inferences evolved out of discussion and consolidates the activity as food security is the situation that ensures sufficient food for everyone to lead a healthy life. Thereafter she shows a power point presentation showing pictures related to food scarcity. Teacher sites some examples of <u>scientific ways of agriculture</u> (BB) and its relevance in ensuring food security.
.
</td><td>
Pupil observe and writes inferences
</td></tr>
</table>

Learning Activity	Evaluation

Activity 2

Teacher asks the children to observe the table showing year, production of rice, available land for cultivation and population on the chart. Students were asked to analyze the chart carefully and write their inferences based on the indicators in their science diary

CHART

Year	**Rice Production**		Population in crores
	Land for cultivation in lakh hectors	Production in lakh tones	
1971	8.75	13.65	2.13
1991	5.5	10.6	2.91
2011	2.08	5.69	3.34

Indicators

- What are the changes that occurred in the area of agricultural fields from the year 1971 to 2011?
- What tendency could be observed in rice production and population growth during the period?
- Is this tendency desirable?

Consolidation

Teacher consolidates the activity by asking students to read their inferences. Summarizing main points from students, teacher says that with increasing population there is no increase in area available for cultivation of crops and production of rice which leads to food scarcity (BB). In order to ensure food security in the country, for a prosperous future, everyone should promote agriculture.

Evaluation: After careful observation of chart , students writes inferences in the science diary

Review Questions

What is meant by food security?

What is meant by food scarcity?

State the need and significance of food security?

Follow up activity

Write an assignment on the topic “Role of food security in the prosperity of a nation”

APPENDIX- X B

LESSON PLAN TRANSCRIPT BASED ON MC CORMACK AND YAGER'S TAXONOMY 1 (Malayalam Version)

Name of the teacher : രേവതി എൻ

Name of the school : എൻ.എസ്.എസ്,ബോയ്സ് ഹൈസ്കൂൾ,പെരുന്ന   Std : VIII   Duration : 35min

Subject : ജീവശാസ്ത്രം   Date :

Unit : വീണ്ടെടുക്കാം വിളനിലങ്ങൾ

Topic : ഭക്ഷ്യസുരക്ഷ

Content Overview:	ഭക്ഷ്യസുരക്ഷ
Content Analysis	
Terms:	ഭക്ഷ്യസുരക്ഷ, ഭക്ഷണദൗർലഭ്യം
Facts:	• എല്ലാവർക്കും ആവശ്യാനുസരണം ഭക്ഷണം ലഭ്യമാകുന്ന സാഹചര്യമാണ് ഭക്ഷ്യസുരക്ഷ. • ആരോഗ്യപൂർണമായ ഒരു നല്ല സമൂഹത്തിന് ഭക്ഷ്യസുരക്ഷ അത്യന്താപേഷിതമാണ്. • ജനസംഖ്യാവർദ്ധനവ്, അറിവില്ലായ്മ, വളക്കൂറുള്ള മണ്ണിന്റെ ലഭ്യതകുറവ്, കാലാവസ്ഥാവ്യതിയാനം, കീടങ്ങളുടെ ആക്രമണം എന്നിവ ഭക്ഷ്യദൗർലഭ്യതയ്ക്കു കാരണമാകുന്നു. • ശാസ്ത്രീയമായ കൃഷിരീതികളിലൂടെ ഭക്ഷ്യസുരക്ഷയുടെ പ്രശ്നങ്ങൾ പരിഹരിക്കാനാവും. • ആവശ്യമായ അളവിൽ ഭക്ഷണം ലഭ്യമാകാതിരിക്കുക, ഭക്ഷണ പദാർത്ഥങ്ങളുടെ കുറവ് എന്നിവ ഭക്ഷ്യദൗർലഭ്യതയിലേക്ക് നയിക്കുന്നു. • ഭക്ഷ്യദൗർലഭ്യത ദാരിദ്രത്തിനും, പോഷകാഹാരകുറവിനും കാരണമാകുന്നു. • ജനസംഖ്യ, ഭക്ഷ്യലഭ്യത, ഭക്ഷ്യഅഭിഗമ്യത ഭക്ഷ്യോപയോഗം എന്നിവ ആണ് ഭക്ഷ്യദൗർലഭ്യതയെ നിർണയിക്കുന്ന ഘടകങ്ങൾ • ജനസംഖ്യാ വർദ്ധനവ് ഭക്ഷ്യസുരക്ഷയ്ക്ക് ഒരു വെല്ലുവിളിയാണ്.

Concepts	
Major concept:	***ഭക്ഷ്യസുരക്ഷ:***ഏവർക്കും ആരോഗ്യപരമായ ജീവിതം നയിക്കുന്നതിനു വേണ്ട ഭക്ഷണം ആവശ്യാനുസരണം ലഭ്യമാകുന്ന സാഹചര്യമാണ് ഭക്ഷ്യസുരക്ഷ.
Learning Objectives	
Knowledge Domain:	Pupil develops knowledge in the above mentioned terms and facts, Relationship between population growth, availability of agricultural land and rice production. Population growth as a threat to food security. Ways to solve problems related to food security.
Process Domain:	Pupil develops process skills in, Observing news on food security bill in the newspaper. Drawing inferences from the newspaper report about the need and importance of food security. Discussion on food security of Kerala. Listing different factors causing food scarcity during group discussion.
Application Domain:	Pupil applies knowledge in, Sensitizing society about the importance of food security. Observing production of different crops. Using barren land for agriculture. Starting agriculture at home and school premises.

Attitude Domain:	Pupil develops positive attitude towards, The need to ensure food security in our country. Responsibility of every citizen to promote agriculture. To minimize the misuse of food. Practising scientific ways of doing agriculture.
Creativity Domain:	Pupil develops creativity in, Organizing a street play on the needs to ensure food security. Writing an article on the importance of food security. Creating an album on various methods of agriculture.
Pre requisites:	• ആരോഗ്യപരമായ നല്ലജീവിതം നയിക്കാൻ ഭക്ഷണം ആവശ്യമാണ് • കൃഷിയിലൂടെ ഭക്ഷണം ലഭ്യമാകുന്നു • കേരളത്തിലെ പ്രധാന കാർഷിക വിളകളിൽ ഒന്നാണ് നെല്ല് • ഭക്ഷണത്തിന്റെ ലഭ്യതക്കുറവ് അപപോഷണത്തിലേക്ക് നയിക്കുന്നു
Learning materials:	• നെല്ലുൽപാദത്തിന്റെ അളവ്, കൃഷിയിടത്തിന്റെ വിസ്തൃതി, ജനസംഖ്യ എന്നിവ വിശകലനം ചെയ്യാനായ്8-ാം ക്ലാസ്സ് അടിസ്ഥാനശാസ്ത്ര പുസ്തകം • ഭക്ഷ്യദൗർലഭ്യതയുടെ ചിത്രങ്ങൾ അടങ്ങിയ പവർപോയിന്റ് പ്രസന്റേഷൻ

Learning Activity	Response/ Evaluation
<u>Introduction</u> ടീച്ചർ രാമു എന്നു പേരുള്ള ഒരു കൃഷി സ്നേഹിയുടെ കഥ പറയുന്നു. "ഹരിതം" എന്ന പേരുള്ള വീടു തന്നെ അദ്ധേഹത്തിന്റെ പ്രകൃതിയോടുള്ള സ്നേഹത്തെ കാണിക്കുന്നു. അമ്പത് ഏക്കറോളം വരുന്ന കൃഷിയിടം പരമ്പരാഗത രീതിയിൽ ചെടികൾ കൊണ്ടുള്ള വേലികൾ കൊണ്ട് വേർതിരിച്ചിരിക്കുന്നു അവിടെ പലതരത്തിലുള്ള പച്ചക്കറികൾ, ഫലവർഗ്ഗങ്ങൾ, കിഴങ്ങുവർഗ്ഗങ്ങൾ, തെങ്ങ് എന്നിങ്ങനെ പല കൃഷികൾ ഉണ്ടായിരുന്നു. രാമുവിന്റെ കൃഷിയിടത്തിന്റെ പ്രകൃതിഭംഗി വിവരിച്ചുകൊണ്ട്രാമുവിനെ പോലുള്ള ആളുകൾ ഇല്ലായിരുന്നു എങ്കിൽ എന്ത് സംഭവിക്കും എന്നതു പോലുള്ള ചോദ്യങ്ങൾ ചോദിച്ചുകൊണ്ട് ടീച്ചർ കുട്ടികളുടെ പ്രതികരണങ്ങൾ ആരായുന്നു. കുട്ടികളുടെ ഉത്തരങ്ങൾ ഏകോപിപ്പിച്ചുകൊണ്ട് ടീച്ചർ <u>ഭക്ഷ്യസുരക്ഷ</u> (BB) എന്ന പാഠഭാഗത്തേയ്ക്ക് കടക്കുന്നു. ***<u>പ്രവർത്തനം 1</u>*** 8-ാം ക്ലാസ്സ് അടിസ്ഥാനശാസ്ത്ര പാഠപുസ്തകത്തിലെ 35-ാമത്തെ പേജിലെ വിവരണവും പത്രറിപ്പോർട്ടും നിരീക്ഷിക്കുന്നതിന് ടീച്ചർ നിർദ്ദേശം നൽകുന്നു. ആക്ടിവിറ്റികാർഡിലെ സൂചകങ്ങൾക്കനുസരിച്ച് ഗ്രൂപ്പിൽ വിഷയം ചർച്ച ചെയ്യുവാനും സയൻസ് ഡയറിയിൽ ചർച്ചയുടെ ഫലമായുള്ള നിയമനങ്ങൾ രേഖപ്പെടുത്തുവാനും പറയുന്നു <u>ചർച്ചാസൂചകങ്ങൾ</u> • ഭക്ഷ്യദൗർലഭ്യതയുടെ കാരണങ്ങൾ. • കൃഷി അഭിമുഖീകരിക്കുന്ന പ്രശ്നങ്ങൾ പരിഹരിക്കുന്നതിൽ ശാസ്ത്രത്തിന്റെ പങ്ക്. • ഭക്ഷ്യസുരക്ഷയുടെ പ്രസക്തി.	കുട്ടികൾ നിരീക്ഷണത്തിന് ശേഷം നിഗമനങ്ങൾ എഴുതുന്നു

Learning Activity	Response/ Evaluation

ക്രോഡീകരണം

ചർച്ചയിലൂടെ രൂപപ്പെട്ട നിഗമനങ്ങൾ ഗ്രൂപ്പ് ലീഡർ ക്ലാസ്സിൽ വായിക്കുകയും ആരോഗ്യപൂർണ്ണമായ ജീവിതം നയിക്കുന്നതിനാവശ്യമായ ഭക്ഷണം ആവശ്യാനുസരണം ലഭ്യമാക്കുന്ന സാഹചര്യമാണ് ഭക്ഷ്യസുരക്ഷ എന്ന അഭി പ്രായത്തിൽ എത്തിച്ചേരുകയും ചെയ്യുന്നു.അതിനുശേഷം ടീച്ചർ ഭക്ഷ്യദൗർലഭ്യതകാണിക്കുന്ന പവർപോയിന്റ് പ്രസ ന്റേഷൻ കാണിക്കുകയും <u>ശാസ്ത്രീയമായ രീതി ലൂടെയുള്ള കൃഷിരീതികളിലൂടെ (BB)</u> ഭക്ഷ്യസുരക്ഷ ഉറ പ്പുവരുത്തുന്നതിനുള്ള കുറച്ച് ഉദാഹരണങ്ങൾ സൂചിപ്പി ക്കുകയും ചെയ്യുന്നു.

പ്രവർത്തനം 2

വർഷം, നെല്ലുൽപ്പാദനത്തിനാവശ്യമായ കൃഷിയിട ത്തിന്റെ വിസ്തൃതി, നെല്ലുൽപ്പാദനത്തിന്റെ അളവ്, ജന സംഖ്യ എന്നിവ കാണിക്കുന്ന ചാർട്ട് നിരീക്ഷിക്കുവാനും നിരീക്ഷണത്തിൽ നിന്നും രൂപപ്പെടുന്ന നിഗമനങ്ങൾ സയൻസ് ഡയറിയിൽ രേഖപ്പെടുത്താനും ടീച്ചർകുട്ടിക ളോട് നിർദ്ദേശിക്കുന്നു.

ചാർട്ട്

വർഷം	നെല്ലുൽപ്പാദനം		ജനസംഖ്യ (കോടി)
	കൃഷിയിടത്തിന്റെ വിസ്തൃതി	ഉൽപ്പാദനം (ലക്ഷംടണ്ണിൽ)	
1971	8.75	13.65	2.13
1991	5.5	10.6	2.91
2011	2.08	5.69	3.34

സൂചകങ്ങൾ

- 1971 മുതൽ 2011 വരെ കൃഷിയിടത്തിന്റെ വിസ് തൃതിയിൽ ഉണ്ടായിട്ടുള്ള മാറ്റം എന്താണ്?

Response/ Evaluation:

ചാർട്ട് നിരീക്ഷണത്തിന് ശേഷം കുട്ടികൾ നിഗമ നങ്ങൾ സയൻസ് ഡയറി യിൽ എഴുതുന്നു

Learning Activity	**Response/ Evaluation**
• ഈ കാലയളവിൽ നെല്ലുൽപാദനവും ജന സംഖ്യാവളർച്ചയും തമ്മിലുളള ബന്ധത്തിൽ എന്തുപ്രവണതയാണ് കാണാൻ കഴിയുന്നത്? • ഇതൊരു അഭിലക്ഷണിയമായ പ്രവണതയാണോ? ***<u>ക്രോഡികരണം</u>*** കുട്ടികളുടെ നിഗമനങ്ങൾ വായിച്ചതിനു ശേഷം ടീച്ചർ പ്രവർത്തനം ക്രോഡികരിക്കുന്നു. കുട്ടികൾ നൽകിയ പ്രധാനപ്പെട്ട ആശയങ്ങൾ ചുരുക്കി പറഞ്ഞു കൊണ്ട്, ജനസംഖ്യാ വർദ്ധനവിനനുസരിച്ച് കൃഷിയിടത്തിൽ വർദ്ധനവ് ഉണ്ടാകുന്നില്ല എന്നും, അത് നെല്ലുൽപാദനം കുറയ്ക്കുകയും <u>ഭക്ഷ്യദൗർലഭ്യതയ്ക്കു (BB)</u> കാരണമാകുന്നു എന്നും ടീച്ചർ വ്യക്തമാക്കുന്നു.രാജ്യത്ത് ഭക്ഷ്യസുരക്ഷ ഉറപ്പാക്കുവാനും ഐശ്വര്യമായ ഭാവിക്കും വേണ്ടി ഏവരും കൃഷിയെ പ്രോത്സാഹിപ്പിക്കുകയും വേണം	

<u>Review Questions</u>

1. ഭക്ഷ്യസുരക്ഷ എന്നാൽഎന്ത്?
2. ഭക്ഷ്യദൗർലഭ്യതഎന്നാൽഎന്ത്?
3. ഭക്ഷ്യസുരക്ഷയുടെ പ്രാധാന്യംഎന്ത്?

<u>Follow up activity</u>

രാജ്യത്തിന്റെ അഭിവൃദ്ധിയിൽ ഭക്ഷ്യസുരക്ഷയുടെ പങ്ക് എന്നതിനെ കുറിച്ച് ഒരു അസൈൻമെന്റ് തയ്യാറാക്കുക.

APPENDIX –XI A

LESSON TRANSCRIPT BASED ON Mc. CORMACK AND YAGER'S TAXONOMY-II

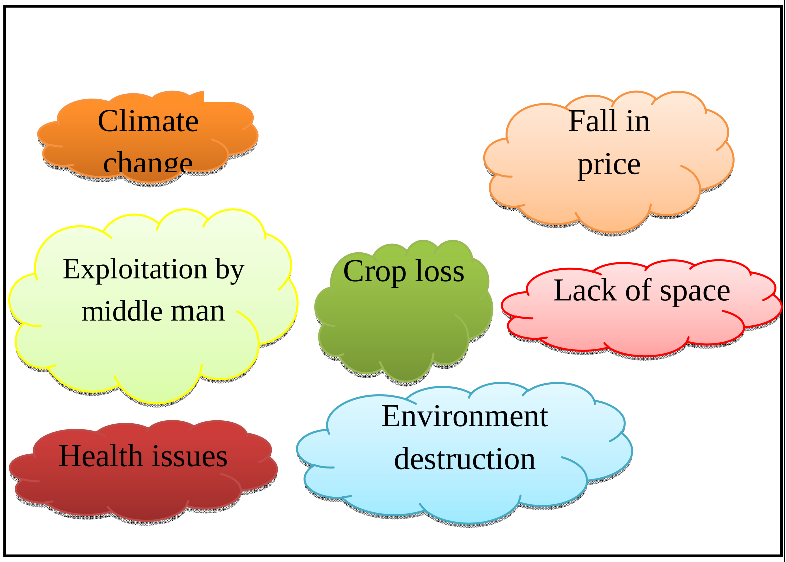
(English Version)

Name of the teacher	:	Ravati N		
Name of the school	:	N.S.S. Boy's High school,Perunnai	Std	: VIII
Subject	:	Biology	Duration	: 35 min
Unit	:	Let's regain our fields	Date	:
Topic	:	Crises in the Agricultural sector		

Content over view:	Crises in the agricultural sector; soil fertility, pH of the soil and soil testing.
Content Analysis:	
Terms :	Crises in the agricultural sector,essential element, pH of the soil.
Facts :	• Problems in agriculture can be solved by scientific approach. • Elements required for the proper growth of plants are known as essential elements. • Essential elements are made naturally available in the soil through decomposition by micro organism. • Climate change, fall in price, cost of production etc are some obstacles faced by farmers. • pH is an important factor that influence the growth of plants. • Presence of elements in the soil and the pH value can be identified by soil testing. • Organisms like bacteria, fungi, algae, termite, earth worm etc. can help to increase soil fertility.
Concept	
Major concept:	Crises in agriculture: Farmers face many obstacles like, climate change, fall in price, cost of production, crop loss, lack of space and exploitation by middle man which leads to crises in agriculture.

Learning Objectives	
Knowledge Domain:	Pupil develops knowledge in, Factors leading to crises in agriculture. Scientific approaches to solve problems of agriculture. Role of pH in plant growth. Identification of soil fertility through soil testing. Significance of essential elements for the proper growth of plants. Soil fertility affects food security.
Process Domain:	Pupil develops process skills in, Observing the pictures related to crises in agriculture. Forming a definition for crises in agriculture. Discussing and listing factors responsible for crises in agriculture. Drawing inference from the activity card regarding soil and essential elements. Forming generalization about the crises in agriculture during group discussion.
Application Domain:	Pupil applies knowledge in, Solving problems in agriculture. Listing important factors for maintaining a vegetable garden at home. Finding and adopting modern trends in the field of agriculture. Adopting scientific agricultural practices. Testing soil to determine its quality.
Attitude Domain:	Pupil develops positive attitude towards, Using scientific approaches in agriculture.

	Testing the soil before farming a crop. Maintaining the pH of the soil. Practicing and promoting agriculture. Maintaining fertility of the soil by use of biological control measures and bio fertilizers
Creativity Domain:	Pupil develops creativity in, Collecting photos showing crises in agriculture. Developing new methods for agriculture and farming. Practicing crop rotation. Organizing awareness programmes to ensure food security.
Learning strategy:	Group Discussion Observation and analysis
Pre requisites:	Problems faced by farmers Climate change adversely affects agriculture. Agriculture land is decreasing Chemical fertilizers destroy quality of the soil.
Learning materials:	Chart showing problems in the agricultural sector Picture of barren land Newspaper cuttings showing crises in agriculture. Chart on soil testing

Learning Activity	Evaluation
<u>Introduction :</u> Teacher shows the picture of barren land which was used as a field about ten years back, and asks students to discuss and report their opinions, related to the picture. Pupil gives a number of opinions and teacher directs their thoughts towards <u>crises in agriculture sector</u> (BB).	
<u>Activity.1</u> Teacher asks children to observe chart showing crises in the agricultural sector. She divides pupils in to different groups for discussion using the indicators written on the activity cards.	Pupil observes chart and found out more factors for crises in agriculture.
Chart  	
<u>Indicators</u> • How these obstacles affect a farmer • List more obstacles for the crises	
Consolidation Pupil discusses and presents their findings by adding more information to the picture and lists obstacles for food security. Teacher consolidates the activity by stressing the need to approach agriculture through <u>scientific methods</u> (BB) to overcome the crises.	

<table>
<tr><th>Learning Activity</th><th>Evaluation</th></tr>
<tr><td>

Activity-2

Teacher displays a chart about soil testing and asks children to observe, discuss and write inferences in their science diary on importance of soil testing.

Soil Testing

- Essential elements are required for proper growth of plants
- Carbon, Hydrogen, Nitrogen Phosphorous are examples of essential elements
- pH of the soil influences the growth of plants
- Presence of elements in the soil and pH can be identified by soil testing.

Consolidation

After collecting inferences from pupils teacher consolidates the activity by saying, elements required for the proper growth of plants are known as Essential Elements (BB) and it is made available in the soil through decomposition by microorganisms. pH is another important factor which influences soil fertility. Elements in the soil and pH value of the soil (BB) can be identified by soil testing (BB) for proper manuaring and better yield.

</td><td>

Pupil discusses and writes inference that; soil testing is an important factor in farming.

</td></tr>
<tr><td colspan="2">

Review of Questions:

- What are essential elements?
- What is the importance of the soil testing?
- What is the significance of pH in soil fertility?

Follow up activity:

Write an assignment on the scientific methods to overcome the crises in agriculture.

</td></tr>
</table>

APPENDIX - XI B

LESSON PLAN TRANSCRIPT BASED ON Mc. CORMACK AND YAGER'S TAXONOMY II

(Malayalam Version)

Name of the teacher : രേവതി എൻ

Name of the school : എൻ.എസ്.എസ്,ബോയ്സ് ഹൈസ്കൂൾ,പെരുന്ന

Duration: 35min

Std : VIII

Subject : ജീവശാസ്ത്രം

Date :

Unit : വീണ്ടെടുക്കാം വിളനിലങ്ങൾ

Topic : കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ

Content Overview:	കാർഷിക മേഖലയിലെ പ്രതിസന്ധികൾ, മണ്ണിന്റെ ഫലപൂഷ്ടി, മണ്ണിന്റെ pH,മണ്ണുപരിശോധന.
Content Analysis:	
Terms:	കാർഷിക മേഖലയിലെ പ്രതിസന്ധികൾ അവശ്യമൂലക ങ്ങൾ, മണ്ണിന്റെ pH
Facts:	• ശാസ്ത്രീയ സമീപനത്തിലൂടെ കാർഷിക മേഖലയുടെ പ്രശ്നങ്ങൾ പരിഹരിക്കാനാകും • സസ്യങ്ങളുടെ ത്വരിതമായ വളർച്ചയ്ക്കാവശ്യമായ മൂലക ങ്ങളെ അവശ്യമൂലകങ്ങൾ എന്നു പറയുന്നു. • സൂക്ഷ്മജീവികളുടെ വിഘടിപ്പിക്കൽ പ്രവർത്തനം മൂലം അവശ്യമൂലകങ്ങൾ മണ്ണിൽ പ്രകൃതിദത്തമായി ലഭ്യമാണ്. • കാലാവസ്ഥാവ്യതിയാനം, വിലനഷ്ടം, ഉൽപ്പാദനച്ചെലവ്, എന്നിങ്ങനെ ഒരുപാട് പ്രതിസന്ധികൾ കർഷകർ നേരിടു ന്നുണ്ട്. • സസ്യങ്ങളുടെ വളർച്ചയെ സ്വാധീനിക്കുന്ന ഒരു പ്രധാന ഘടകം ആണ് മണ്ണിന്റെ pH • മണ്ണുപരിശോധനയിലൂടെ മണ്ണിലെ മൂലകങ്ങളുടെ സാന്നി ധ്യവും, pH മൂല്യവും തിരിച്ചറിയാം. • ബാക്ടീരിയകൾ, കുമിളുകൾ, ആൽഗകൾ, ചിതൽ, മണ്ണിര തുടങ്ങിയ ജീവിവർഗ്ഗങ്ങൾ മണ്ണിന്റെ ഫലപൂഷ്ടി വർദ്ധിപ്പിക്കുവാൻ സഹായിക്കുന്നുണ്ട്.

Concepts **Major concept:**	***<u>കാർഷിക മേഖലയിലെ പ്രതിസന്ധികൾ</u>:*** കൃഷിക്കാർ അഭിമുഖീകരിക്കേണ്ടി വരുന്ന കാലാവസ്ഥാവ്യതിയാനം, വിലനഷ്ടം, ഉൽപാദനച്ചെലവ്, വിളനഷ്ടം, സ്ഥലപരിമിതി, ഇടനിലക്കാരുടെ ചൂഷണം എന്നീ പ്രതിബന്ധങ്ങൾ കാർഷിക മേഖലയിലെ പ്രതിസന്ധിക്കു കാരണമാകുന്നു.
Learning Objectives	
Knowledge Domain:	Pupil develops knowledge in, Factors leading to crises in agriculture. Scientific approaches to solve problems of agriculture. Role of pH in plant growth. Identification of soil fertility through soil testing. Significance of essential elements for the proper growth of plants. Soil fertility affects food security.
Process Domain :	Pupil develops process skills in, Observing the pictures related to crises in agriculture. Forming a definition for crises in agriculture. Discussing and listing factors responsible for crises in agriculture. Drawing inference from the activity card regarding soil and essential elements. Forming generalization about the crises in agriculture during group discussion.
Application Domain :	Pupil applies knowledge in, Solving problems in agriculture. Listing important factors for maintaining a vegetable garden at home. Finding and adopting modern trends in the field of agriculture. Adopting scientific agricultural practices. Testing soil to determine its quality.

Attitude Domain :	Pupil develops positive attitude towards, Using scientific approaches in agriculture. Testing the soil before farming a crop. Maintaining the pH of the soil. Practicing and promoting agriculture. Maintaining fertility of the soil by bio fertilizers and biological control measures.
Creativity Domain :	Pupil develops creativity in, Collecting photos showing crises in agriculture. Developing new methods for agriculture and farming. Practicing crop rotation. Organizing awareness programmes to ensure food security.
Pre requisites	• കർഷകൻ അഭിമുഖീകരിക്കുന്ന പ്രശ്നങ്ങൾ • കാലാവസ്ഥാവ്യതിയാനം കൃഷിയെ പ്രതികൂലമായി ബാധിക്കുന്നു. • കൃഷിയിടത്തിന്റെ അളവ് കുറഞ്ഞു കൊണ്ടിരിക്കുന്നു. • രാസവളങ്ങൾ മണ്ണിന്റെ മേന്മ തർക്കുന്നു.
Learning Materials:	• കാർഷിക മേഖലയിലെ പ്രതിസന്ധികൾ കാണിക്കുന്ന ചാർട്ട്. • തരിശു നിലങ്ങളുടെ ചിത്രം. • കാർഷിക മേഖലയിലെ പ്രതിസന്ധികൾ കാണിക്കുന്ന പത്രവാർത്തകൾ. • മണ്ണു പരിശോധനയുടെ ചാർട്ട്.

Learning Activity	Response/ Evaluation
Introduction പത്തുവർഷം മുമ്പ് നല്ല രീതിയിൽ കൃഷിനടത്തിയിരുന്നതും ഇപ്പോൾ തരിശുനിലമായി കിടക്കുന്നതുംമായ ഒരു കൃഷിയിടത്തിന്റെ ചിത്രം കാണിച്ച് അതിനെ പറ്റി കുട്ടികളോട് ചർച്ച ചെയ്യാൻ ആവശ്യപ്പെടുന്നു. കുട്ടികളുടെ വിവിധങ്ങളായ അഭിപ്രായങ്ങൾ ക്രോഡീകരിച്ചുകൊണ്ട് <u>കാർഷികമേഖല ഇന്നു നേരിടുന്ന പ്രതിസന്ധികൾ</u> (BB) എന്ന പാഠഭാഗത്തേയ്ക്ക് നീങ്ങുന്നു. ***<u>പ്രവർത്തനം-1</u>*** കാർഷികമേഖലയിലെ പ്രതിസന്ധികൾ രേഖപ്പെടുത്തിയ ചാർട്ട് നിരീക്ഷിക്കുവാൻ ടീച്ചർ കുട്ടികൾക്ക് നിർദ്ദേശം കൊടുക്കുന്നു. ആക്റ്റിവിറ്റി കാർഡിൽ കൊടുത്തിരിക്കുന്ന സൂചകങ്ങൾക്കനുസൃതമായി വിഷയം ചർച്ച ചെയ്യാൻ കുട്ടികളെ ഗ്രൂപ്പുകളായി തിരിക്കുന്നു. ***ചാർട്ട്*** ***ഇന്നത്തെ കർഷകൻ അഭിമുഖീകരിക്കുന്ന പ്രതിസന്ധികൾ*** 	ചാർട്ട് നിരീക്ഷിക്കുകയും കാർഷിക മേഖലയിലെ പ്രതിസന്ധിയിലേക്കു നയിക്കുന്ന കൂടുതൽ കാരണങ്ങൾ കണ്ടുപിടിക്കുകയും ചെയ്യുന്നു

<table>
<tr><th>Learning Activity</th><th>Response/ Evaluation</th></tr>
<tr><td>

<u>*സൂചകങ്ങൾ.*</u>

- ഈ പ്രതിസന്ധികൾ എങ്ങനെ ഒരു കർഷകനെ ബാധിക്കുന്നു?
- പ്രതിസന്ധികൾക്കു കാരമണമായ കൂടുതൽ കാരണങ്ങൾ കണ്ടുപിടിക്കുക.

<u>*ക്രോഡീകരണം*</u>

ചർച്ചയ്ക്കു ശേഷം ഭക്ഷ്യസുരക്ഷയുടെ പ്രതിസന്ധിയ്ക്കു കാരണമായ കൂടുതൽ കാരണങ്ങൾ കണ്ടെത്തുകയും ക്ലാസ്സിൽ അവതരിപ്പിക്കുകയും ചെയ്യുന്നു. ഈ പ്രതിസന്ധിയെ മറികടക്കാനുള്ള <u>ശാസ്ത്രീയമായ സമീപനത്തിന്റെ</u> (BB) ആവശ്യകതയ്ക്ക് ഊന്നൽ കൊടുത്തുകൊണ്ട് ടീച്ചർ പ്രവർത്തനം ക്രോഡീകരിക്കുന്നു.

<u>*പ്രവർത്തനം 2*</u>

മണ്ണു പരിശോധനയെ പറ്റിയുള്ള വിവരങ്ങൾ അടങ്ങിയ ചാർട്ട് നിരീക്ഷിച്ച് മണ്ണു പരിശോധനയുടെ ആവശ്യകതയെ പറ്റി ചർച്ച ചെയ്ത് നിഗമനങ്ങൾ സയൻസ് ഡയറിയിൽ എഴുതാൻ ആവശ്യപ്പെടുന്നു.

ചാർട്ട്

മണ്ണുപരിശോധന

- സസ്യങ്ങളുടെ നല്ലരീതിയിലുള്ള വളർച്ചയ്ക്ക് അവശ്യമൂലകങ്ങൾ വേണം
- കാർബൺ, ഹൈഡ്രജൻ, നൈട്രജൻ, ഫോസ്ഫറസ്, എന്നിവ അവശ്യമൂലകങ്ങൾക്ക് ഉദാഹരണങ്ങളാണ്.
- മണ്ണിന്റെ pH ചെടിയുടെ വളർച്ചയെ സ്വാധീനിക്കുന്നു.
- മണ്ണുപരിശോധനയിലൂടെ മണ്ണിന്റെ pH മൂല്യം, വിവിധ മൂലകങ്ങളുടെ സാന്നിധ്യം എന്നിവ അറിയാം.

</td><td>കുട്ടികൾ ചർച്ചയ്ക്കുശേഷം കൃഷിയിൽ മണ്ണു പരിശോധനയുടെ ആവശ്യകതയെ പറ്റി നിഗമനത്തിൽ എത്തുന്നു.</td></tr>
</table>

Learning Activity	**Response/ Evaluation**
ക്രോഡീകരണം കുട്ടികൾ രൂപീകരിച്ച നിഗമനങ്ങൾ ഏകോപിപ്പിച്ചുകൊണ്ട് ടീച്ചർ പ്രവർത്തനം ക്രോഡീകരിക്കുന്നു. സസ്യങ്ങളുടെ ശരിയായ വളർച്ചയ്ക്ക് ആവശ്യമായ മൂലകങ്ങൾ ആണ് അവശ്യമൂലകങ്ങൾ (BB)എന്നറിയപ്പെടുന്നത്. സൂക്ഷ്മജീവികളുടെ വിഘടിപ്പിക്കൽ മൂലമാണ് അവ മണ്ണിൽ ലഭ്യമാകുന്നത്. pH എന്നത് മണ്ണിന്റെ ഫലപൂഷ്ടിയെ നിർണ്ണയിക്കുന്ന മറ്റൊരു പ്രധാന ഘടകമാണ്. മണ്ണുപരിശോധനയിലൂടെ മണ്ണിന്റെ pH മൂല്യവും മണ്ണിലെ മൂലകങ്ങളുടെ സാന്നിധ്യവും തിരിച്ചറിഞ്ഞ് ശരിയായ രീതിയിൽ വളപ്രയോഗം നടത്തി നല്ല വിളവ് ലഭിക്കുന്നതാണ്.	

Review Question

- എന്താണ് അവശ്യമൂലകങ്ങൾ?
- മണ്ണുപരിശോധനയുടെ പ്രാധാന്യം എന്ത്?
- മണ്ണിന്റെ ഗുണനിലവാരം നിർണ്ണയിക്കുന്നതിൽ pHന്റെ പ്രാധാന്യം എന്ത് ?

Follow up activity

കാർഷിക മേഖലയിലെ പ്രതിസന്ധികളെ തരണം ചെയ്യാൻ വേണ്ട ശാസ്ത്രീയ രീതികളെ കുറിച്ച് ഒരു അസൈൻമെന്റ് തയ്യാറാക്കുക.

APPENDICES

Published by: South Asian Academic Research Journals

ACADEMICIA: An International Multidisciplinary Research Journal

(A Double Blind Refereed & Reviewed International Journal)

DOI NUMBER: 10.5958/2249-7137.2017.00016.7

AN INVESTIGATION ON HIGHER EDUCATION TEACHING STRATEGIES BASED ON BLOOM'S TAXONOMY FOR THE ACQUISITION OF HIGHER ORDER THINKING SKILLS

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ABSTRACT

Higher education in India shows a teacher centred, information based and test driven instructional format. India needs skilled higher educated people who can lead our country forward. When India become capable of sending skilled people to the outside world; the country can be very easily become a developed nation from developing nation. Now the time has come to create a second wave of institution building and excellence in the field of education, research, and capability building (Aggarwal, 2006). In the present study, investigators designed a Thinking skill inventory to determine whether higher order thinking skills or lower order thinking skills are prevailing in the teaching strategies of higher education. The study showed that instructors of higher education in Kottayam district of Kerala , India, taught lower thinking skills associated with the first three levels of Blooms Taxonomy, namely, knowledge, comprehension and application. Normative survey method is used to study the problem. The sample consists of 200 college teachers of Kottayam District. The study proposes some possible reasons for such practices, and suggests that teaching higher order thinking skills to higher education students might widen their horizon in engaging more actively in learning.

KEYWORDS: *Higher education, Blooms Taxonomy, Lower order thinking skills, Higher order thinking skills.*

INTRODUCTION

In terms of student population, world's third largest higher education system is that of India, while first and second positions are for United States and China. Higher education enrolment in India is less compared to China. It is University grants commission, the governing body in India, which enforces standards, advises government, and helps to co ordinate between centre and state government (Ramesh, 2006). However, India has failed to produce excellent education institutions like Harward and Cambridge. However some institutions like Indian Institute of Technology have been globally known for their standard of education. According to The London Times higher Education, Quacquarelli Symonds (QS) World University rankings, no Indian University features among the first 100.But universities in East Asia have been included in the first hundred. Hong Kong has three, ranked at 24,35 and 46; Singapore ranked at 30 and 73; South Korea two, ranked at 47 and 69 and Thaiwan, one in the 95th position.

Indian Government is taking many initiatives in Higher education to compete with world class Universities.UGC and other regulatory bodies are trying very hard to cancel the recognition of many private universities, which are running without any affiliation, or recognition (Novak, 1998). This is an era of knowledge. Those who are having more knowledge is considered to be the most empowered one. Critical appraisals done by academicians and Government committees pointed out that, increasing educated unemployment, weakening of student motivation, increasing unrest and indiscipline on the campuses ,deterioration of standards, inadequate infrastructure and facilities, large unfilled vacancies of faculty, low student enrolment rate, outmoded teaching methods, declining research standards, gender and ethnic imbalances and demoralising effect of irrelevance and purposelessness are the critical issues faced by the higher education scenario(Dennis,2002). However, Government is taking many measures to alleviate problems of higher education sector to make India a knowledge super power.

Majority of colleges and universities of India become fund less and ungovernable institutions. Academic appointments and decisions across the institutions are influenced by politics. Scarcity of funding for classic libraries and well equipped laboratories made low quality instruction in Higher education institutions. Increased number of part time teachers and non-appointment of full time teachers had affected academic activities (Reid &Sanders, 2011). Higher education is an area where researches are less compared to other levels of education. Academic institutions and systems have become large and complex. They need good data ,careful analysis and creative ideas. In China more than two dozen higher education research centres, and several government agencies are involved in higher education policy (Philip, 2005). Purpose of education is the all round development of personality. Nevertheless, the present day education is a failure in imparting true knowledge of life, helping one stand on one's own leg and improving the talent of a student by which one can achieve laurels in the field of interest (Arunachalam, 2010). In a study on higher education in India, conducted by professor Philip G Altbach; students complained that, method of education is childish and it does not consider them as mature persons , and university is giving them classes which was not at all applicable in their life. After collegiate education they are not even capable of doing a presentation. The Indian youth is deprived of some important soft skills which enable them to perform in their jobs in a better way. Instead of imparting skills, Indian higher education system has simply turned into examination centres where students enter to pass exams and earn degrees.

NEED AND SIGNIFICANCE OF THE STUDY

Quality of teaching and learning is an important issue in higher education which is continuously changing. In India student populations are highly diversified in terms of social factors and geographical factors. Government, funding agencies, parents and students demands value for their money by expecting maximum efficiency in teaching (Hogg, 1995). Research points out that quality teaching is, student centred and it aims for all students. So attention should be given to both teacher skills and the learning environment. Planning of higher objectives and implementation of activities, which can fulfil the objectives, should be there. A learning environment in which teacher and students learn collaboratively and build knowledge through interaction is one of the best ways of learning in higher education. Teaching up to secondary level is planned to fulfil the objectives defined by the curriculum. But after then there is great disparity between what was planned and what is implemented .There is little co ordination between the teachers and the curriculum setters of higher education. Therefore, there is a threatening gap between objectives and the way in which its attainment was worked out (Sallis, 2005).

Increasing globalisation creates certain challenges in ongoing higher education methods and strategies. Nation building efforts should take into account the increasing demand for professional skills and knowledge for filling the ‘demographic deficit’ in certain regions of the country. This can open tremendous opportunities for growth and employment of youth (Long, 2005). In view of the challenges faced by the Indian community, all institution should take up the responsibility to make their students aware of social, economic, scientific, and cultural issues and a students’ ability to respond to those issues. Quality improvement in higher education will bring about by restructuring academic activities to satisfy the demands of the open market. Complete revamping of teaching and learning strategies should be done; from instruction and rote learning to an interactive process that encourages creativity and innovation of students (Duderstadt, 1999). For that, the institution shall set certain higher objectives and ensure its attainment through proper ways of assessment.

BLOOMS TAXONOMY

Bloom’s taxonomy is classification of learning objectives in education developed by a committee of educators chaired by Benjamin S Bloom in 1956. The aim of the committee was to develop a system of, categories of learning to assist in designing and assessment of educational programmes. It identifies three domains of learning, each of which is organized as a series of levels, as pre-requisites. It is suggested that one cannot effectively address higher levels until those below them have been covered. It provides a basic sequential model for dealing with topics in the curriculum, and also suggests a way of categorizing levels of learning, in terms of expected outcome of a programme (Artherton, 2013) .Each of these categories requires learner to use different sets of mental processing to achieve stated outcomes within learning environment.

These objectives or a behavioural outcome of individuals resulting from instructions was classified into three domains.

1. Cognitive domain: Includes those objectives which deal with recall and recognition of knowledge and development of intellectual abilities. The objectives coming under this domain are knowledge, comprehension, application, analysis, synthesis and evaluation.
2. Affective domain: This domain deals with interests, attitudes, opinions, appreciations, values and emotional sets. Objectives coming under this category are, perception, set, guided response, mechanism, complex overt response, adaptation and organisation.
3. Psychomotor domain: Includes physical and motor skills. Objectives of this domain are receiving, responding, valuing, organisation, and characterisation.

Goal of Blooms Taxonomy is to motivate educators to focus on all the three domains creating a more holistic form of education. The cognitive domain objectives are the primary focus of all traditional education and it is commonly used to structure curriculum, learning objectives, learning experiences and assessment.

BLOOM'S REVISED TAXONOMY

In 1990s, Lorin Anderson, a former student of Benjamin.S. Bloom revised the original Bloom's Taxonomy and named it Revised Bloom's Taxonomy. In the new version of Bloom's Taxonomy, the names of the six categories changed from noun to verb forms, because thinking is an active process (Anderson, 2001). There was a change in terminology also i.e., knowledge changed into remembering, comprehension become understanding and synthesis into creating. Anderson rearranged the six categories with higher objective as creating. The knowledge level of the original taxonomy is divided into four levels; factual, conceptual, procedural, and metacognitive. Objectives of revised Bloom's taxonomy are remembering, understanding, applying, analysing, evaluating, and creating.

TERMINOLOGY CHANGES

The six major categories changed from noun to verb forms. The lowest level of original taxonomy, knowledge renamed as remembering. Comprehension and synthesis are retitled as understanding and creating.

DEFINITIONS OF NEW TERMS ARE AS FOLLOWS

- **Remembering:** Retrieving, recognizing and recalling relevant knowledge from long term memory.
- **Understanding:** constructing meaning from oral, written and graphic messages through interpreting, exemplifying, classifying, summarising, inferring, comparing and explaining.
- **Applying:** carrying out or using a procedure through executing or implementing.
- **Analyzing:** Breaking material into constituent parts, determining how the parts relate to one another, and to an overall structure or purpose, through differentiating, organizing, and attributing.
- **Evaluating:** Making judgments based on criteria and standards through checking and reviewing.

- **Creating** : Putting elements together to form a coherent or functional whole. Recognizing elements into a new pattern or structure through generating planning or producing **(**Anderson &Krathwohl,2001)

STRUCTURAL CHANGES

In the structure of original Bloom's taxonomy certain logical changes has been made. Original taxonomy was in one-dimensional form while the new taxonomy taken the form of a two dimensional table. The two dimensions considered here are, knowledge dimension the cognitive process dimension. (Maryforhand, 2005)

THE REVISED TAXONOMY TABLE

	Cognitive Process dimension					
The Knowledge Dimensions	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual						
Procedural						
Metacognitive						

Knowledge Dimension of Revised Blooms Taxonomy

Factual knowledge: This dimension contains knowledge, which is basic to specific disciplines. It includes all the details that a student must know, to understand a particular discipline like facts, terms, details of elements etc.

Conceptual knowledge: Includes classifications generalizations, theories, models and structures pertinent to a particular disciplinary area.

Procedural knowledge: This comes under the doing aspect of knowledge. This area of knowledge includes methods of inquiry, specific skills, algorithms, techniques and particular methodologies.

Metacognitive knowledge: This is the knowledge of one's own cognitive process and cognition. It includes self-knowledge about cognitive process as, solving problems, processing information etc. It is a higher order thinking skill involving active control on cognitive process.

A teacher can use of all these knowledge dimensions plotted in a Taxonomy table for ensuring necessary objectives of a unit and for a better and effective transaction. For a particular unit teacher can make sure that pupil are getting knowledge related to factual areas, conceptual areas, procedural areas and lastly the metacognitive procedures involved in learning. Teachers can make use of new taxonomy dimension for the formulation of objectives, refinement of existing objectives and for better assessment methods. In all areas of instructional procedure, a teacher can make use of the set up standards of Revised Bloom's Taxonomy. Blooms **t**axonomy helps a teacher to set standards for his/her teaching. In higher education, attainment of higher order objectives is very important. Through this study, the investigators attempted to test whether there is a teaching based on higher order objective or lower order objectives of Bloom's Taxonomy in the ongoing system of higher education.

Indian teachers clung to traditional pedagogical outlooks, tending to emphasize knowledge, content, teacher centred class rooms, and exam results. Indian teachers tend to stick to the textbook, which is often same to the whole students coming to that semester for years. Teaching in India is focussed exclusively on transmitting orthodox subject knowledge; concepts such as flexibility, problem solving, critical thinking, and independent learning are not recognised (Basterfield, 2008). In India there is fixed hierarchical structure in teaching in which there are certain prescribed mode of conduct to teachers and students. This hierarchical structure force a student, not to challenge his teacher, and teachers are considered as absolute authority figures in knowledge. The crisis of this situation is that, students are in a fixed pedagogical mode where analysis, synthesis, evaluation, and creativity are not encouraged. In contrast to this condition of India, critical thinking is the most practiced objective in western countries. Critical thinking is a higher order thinking skill that consists mainly of arguments, and it is a purposeful and self-regulatory activity resulting in interpretation, analysis, analysis, and inference, as well as explanations of the evidential, conceptual, methodological, or contextual considerations upon which the judgement is based (Astleitner, 2002)

OBJECTIVES

- To find out teaching strategies adopted by teachers of higher education institutions in Kottayam District for the acquisition of lower order thinking skills or higher order thinking skills among their students based on Bloom's Taxonomy

HYPOTHESIS

- Teachers of colleges in Kottayam District teach for the acquisition of higher order thinking skills among their students.

METHOD OF STUDY

Normative survey method was used to study the problem.

SAMPLE

The sample consists of 200 college teachers of Kottayam District who were randomly selected. Colleges selected for collection of data include both rural and urban types; both male and female teachers were there in the sample. These colleges offered graduate and postgraduate courses in science and arts subjects. Students of diverse geographical and socio economic background study there.

TOOL USED FOR THE STUDY

Benjamin Bloom classified Cognitive Domain into six subdivisions of learning; knowledge, comprehension, application, analysis, synthesis and evaluation (Bloom, et.al., 1956) .This classification is based on a hierarchy, in which lower order objectives ; knowledge, comprehension and application are at the bottom level.; and higher order objectives; analysis, synthesis and evaluation are at the top;. Performance of the lower order hierarchy is essential for acquiring higher order levels. However, teachers generally select either a cluster of lower level skills or a cluster of higher-level skills. Investigators made a tool to analyse whether teachers of higher education taught lower order thinking skills or higher order thinking skills namely Thinking Skill Inventory. This tool consists of six sub criteria, which will indicate a teacher's approval or disapproval of a particular teaching mode. Validity and reliability of the tool was ensured and the reliability coefficient was .92

STATISTICAL TECHNIQUES USED

Analysis of each question was done using descriptive statistics, Mean and Standard deviation.

ANALYSIS AND INTERPRETATION OF DATA

Analysis of each question of the research tool was done. For each participant response; descriptive statistics, mean and standard deviations were calculated. Mean scores for each response from teachers of higher education were given in tables one to six. Each table shows each objective in the cognitive domain of Bloom's Taxonomy. Scores on each table will show teacher's preference for a typical order thinking skill. Knowledge, comprehension, and application are considered to be of lower order thinking skills while analysis, synthesis and evaluation are considered to be higher order thinking skills.

TABLE 1 Questions based on lower order thinking skills, Knowledge

	M	SD
1.I allow students to define concepts in my class .	3.04	0.90
7.I permit students to memorise concepts in my class	3.12	0.89
13.I let students to repeat concepts in my class.	3.14	0.88
19.I allow students to name the concepts in my class.	3.16	0.77
25I allow students to recall concepts in my class	3.34	0.76
31.I permit students to label concepts in my class.	2.76	0.81

Table 1 shows the summary of scores related to responses to the first level of Bloom's Taxonomy; Knowledge. The data shows a high score on lower order thinking skills.

TABLE 2 Questions based on lower order thinking skills, Comprehension

	M	SD
2.I allow students to describe concrete concepts in my class .	3.21	0.79
8..I motivate students to discuss concrete concepts in my class	3.02	0.99

14.I encourage students to explain concrete concepts in my class.	3.23	0.77
20.I support students to identify concrete concepts in my class.	2.98	1.22
26 I promote students to recognize concrete concepts in my class	3.34	0.87
32.I encourage students to locate concrete concepts in my class.	3.14	0.78

Table 2 shows the summary of responses of survey questions related to responses to the second level of Bloom's Taxonomy; Comprehension. The data shows a high score on lower order thinking skills.

TABLE 3 Questions based on lower order thinking skills, Application

	M	SD
3.I support students to apply rules and principles in my class .	3.63	0.92
9..I motivate students demonstrate rules and principles in my class	3.19	0.67
15.I encourage students to translate rules and principles in my class.	3.06	0.86
21.I support students to manipulate rules and principles in my class	3.57	0.98
27. I promote students practise rules and principles in my class	3.48	0.76
33.I encourage students to illustrate rules and principles in my class	3.59	0.84

Table 3 shows the summary of responses of survey questions related to responses to the third level of Bloom's Taxonomy; Application. The data shows a high score on lower order thinking skills.

TABLE 4 Questions based on higher order thinking skills, Analysis

	M	SD
4.I help students to distinguish rules and principles in my class .	2.34	1.03
10..I motivate students differentiate rules and principles in my class	2.44	1.17
16.I encourage students to compare rules and principles in my class.	2.14	0.84
22.I allow students to contrast rules and principles in my class	2.61	1.13
28 I let students critique rules and principles in my class	2.88	0.78
34.I encourage students to examine rules and principles in my class	2.16	0.86

Table 4 shows the summary of responses of survey questions related to responses to the third level of Bloom's Taxonomy; Analysis. The data shows a low score on higher order thinking skills. In other words, even though many critical tasks appeared to have occurred regularly, higher order thinking skills were not taught in the class.

TABLE 5 Questions based on higher order thinking skills, Synthesis

	M	SD
5.I plan activities that will encourage students to do problem solving in my class	2.04	0.87
11.I set activities that will encourage students to propose problem solving in my class	2.16	0.67
17.I develop activities that will motivate students to design problem solving in my class	2.43	0.75
23.I arrange activities that will help students to arrange problem solving in my class	2.56	1.03
29.I design activities that will support students to modify problem solving in my class	2.96	0.78
35. I design activities that will promote students to organise problem solving in my class	1.68	1.01

Table 5 shows the summary of responses of survey questions related to responses to the fifth level of Bloom's Taxonomy ; Synthesis..The data shows a low score on higher order thinking skills. In other words, teachers rarely use opportunities to synthesize information.

TABLE 6 Questions based on higher order thinking skills, Synthesis

	M	SD
6.I produce conditions within which students evaluate their cognitive strategy	1.65	0.76
12.I create situations within which students rate their cognitive strategy	1.67	0.65
18.I make circumstances within which students judge their cognitive strategy	2.14	0.77
24.I arrange environments within which students justify their cognitive strategy	2.58	1.02
30.I construct situations conditions within which students summarize their cognitive strategy	3.02	0.86
36. I make settings within which students asses their cognitive strategy	2.86	0.63

Table 6 shows the summary of responses of survey questions related to responses to the sixth level of Bloom's Taxonomy; Evaluation. The data shows that teachers created situations where their students sometimes practised certain levels of evaluation processes especially, summarise and assess. However, students rarely evaluated or rated their cognitive strategy.

DISCUSSION AND CONCLUSION

The purpose of the study was to determine whether higher education teaching methods in Kottayam district were driven by lower order thinking skills related to the first three levels of cognitive domain of Bloom's Taxonomy characterised by knowledge, comprehension, and application. The findings showed that teachers of higher education at Kottayam district were not accustomed to teaching higher order thinking skills associated with the next three levels of Bloom's original Taxonomy, characterised by analysis, synthesis, and evaluation. As shown in the findings from this qualitative analysis ,teachers of higher education at Kottayam district almost unanimously taught lower order thinking skills, which is based on idealistic philosophy of Indian culture. In Indian tradition teachers are regarded as unchallengeable authority who rely on lectures and focus on best exam results. For centuries teachers of higher education have not deviated from the traditional instructional approach. Higher education teaching strategies should include self-regulatory learning methods, compiling personal learning journals, relying on open ended discussion methods etc.

REFERENCES

- Basterfield ,D.H.,C.B.&et al.(2008). "Totall Quality Management",Pearson Publishers, 3rd edition:13.
- Charantimath, P.M.(2009). "Total Quality Management" ,Dorling Kindersley Publishers:6.
- Higher Education In India: Issues,Concerns and New Directions,2003, Recommendations of UGC Golden Jubilee Seminars-2003 Held At Eleven Universities in India ,UGC, New Delhi.
- Krishnan,A. (2011). "Quality in Higher Education: Road to competativeness for Indian Business Schools" ,Vol.1:1-14
- Pour M.H., Yasodhara,K..,TotalQuality Managenent Management (TQM)in Education-Perception of Secondary School Teachers":1-2, available on http://www.cloudeea.com/index.php?s=tqm%20for%20 training.
- Higher education in India Philip G. Altbach , April 12,2005.http://www.hindu.com/2005/04/12/stories/2005041204141000.htm. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1063601
- Analysis of Present System & Higher Education in Indiaby TA Ramesh February 3, 2007, http://www.boloji.com/analysis2/0181.htm
- Philip G Altbach, The title of their article in International Higher Education is"India's Effort to Join 21st Century Higher Education". INDIA: Effort to join21st Century highereducationhttp://www.universityworldnews.com/article.php?story=20090108193113947
- Pawan Agarwal (2006), ED200145 - Problems of Higher Education in India. An Approach to Structural Analysis and Reorganization .http :// eric.ed. gov/ ERIC Web Portal/custom/portlets/recordDetails/detailmini.jsp?_nfpb=true&_&ERICExtSearch_SearchValue_0=ED200145&ERICExtSerch_SearchType_0=no&accno=ED200145, ICRIER Working Paper No. 180

Metacognitive Awareness of Science Students at Secondary Level: An Experimental Analysis

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ABSTRACT

We are living in a world of scientific discoveries. There is application and influence of science in every field. Understanding the concepts and theories of science is a growing necessity. Science education develops certain abilities which every human need like, reasoning, curiosity, creativity, scientific attitude, problem solving approach etc. Metacognitive practices enhance student abilities to apply their learning in new contexts (Brown 1984). Pintrinch (2002) argues that "students who know about different kinds of strategies for learning, thinking and problem solving will be more likely to use them, not just practice them". Metacognition helps students to recognize their strength and weakness in every field of their life. In the present study investigators tried to analyse metacognitive awareness of secondary school students in their science class room based on co operative and activity based learning instructions. Experimental method was used to study the problem. Sample consisted of 180 secondary school students of Kottayam District of Kerala, India. In the present study investigators used Metacognitive Awareness Inventory designed by Schraw and Dennison. The study showed that students who received co operative learning strategy had improved their metacognitive awareness than those who received activity based learning.

Keywords: Metacognitive Awareness, Cooperative Learning, Activity Based Learning, Secondary School Students

Introduction:

Science is of great importance for people and society that people live in an "age of science". Canon Wilson a famous educationist in 1867, in support of inclusion of science as a school subject wrote "Science teaches what evidence is; what proof is". We are living in a world of scientific discoveries. There is application and influence of science in every field. Understanding the concepts and theories of science is a growing necessity. Science as a field of knowledge influenced our existence, culture and civilization. It is the building block for personal and social development and its products advances human society and offer prosperity (Cobern, 1998).Because of the utility and significance of science, importance of science education has tremendously increased.

Science education develops certain abilities which every human need like, reasoning, curiosity, creativity, scientific attitude, problem solving approach etc. Science and technology education is the backbone of a countries' economic stability and growth (Kalra,1972). Scientifically literate peoples all over the world are known to be more reliable in decision making areas like agriculture production, nutrition and health, land and resource management, population control and industrial growth.

As a result of education students should gain certain thinking skills and strategies which will be useful to their lives rather than storing information. Education should enable children, how to learn, how to remember, how to motivate themselves and how to control their own learning so that they can teach how to learn. Training in metacognitive skills will help them to acquire these functions of education. Apart from these academic benefits, metacognitive approach has been found to promote self esteem, and improved attitudes towards school and peers (Magno,2001).Kramarski et al (2004)found that different metacognitive strategies can be employed to help low ability students to improve achievement, who had difficulties making success in the traditional classroom .In general, metacognitive strategies can be said to lead to the promotion of critical thinking ,reasoning, and problem solving behaviour (Shiela,1999;Lippman,2005;Coutinbo,2007).

METACOGNITION:

Metacognition is a new concept in the field of educational psychology. Metacognition is a word denoting awareness of one's own thoughts. It enables the student to become a successful learner and is associated with intelligence. Metacognition is a higher order thinking skill involving active control on cognitive process while learning occurs. It is the "thinking about thinking" helping learners in 'learning how to learn" . More precisely it is the mental activities used to plan, monitor and assess ones understanding and performance. It also includes awareness about one's thinking and learning and oneself as a thinker and learner.

Metacognitive practices enhance student abilities to apply their learning in new contexts (Brown 1984). Pintrinch (2002) argues that students who know about different kinds of strategies for learning, thinking and problem solving will be more likely to use them, not just practice them". Metacognition helps students to recognize their strength and weakness is every field of their life. This knowledge will help them to expand the extent of their ability. According to Bransford (1984) "those who know, strength and weakness in their areas will be more likely to actively monitor this learning strategies and resources and assess their readiness for particular tasks and performances". According to Schraw and Dennison (1994) "Metacognition refers to the ability to reflect upon, understand and control one's own learning". Flavell (1979) defined metacognition as "individual's awareness of how he learns and what he does".

Conceptions of Metacognition:

Mental processing of information is known as cognition, it is the function of human mind which allows perceptions to grow into conceptions. Control over our own cognition is known as metacognition. It involves both monitoring and regulations of one's own thinking process. It is a conscious verification of one's own cognition to expand knowledge. A metacognitive skill acts as predictors of academic achievement. It is related to all areas of learning like, communication, reading, comprehension, language acquisition, social cognition, attention, self control, memory, self instruction, problem solving and personality development (Cooper , 1999).

James in 1911 considered cognition and metacognition as two processes of mental mechanics. Dewey asserted that learning is an action process involving assimilation from within. He concentrated on the inductive process of learning through observation. He gave a scientific outlook of metacognition. According to him metacognition of reflective thinking occurs by two processes, first a conscious recognition of doubt and feeling a state of restlessness, second involving in an active process of induction by searching and inquiring to solve the difficulty or doubt. Dewey gave an early conceptual frame work of metacognition by describing it as self monitoring and self regulation process. Piaget (1980- 1996) coined the term "consciousness of cognizance" for metacognition. He studied metacognitive activities of young children and noted that, they are doing mental activities in the direction of metacognition but are unaware of that.

Components of Meta cognition:

Metacognition is classified into three components, metacognitive knowledge or metacognitive awareness, metacognitive regulation and metacognitive experiences.

Metacognitive knowledge or metacognitive awareness:

Metacognitive knowledge is what individuals know about themselves and others as cognitive processors. It is divided in three categories knowledge of person variables, task variables and strategy variables. Flavell stated that all these variables overlap and combine when an individual works. Result of that work is due to the interactions of the various variables and metacognitive knowledge available at that particular time.

1. Person variables: It refers to the knowledge about one's own learning processes as well as other people's learning processes.
2. Task variables: It includes knowledge about the nature and characteristics of a task and how to manage the task. This helps the individual in successful completion of the task.

3. Strategy variables: This includes the knowledge and identification of metacognitive strategies and using it appropriately and effectively.

Metacognitive awareness is of three types:

Declarative knowledge It is also known as world knowledge. It is the knowledge about the factors which can influence one's own learning or performance. This is the actual knowledge which are knows as written or spoken.
Procedural knowledge: is the knowledge about how to do something. One who possesses a clear procedural knowledge can perform the tasks automatically. This is done by effective use of various strategies. This involves abilities like identifying the task, checking the progress of task, evaluating, predicting the outcome allocating of one's own resources for the task , determination of order or sequences of activities for the completion of task etc.
Conditional knowledge: It is the knowledge about when and why to use declarative and procedural knowledge. This knowledge helps the students to use strategies more effectively. This allows maximum utilization of their resources for learning.

Metacognitive regulation:

This is the second component of metacognition. It refers to the monitoring and control of one's cognitive process during learning (Nelson & Narens, 1990). Through this one can regulate one's own cognition and experiences related to learning through prescribed activities. This includes activities like; oversee learning, planning and monitoring activities related to cognition, monitoring the outcomes etc. The sub components coming under metacognitive regulation is planning, information management strategies, comprehension, monitoring, de bugging strategies and evaluation.
Planning: This involves cognitive activities done prior to learning like, planning, goal setting, collecting resources etc.
Information management strategies: This involves effective sequencing and processing of information, which is a key element of metacognition. Some activities are organising, elaborating, summarising and selective focussing.
Comprehension Monitoring: It is self evaluation or assessment of one's own learning or use of a particular strategy.
Debugging Strategies: This denotes the diagnosis and remediation of one's own strategy use. This is used to correct comprehension and performance errors.
Evaluation: This is the evaluation of performance and strategy use after a learning episode.

Metacognitive experiences:

These are experiences which help current ongoing cognitive work. These experiences always occur after a cognitive activity. Metacognitive experience involves the use of metacognitive strategies or metacognitive regulation (Brown, 1987). Metacognitive strategies are essential processes that a person uses to control cognitive activities and to make sure that a cognitive goal has been achieved. Metacognitive experience helps a person to process information, memories or other earlier experiences, to recall and use them as resources in processing or solving a current cognitive problem. It is also affected by certain affective responses like success or failure, frustration or satisfaction, and many other responses that effect a person's willingness or interest to do similar tasks in future.

Objectives of the study:

- To compare the effectiveness of activity based learning and co operative learning based instructions in science class on the metacognitive awareness of secondary school students.
- To compare the effectiveness of activity based learning and co operative learning based instructions in science class on the metacognitive awareness of low ability secondary school students.

Hypothesis of the study:

- There is no significant difference between metacognitive awareness of pre test mean scores achieved by Experimental group and control group.
- There is significant difference between post test scores of metacognitive awareness among control group and Experimental groups who received co operative learning and activity based learning instructions.
- There is significant difference between post test scores of metacognitive awareness among control group and Experimental groups of low ability students who received co operative learning and activity based learning instructions.

Design of the study:

The research was carried out using a quasi–Experimental design with pre and post tests with two Experimental groups and one control group .Secondary school students from NSS Boys High School Perunna of Kottayam District, Kerala, India were taken as the sample for the study. The sample was divided into three groups consisting of 50 students. Each group was almost having equal number of low ability students and high ability students. Those students have scored below 18 out of 50 in science in school record are treated as low ability students. Remaining students are treated as high ability students. The three groups were first administered a Metacognitive awareness test and the results have been compared in order to study the equivalence of the groups.

Tools for the study:

For testing the metacognitive awareness of secondary school students, Metacognitive Awareness Inventory made by Schraw and Dennison (1994) was used in the study. The tool consists of 52 items.

Statistical Techniques:

Both inferential and descriptive statistics were used for analysis of the data. In descriptive statistics Mean, and Standard Deviations were used. In inferential statistics, t test was used to test the data .

Procedure of Experimental study:

The researcher had gone through the 10th standard text book of State Council for Research and Training of Kerala Government. The chapter “Genetics for Future” was selected for the study. The study consisted of three different treatments: a control group ,activity based metacognitive instruction group and collaborative learning based metacognitive instruction group. The study lasted for 15 days. The control group was taught by lecturing method of teaching followed by question and answer sessions related to the content. It was truly a text book based instruction and individual assignments were given to students.
The Experiment group 1; followed co operative learning based metacognitive instruction. After an introductory description about the topic teacher asks the students to pair with a class mate to discuss about the topic with the help of text book through metacognitive instructions. Co operative learning strategies based on metacognitive instruction was included; defining what students know and what they do not know, talk about what children are thinking, keeping a diary of thinking, planning and self control, thinking process briefing, self assessment (Blakey and Spence,1990).All these strategies help the students to regulate control and evaluate their learning.
The Experiment group 2 ; metacognitive instruction based on activity based learning group, followed learning based on different kinds of activities. Group activities were planned scientifically for each sub topics. After each activities a review session has arranged for discussion ,conclusion and evaluation of activity procedures. Every group in the class shares their experiences with their class mates. It forces a student to analyse their thinking and express their opinions in the class. This session is mediated by teacher intervention ;by providing clarifications and asking questions etc.

Analysis and Interpretation of data:

Table 1: Comparison between control and Experimental group in Metacognitive awareness pre- test

Group	N	Mean	S.D	't' value	Remarks at 0.01 level
Control group	60	22.8	7.1	0.76	Not significant
Experimental group 1 (Activity based learning)	60	24.3	6.8		
Control group	60	22.8	7.1	0.45	Not significant
Experimental group 2 (Co operative learning)	60	23.6	7.2		

From Table 1, there is no significant difference between metacognitive awareness pre test mean scores achieved by Experimental group and control group.

Table 2: Comparison of Metacognitive Awareness test score using paired t test

Group	N	Mean		S.D		't' value	Remarks at0.01 level
		Pre test	Post test	Pre test	Post test		
Control group	30	22.8	24.2	7.1	5.3	2.1	NS
Experimental group 1 (Activity based learning)	30	24.3	31.1	6.8	4.3	5.5	S
Experimental group 2 (Co operative learning)	30	23.6	36.6	7.2	3.7	7.1	S

NS- Not significant S-Significant

The observed't' value of control group was 2.1 .Hence there is no significant increase in metacognitive awareness in control group. In the Experiment group 1 the value was 5.5.It shows that there is significant important in metacognitive awareness in Activity based learning. In the Experiment group 2 the t value was 7.1.It shows that there is significant improvement in metacognitive awareness in co operative learning. The results revealed that co operative learning group received higher metacognitive awareness and they could also answer higher level of cognitive questions compared to activity group and control group.

Table 3: Comparison of Metacognitive Awareness test score of low ability students using paired t test

Group	N	Mean		S.D		Paired 't' value	Remarks at 0.01 level
		Pre test	Post test	Pre test	Post test		
Control group	30	15.3	24.1	4.1	3.5	1.8	NS
Experimental group 1 (Activity based learning)	30	16.2	23.6	4.3	3.2	2.2	S
Experimental group 2 (Co operative learning)	30	15.8	31.6	4.2	2.7	7.7	S

NS- Not significant S-Significant

The observed t value of the control group was 1.8. Hence there is no significant improvement in metacognitive awareness low ability students in the conventional lecture method. In the Experiment group 1 the t value was 2.2 .It shows that there is no significant improvement in metacognitive awareness of low ability students in activity based learning .In the Experiment group 2 the t value was 7.7.It indicates that there is significant increase in the metacognitive awareness of low ability students of co operative learning group.

Conclusion:

The findings of this study have demonstrated the effectiveness of two different methods to promote metacognitive awareness in the teaching learning of science at secondary school level.This study is also significant in that it demonstrated the effects of activity based learning and co operative learning on student's metacognitive awareness .One major finding of this study is that students taught using the co operative learning approach scored higher mark than those taught using activity based method. This may have been achieved by the high level of student's participation in learning activities. When learners are faced with problems which they must solve, they are forced to reason and think critically in order to solve the problems. It is believed that when properly and carefully used metacognitive activities engage the students in the learning process; improves the critical thinking, reasoning and problem solving skill of learners (Tylor,1999;Coutinbo.2007,Magno,2010).Teachers must improve their student's metacognitive awareness in order to improve their learning abilities. "The more students know about effective learning strategies, the greater their metacognitive awareness and the higher their classroom achievement is likely to be" (Mango ,2010)

References:

Blakey M, Spence S (1990). Developing Metacognition. Syracuse, NY: ERIC Resources Information Center[ED327218].

Brown AL (1980). Metacognitive Development and Reading. In R.J. Spiro, B. Bruce, W. Brewer (Eds.),Theoretical Issues in Reading Comprehension. Hillsdale, NJ: Lawrence Erbaum

Brown, A. L. (1987). Executive control, self- regulation, and other more mysterious mechanisms. In F. Weinart &R. Kluwe (Eds.), Metacognition, Motivation and Understanding (pp 65-116). Hillsdale,NJ: Erlbaum.

Candan AS (2005). Metacognitive Theory and History Teaching. Kastamonu Educ. J., 13 (2): 327-332.

Coutinbo, S.A.(2007). The relationship between goals, metacognition and academic success. *Educate*, 7(1), 39-47.

Ellis, G. (1999). Developing metacognitive awareness-the missing dimension. The Journal, 10, 1-6.

Flavell JH (1976). Metacognitive Aspects of Problem Solving. In L.R. Resnick (Ed.), The Nature of Intelligence.

Hillsdale, NJ: Lawrence Erbaum.Hartman, H.J. (2001). Metacognition in learning and instruction, theory, research and practice, Hillsdale, NJ:Lawrence Erlbaum Associates, Inc.

Kramarski, B., Mavrech, Z. R & Arami, M. (2004). The Effects of metacognitive instruction on solvingmathematical authentic tasks. *Educational Studies in Mathematics*, 49, 225-250.

Lin, X.D. (2002). Developing students' metacognitive awareness in asynchronous learning networks incomparison to face to face discussion groups. *Journal of Educational Computing Research,* 36(4), xxx.

Lippmann, R. (2005). Analyzing students' use of metacognition during laboratory activities. *Learning Individual differences*, 14, 131-137.

Magno, C. (2010). The role of metacognitive skills in developing critical thinking. *Learning, Memory, and Cognition*, 36(1), 255–262.

Ozsoy G (2008). Metacognition. Turkish Educ. Sci. J., 6 (4): 713-740.

Taylor S (1999). Better learning through better thinking: Developing students' metacognitive abilities", J.College Reading and Learning, 30(1): 34.
