Multidisciplinary Teaching for Developing Concreteness of Abstract Concepts in Science

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ABSTRACT:

Every Discipline taught in school is equally important, as it necessitates learning for leading a comprehensive living. Knowledge about the core concepts learned during schooling along with their application eases our living. Disciplines having concrete objects to associate with learning can be transacted faster than those like Science and Mathematics which have based on an abstract premise. Using an appropriate pedagogy and engaging the students in learning, leads to a valuable outcome is the aim and vision of education. The pedagogical approach used for the transaction should be attractive, engrossing, and interesting for students to completely involve themselves in learning as well as dwell deep into the subject matter. Lest the teacher creates interest in the students' minds, the disciplines fail to create interest in the learner. The responsibility of teachers to catch young minds into learning abstract disciplines is much higher than building superficial knowledge. Teacher and their pedagogy should be connected to students learning to make it a joyful, meaningful, and valuable experience. This research paper encompasses empirical pieces of evidence to understand how concreteness can be brought about the abstract concepts, making students enjoy abstractness while helping students reach a higher level of abstractum.

Key Words: Concreteness, Abstract Concepts, inquisitiveness, critical thinking, Joyful and Meaningful Learning

1. INTRODUCTION

"Knowledge emerges only through invention and re-invention through the restless, impatient, continuing hopeful inquiry human beings pursue in the world,with the world, and with each other" - Paulo Freire (1973)

Knowledge is abundantly available in the world. Seekers chase it according to their interests and needs, either for physical, cognitive, or economic stability and sustainability. The ideas and disciplines that interest each seeker depends on the interests developed in any individual as a learner during schooling. The teacher develops love, interest, and passion for the discipline being taught by incorporating them during transactions. The level of understanding attained by each learner in acquiring knowledge develops their thought process for the disciplines through critical thinking leading to analysis of knowledge gained and knowledge available in the surrounding. Thus, begins the development of concreteness of the abstractum from surroundings.

According to the dictionary, Concrete means seeing and feeling things that are definite or real. Concreteness in its noun form, usually used in education and teaching, refers to the cognitive understanding of abstract concepts as though they are real and definite. Etymologically, it means adhering to the concrete construal of things. Learning begins by holding, touching, and feeling objects through physical analysis. The cognition gained in the concreteness of physical appearance induces the mind to think more about its composition and make. This thought process is abstract, about imagining something that has not yet been seen or felt. If it is an apple or an orange, one can cut it open, reveal the concrete inside, and establish the concreteness of the abstract idea. According to the dictionary, abstract refers to an idea, a theory, or a thought in the mind without a physical or concrete existence or a conception. In teaching disciplines like Science, Mathematics, Statistics, etc., the abstract is not there to be seen or felt nor can the concreteness be physically felt. Understanding those concepts is equally important, but poses the challenge of bringing concreteness in learning for those abstract ideas andthinking. (Jackson, 2012)

The usual delusion of the meaning of concrete and abstract lies in the fact that concrete is anything that one can physically feel or hold while abstract is a thought. During teaching, it is expected that the teacher should and must proceed from things physically felt concreteness - to the understanding - which is the goal - to be achieved - in the form of abstraction. Concrete or concreteness does not and cannot be referred to as a 'thing only' without any thought process attached to it and the attachment of the thought process is not the abstractness to be achieved. Concreteness is not the physical perception of an object without any cognitive involvement in its perception; on the contrary, the cognition achieved after attaching the thought process for understanding without the object's physical presence is termed abstractness, presuming the goal as acquiring knowledge and learning abstractum. (I*bid.,* Pg 136)

Casually, the direct and indirect understanding is also bridged to concrete and abstract knowledge. In education, especially in teaching-learning, concrete and abstract are not directly utilized, it is in their noun form as the concreteness and abstractness that the teaching-learning is carried forward. (I*bid.,* Pg 137)

Concreteness does not always denote something physical. Concreteness in education refers to the mental concreteness where the learning has occurred. It is the mental ability of a person to understand an idea as though it is happening physically and can visualize it occurring incognito spatially. Each person has a different level of concreteness in each discipline. None is all perfect to understand the abstractness in all folds of life. We can now understand that concreteness is nothing but the ability of every student to understand the concept taught and apply it to use in their daily life. Logical thinking helps one to attain the concreteness of abstractum. There is no definite time limit or a pattern that each can follow to attain the concreteness of all or any abstractness. It depends on how things are presented, how the person can perceive them, and the ability of the mind to inherit the learning in bringing concreteness to abstract ideas. It could be as simple as understanding the concept of breathing or could be as difficult as understanding the physiology of the human body. It is indeed a stepwise process where the concreteness of one topic brings more inquisitiveness leading to abstract knowledge furthering the learning. When the learning abstract knowledge has occurred, it has reached the mental concreteness leading towards higher abstractum and knowledge in the field. This in a way, helps to attain a higher level of cognition and thus leads to creating more knowledge, be it new or renewed. (I*bid.,* Pg 138)

Abstract on the other hand is merely theoretical, least associated with the practical aspect of its application. An abstract thinker develops theoretical ideas without involving in the practical aspect or difficulties in the application of the theories developed. The concreteness of the abstractum achieved is

only in the mind of the thinker rather than analysis and empirical performance of the same. Is developing abstractum more important than achieving concreteness or achieving concreteness be equally important? Without abstractum, many theories would have not been developed, of which, concreteness is now being achieved after centuries of abstract theory development. Moreover, the concreteness achieved may or may not be used in the same discipline or context but has been utilized in a very different context for an altogether different purpose and use. (I*bid.,* Pg 138)

"Many notions of science are abstract, not only because they cannot be understood without a long apprenticeship in the science (which is equally true of technical matters in the arts), but also because the whole content of their meaning has been framed for the sole purpose of facilitating further knowledge, inquiry, and speculation. When thinking is used as a means to some end, good, or value beyond itself, it is concrete; when it is employed simply as a means to more thinking, it is abstract." (Jackson, 2012)

2. THEORETICAL BACKGROUND

The mind and thinking are the bridge between the concrete and the abstract. After developing an abstract theory, if it is used to achieve an end goal of understanding and applying to use through thinking and application of the same cognitively leading to the concreteness of the concept. The abstract used to develop more theories and higher cognition is still abstract. Joyful and meaningful learning is attached to both concrete and abstract learning. It is an important and integral part of learning. The ability of every individual to attain concreteness or understand the abstract concept is different. While some of us enjoy learning with the senses using touch, sight, feel, odour, or hear, others might just get mesmerized by the thought and the way things proceed further. The ability of the mind to construct incognito helps the learner enjoy abstract thinking and learning even without achieving the concreteness of the same. The decisive factor here is the level of cognition the learner has accomplished. Attaching meaning to learning associates joy with learning increases inquisitiveness, and paves path for higher learning. (Jackson, 2012, Pg 139)

"The history of the more mature sciences shows two characteristics. Their original problems were set by the difficulties that offered themselves in the ordinary region of practical affairs. Men obtained fire by rubbing sticks together and noted how things grew warm when they pressed on each other, long before they had any theory on heat. Such everyday experiences in their seeming inconsistency with the phenomena of flames andfire finally led to the conception of heat as a mode of molecular motion. But it led to this conception only when the ordinary phenomena were reflected upon in detachment from the conditions and uses under which they exhibit themselves in practice. There is no science without abstraction; abstraction means that certain occurrences are removed from the dimension of familiar practical experiences into that of reflective or theoretical inquiry." Dewey, J. (1929)

The aim of the foundation for every discipline at all levels of learning is to help the students achieve concrete knowledge, understand the concreteness of the abstractum and accomplish the level of incognito abstract understanding. A learner reaching this level of understanding by the end of secondary education has matured as a learner who can adopt and adapt any or every knowledge present around self, invariable of the disciplines, leading to a multidisciplinary approach and thought process in learning and developing knowledge. As the saying goes, "the wider the foundation, the stronger the structure" is perfectly correct in the field of education as well.

Emphasizing on inculcation of constitutional values, ethics, equality, equity, humanness, and respect for diversity in all spheres of education should become a part and parcel of lesson planning along with the transaction of the concepts while teaching. Promoting multilingualism and realizing the power of being multilingual in local and global languages would help understand the culture and history, paving the way for implicit learning, rediscoveries, and inventions bringing epiphanyinto numerous students' inquisitive minds. (NUEPA, 2020)

Aim For Teaching Science:

'Science and everyday life cannot and should not be separated" - Rosalind Franklin, Chemist

The basic aim of teaching Science as a discipline lies in the fact that the knowledge of facts and principles deciphered to date are imparted to the students along with the knowledge of their application following the cognitive development and understanding, at every stage of learning. During this process,

the teachers must develop in themselves and their students, skills, and capacity for understanding the discipline matter for learning, so that the thought process always synchronizes with the teaching-learning, enabling the student to develop awareness and inquisitiveness towards further developments in the field. (NCERT, 2019) (Pal, Yash, and et, 1962)

The foundation of any discipline should be laid such that the students learn toquestion and validate every fact and every solution provided to them, thereby creating scientific knowledge in their minds about the existing knowledge leading to Scientific Temperament.

Learning of Science and scientific development are societal needs for the development and progress of every society. The better the understanding of the self and surroundings, the better the standard of human life in terms of environment, health, andsustainability.

Developing and nurturing the aesthetic sense, creativity and natural curiosity toward science and technology is a chief requisite in the making Scientists of young learners. Science also has its way of inculcating humane values like cooperation, co-existence, honesty, integrity, perseverance, etc., as man is a social being. (NCERT, 2019) (Pal, Yash et, 1962)

By cultivating 'scientific temper in the form of objectivity, critical thinking, and freedom from fear and prejudice, Science as a discipline and its teaching is an integral part of the development of any nation. Science as a discipline in the school curriculum is more a developer of scientific and researchable skills rather than byhearting theories and solutions. This is more so the reason for the teachers to have a role modeling personality to get students' attention and transact the curriculum in such a way that it imparts love for the discipline, increases interest in it, and uses the vocabulary in their everyday conversations proving and improving their learning (Position Paper for teaching of Sciences, NCF 2005) (NCERT, 2019) (Pal, Yash, and et, 1962)

Importance in Pedagogical Integration of Science and Mathematics:

"There are four great sciences ... Of these sciences, the gate and key is Mathematics, which the saints discovered at the beginning of the world" - Roger Bacon (1214- 1294)

Scientists and Mathematicians are an integral part of the development of a country as its development depends on the quality of progress in the discoveries and inventions in them. Teachers and parents are both to be sensitized for fostering, identifying, and recognizing the unique capabilities of every student providing the best of opportunities during their studentship. Flexibility to choose their trajectory for learning, and working according to their capabilities and understanding, is of utmost importance for every student as it provides a strong base in learning every discipline. Enhancing holistic, multidisciplinary learning without any hardcore separation betweendisciplines is important. Disciplines like Science and Mathematics are so interrelated that it is impossible to keep them separate. The students at the primary level fail to differentiate between the two disciplines due to strong inter-connectivity between them. (Ministry of Human Resource Development, NEP 2020)

The interdisciplinary spectrum between Science and Mathematics also leads to creativity and enhances critical thinking. Motivated by the student's inability to integrate existing mathematical skills into Biological aspects wherever integration was necessary, a study titled "Integrating Quantitative Thinking into an Introductory Biology Course Improves Students' Mathematical Reasoning in Biological Contexts" was undertaken by Susan Hester, SanlynBuxner, Lisa Elfring, and Lisa Nagy in 2017. In their study, they found that the inability in the undergraduates' stemmed from their high school stage where Math as a discipline posed problems along with the pedagogy which never supported the integration of the two. During graduation, when Mathematics as a discipline is left far behind by the students of Life Sciences, even simple concepts posed evident difficulties in applications and integration. During their research, they developed an integration course for the introductory biology course and found that those students who attended the course were able to perform better in the quantitative analysis of their study. After analyzing the concepts which needed integration of Biology and Mathematics, they developed modules for teaching, taught them, and analyzed with a pre and post-test. The study proved that there is a need to develop the skill of integrating mathematical skills into biology and that it does not happen automatically just because the students are good in both the disciplines i.e., Mathematics and Biology. (Hester et al., 2014)

Developments in the field of Science, Technology, Engineering, and Mathematics have given rise to many new career opportunities and new wings in the field of Life Science as well. The demand of such courses is the ability of a learner to adapt and analysis with an interdisciplinary dimension of Life Science knowledge with Mathematics, Physics, Chemistry, and Technology. Unless the interdisciplinary aptitude

is introduced young and developed in the learner from the formative years, it is difficult to incorporate into Higher education where research is an undivided part of the study. Fostering interdisciplinary competency among not only Biologists but in all disciplines, is the need of the hour as the developmental tangent takes a sharp shift in building new knowledge, discoveries, and inventions based on multidisciplinary thinking right from sustaining life to the environment and daily livelihood. (Feser et al., 2013)

"What attracts students to mathematics, physics, and engineering tends to repel students who are interested in biology. The division between disciplines among the different groups of students is usually established by the time they reach high school. This is the fundamental obstacle that must be overcome". In this study, a course called "Dynamics of Biological Systems" was developed attempting to bridge the gap between biology, math, physics, and engineering, in their concepts and tools, which were been taught to all students be it from biology, engineering, math or physics disciplines. The rationale for the course was that unless a person has some mastery of these different areas, it will not be possible to fully integrate them. The study concluded that it was a difficult task as it required rigorous work in continuum from both the faculty and the students for successful learning. (Chiel et al., 2010)

Developing connections between Science and Mathematics, especially Life Science demands teaching faculty who have in-depth knowledge in both fields and can connect the curriculum content with life examples so that the students are also able to get an insight into the interdependency of the multidisciplinary approach. "Connecting Biology and Mathematics: First Prepare the Teachers", reveals the importance of beginning the multidisciplinary aspect and interconnection of disciplines as early in schooling as possible so that the mind gets trained according to the necessities, requirements, and relevance for each of the concepts accordingly. When knowledge of each discipline is divergently developed without connections, later conjoining the concepts would work superficially rather than in-depth. The best options should be at elementary and secondary levels where the inquisitive minds are eager to learn and fastto grasp. The study concludes that trying to connect the two disciplines in higher education is not up to the requisites or can also be a failure as many Life Science students take up the discipline as they are interested in learning Science without the interference of Mathematics. Thus, the interdisciplinary aspect of teaching Science and Mathematics at the foundation level in the schools should become an integral part of pedagogy and teachers should be equipped with such kind of knowledge to develop them in their students. "Because teachers are the most important factor in schools, the introduction of any new trend should start with them." (Šorgo, 2010)

3. METHODS AND MATERIALS:

Methodology:

The research question stemmed from students' disinterest in choosing science in higher education. The objective of this research was to explore the teachers' ability to transact with a multidisciplinary strategy on abstract concepts included in the science curriculum in grades 6-8 for joyful and meaningful learning. The descriptive research design uses qualitative techniques for understanding and anlaysis. The first part of the research consisted of Data collection through non-participatory unscheduled observation for understanding the current practices that the teachers are using during transactions. The second part deals with the analysis of obtained data with parameters by the **SDGs** set by the **UN** for achievement before 2030 and the policies that the Indian Government has drawn for implementing the same into practices for achievement of the **SDGs**, which is the **National Education Policy2020**. Also in consideration were the **National Position Papers** written by **the Focused Group** giving guidelines for the educationists.

Population And Sample

Population in consideration for research were schoolteachers teaching grades 6-8. This stage is the most vulnerable in developing interest and inquisitiveness for learning any discipline. Developing concept clarity is the best way forwards as it ignites inquisitiveness and instigates the wandering mind to anchor into experimenting with the thought processes enthusiastically and fearlessly. As explicated by Jean Piaget, this is the stage where individuality and self-interests in a conjoined way lead to the development of coherent personality.

The sample for the study was the middle school teachers teaching grades 6-8 from Delhi-NCR region as it is the researcher's geographical location. Permission was sought from 10 schools while permission was given by only 1 school. Many schools were still conducting online mode of schooling while some of

them had a hybrid mode. The only school which was fully functional in physical mode was considered for sampling.

The school had 9 science teachers for teaching science pedagogy in grades 6-8. All the teachers and classes were considered for observation. In the given span of permission time, 10 classes were observed. 5 were considered for the study as the rest of them were repetitive classes either on topics or of teachers.

Instrument For Research

The observation was selected as the most appropriate method for understanding the current pedagogical practices used by the teachers to bring in multidisciplinary meaningful teaching-learning of the concepts. Of the participatory and non- participatory observations, the researcher chose to be non-participatory with no intentions of intervening in the class schedule. Moreover, was interested in understanding the lag and the gap rather than intervening and rectifying it.

Of the Scheduled and Unscheduled observation methods, Unscheduled observation was chosen as it provides more scope for noting down the accurate methods used by teachers without any judgment. Scheduled parametric observations would frame the observations and give little freedom for understanding the variation that every teacher would bring into the class along with their experiences. Unscheduled Observation was an apt tool as this allowed the researcher to bring out the exact classroom behavior in transaction and learning accountable. Scheduled Observation with well-defined parameters would only bring the researcher's attention to those parameters and variables that the researcher would have listed down. Unscheduled Observation gave the researcher a broader spectrum helping to note down the complete activity of the class under observation.

Procedure and Ethical Consideration:

Deciding Unscheduled Non-Participatory Observation as a tool after discussion with the guide, the focal points were validated. Permission was sought from the principals of different schools in Delhi-NCR for research observation of science teachers and the pedagogy used by them. Due to ongoing pandemic situation of online and hybrid mode schooling, only 1 school which was in complete physical mode could be observed. The 10 classes of the same school in science pedagogy with different teachers and sections were observed. Out of that 5 are considered for the study as the others were either repetitive topics or for teachers. All procedure was conducted in a natural school environment, without disturbance either to the teacher or the students or to the code and conduct of the school's schedule. The Principal, Teachers, and Students were informed about the procedure and permission sought to be present amongst them. There was no disturbance or intervention during the class transaction by theresearcher.

Data Collection and organization:

Understanding of the current practices used in the pedagogy for bringing in conceptual clarity of the abstract concepts in the teaching of science was carried out through Unscheduled Observations. As expected during the empirical study, the Unscheduled Observation brought into light many misguides and misinterpretations that the teacher themselves had acquired that were being passed on to the students likewise. The purpose was to highlight the areas where teaching needs to improve and rectification in transactions for students' learning to occur. This should also underline the importance and advocate enhancing the ability to reflect on every concept beforethe teacher ventures into transaction. During the Unscheduled Observation, the researcher was present in the classroom for the completed duration of the transaction and noted down sequentially from the teacher's entry into the class to the students' reaction, the methods of teaching, and every single point that occurred during the timeframe. Comprehensive observation brought to light many inappropriate contexts and gestures been followed while transacting but need to be changed for the good. The following 5 observations out of 10 scheduled are picked up as samples for this article in Science discipline noted during the empirical study.

Observation 1

Grade: VI

Topic: Body Movements

- An introductory class for the concept of Body Movements these were the observations:
- Teacher asked the students to make columns for noting the parts of the body and their movements as discussed, the first column was part of the body, and the second column was meant to note of type of

movement

- Starting from the head to toe, the teacher asked the students to move the part of the body in the classroom setting and analyze whether they moved or not
- The movement of their head, meant skull – analysed as the support of the neck
- Similarly, eyes, jaw (upper and lower), neck, shoulders, arms, elbow, wrists, hands, fingers, phalanges, hip bone, thigh, lower legs, ankles, knees, and toes were discussed.
- The chest, abdomen, and spinal cord were moved from the chest to the abdomen and the directions of the movement discussed
- Recapitulation of the topic was discussed by repeating the movements

Observation 2

Grade: VII

Topic: Soil

- The topic was in continuation with the previous session and so the class began withrevision in the form of few question-answers
- The home assignment given – was to prepare a content table of the soil sample thatthe students examined in their neighborhood
- Few students were asked to discuss findings
- Emphasis was on new vocabulary
- Transaction was in question-and-answer format raising inquiry and reasoning
- Students spontaneously responded to the question according to their understanding
- Analyzing the answers - plastic, glass, electric and electronic waste thrown are soil pollutants and not part of soil profile
- Discussed - living plants and animals, the parts of dead plants and animals, plant and animal waste formed "HUMUS", the topmost portion of the soil along while decomposition of the same enriched the soil
- Effect of water air and temperature on rocks forming sand
- Change in color, nature, and chemical composition of soil depended upon the rocks from which they weathered along with introduction to soil layers
- The concept of color, texture, and content of the soil change as we proceed downwards was discussed termed as the horizon, and the layers of soil are labeled as A, B, and C horizons to represent different layers and textures discussed in detail the content of each of the layers
- The bedrock was introduced consisting of big pieces of solid rocks that neither can hold the water nor do have the capacity to support plant growth as they have huge gaps between each piece of rock
- Summarizing the topic for the day the teacher wrote layers of soil as it proceeds underground and wrote the composition in the tabular form
- The students were made to repeat in chorus and to spell each word so that they get hold of the vocabulary

Observation 3

Grade: VII

Topic: Parts of the cell

- The topic was in continuation with the previous class
- Began with a video telecast for 6 minutes from YouTube explaining the cell structureand the organelles in English which was repeated for better clarity and visual memory stressing remembering the different colored organelles
- Working through a rough sketch on the blackboard from the cell membrane to the nucleus teacher explained the same
- First the cell membrane/ plasma membrane - the boundary of the cells - holding the cell content in place, and its importance in the exchange of materials like gases, wastes, and nutrients were discussed

- Sturdier outer layer when the cells are exposed to the environment for protection of the cell content was highlighted explaining need for cell walls and their importance

- Examples of whole grams soaked in water overnight and resultant swelling were discussed to indicate water absorption through the porous cell wall
- Twisted thread-like structure inside the cell was labeled as nuclear material - the hereditary material transferring characteristic features from parents to offspring
- The cell controlling functioning of the nucleus discussed
- Types of cells – prokaryotic and eukaryotic with their differences discussed
- The nucleus without a nuclear membrane is a primitive type named Prokaryotic, found in bacteria and some primitive unicellular forms and with a nuclear membrane as Eukaryotic
- Prokaryotic and Eukaryotic cell concept, the nucleus, exchange of materials from the nucleus to and from cytoplasm was discussed
- The thread-like chromosome being the genes carrying genetic/hereditary characteristics was highlighted
- The gap between the cell membrane and the nucleus - filled by jelly-like substance - cytoplasm containing many other organelles like Mitochondria, Golgi bodies, and ribosomes performing important functions of the cell was discussed

Observation 4

Grade: VII

Topic: Physical and Chemical change

- Teacher questioned the previous concept and proceeded to discuss the present topic physics, chemistry, physical and chemical
- Patiently heard each student's explanation – compiled - physics and chemistry as branches of science - physics dealing with the study of time, energy, and motion, - chemistry dealing with chemical composition of the substances and their reaction with other chemicals
- Physical and chemical were discussed in detail for students' understanding and began demonstrating the difference between physical and chemical change
- Taking a sheet of paper, tore it into pieces, and put them together like a puzzle to explain physical change where the change could either be irreversible like the torn paper, or reversible like ice-water-water vapour
- Burning torn paper in Petri Dish - chemical changes were explained - changes that have undergone a complete transformation irreversibly
- Example of water for physical change - the formation of ice - heating to water – heating to water vapor and condensing back to water, to ice as physical change with the composition of water remains H_2O
- While salt or sugar dissolved in water changes its chemical composition and so is termed as chemical change
- Class ended with a repetition of the concepts discussed for the day by putting forth questions to the students and correcting their mistakes as and when required

Observation 5

Grade: VIII

Topic: Microorganisms: Friend And Foe

- Writing CELL and MICROORGANISMS on board discussed the meaning, similarities, and differences between the two words
- Discussion led to bacteria, viruses, fungi, unicellular, multicellular organisms present in the air, water, soil surrounding us, seen only with the help of a microscope – thus microorganisms or shortly called microbes
- The concept of even multicellular organisms not visible to the naked eyes and that it takes a

congregation of lakhs of cells to be seen eyes collaborated

- Later virus, bacteria, and fungi – nature of prokaryotic and eukaryotic cells was discussed

- Virus forming the bridge between the living and the non-living - inactive in environment -entering living organism drains the host cell for life support was discussed
- Bacteria most primitive form of cell without a well-defined nucleus - a few species with a well-defined nucleus
- Fungi as a group of cells with many nuclei in one cell termed multinuclear/multinucleated along differences from bacteria and virus – the habitat of the fungi only found on land was highlighted - devoid of pigmentation dependentson other organisms for food
- Algae and protozoa were introduced stressing spelling
- Algae as the unicellular organisms - with chlorophyll - green silky layer around the tank bottom and lake bottom, produces food - forming primary members of the food chain
- Protozoa as the unicellular animals - lacking chlorophyll and their dependency on food
- Two as separate kingdoms in the 5 kingdoms' division
- Broad spectrum of how useful or harmful can these organisms/microbes are to the plants and animals was discussed before ending the class with a recapitulation

Data Analysis and Interpretation:

"The enchanting charms of this sublime science reveal only to those who dare to go deeply into it."
— Carl Friedrich Gauss

The Unscheduled Observations undertaken by the researcher brought to theforefront many such practices that teachers follow in teaching which are followed from time unnoted but, not the best of practices. The research helped in highlighting such practices and analyzing the importance of changing for a better pedagogy so that the learners are benefited. Each of us as teachers needs to analyse the transaction of the concept and the way the learner has absorbed the same. Either in-class assignments or through the formative or summative assignment, it is the teachers' responsibility to analyse the misunderstood concepts and rectify the same. Assignments are not forgrades and marks but for analyzing whether the concept has been learned and is the learner able to apply it to use.

Parameters Considered for Analysis:

The analysis of the observation was done considering the following parameters intoconsideration:

- Teacher's involvement in transacting the concept
- Students' involvement in learning
- Learners' concept clarity
- Participation of all the students – class as a whole
- Critical thinking and inquisitiveness developed through the concept
- Relation to life experiences with hands-on experience in a multidisciplinary outlooktoward concepts
- Rediscovering and Reinventing
- Human values – ethics – morals involved in the concept
- Requisite of the Sustainable Developmental Goals in Education

Analysis of Observation 1

Grade: VI

Topic: Body Movements

- Introductory class at the end of the day had its effect on teaching-learning and the depth with which the transaction was done seemed lower even though the teacher did put as much life possible into transaction
- Discussion, hands-on experience and physical movements ensuring involvement of all the students were used as teaching strategies for transacting the concept with written work on the board as well as in books

- Understanding was corroborated through rediscovering method with complete students' involvement
- Restriction of space could have been addressed by using Playground environment with the help of physical educator an interdisciplinary aspect for better understanding could have been incorporated
- Emphasis should have been on attaining concept clarity over developing notes
- Home assignment of teaching the movements to parents and grandparents would bring life experience and experiential learning incorporating human values of cooperation and coordination with family
- Critical thinking could not manifest into inquisitiveness at the end of the day

Analysis of Observation 2

Grade: VII

Topic: Soil

- Enthusiastic teacher enquired the students for completion of home assignments
- Writing new vocabulary on the board the teacher emphasised meaning, pronunciation, and spelling
- Recapitulation of the previous concept by creating a diagrammatic representation of the composition of humus on board in inquiry format with students' enthusiastic participation
- Hands-on experience of touching and feeling the soil should have been a guided experience in natural environment than homework for experiential learning while discussing livelier and more practical aspects of learning
- Higher the number of students makes the task difficult for the teacher in a classroom environment, but garden or a nursery would have provided ample space and scope for muddy hand experiential opportunity where tiding the
- The students could have been taken to a nursery or a school garden excursion rather than being confined to the classroom discourse
- Importance of soil exposure rather than cemented dust-free streets for rainwater absorption would enhance the environmental factor of the concept

Analysis of Observation 3

Grade: VII

Topic: Parts of the cell

- Teacher was thoroughly involved, and students were fully engaged in watching thevideo being delivered
- Students questioning in between the video were advised to watch till the end
- Critical thinking and inquisitiveness along with brainstorming were incorporated into transaction, while the teacher drew the diagram of the cell on the board along with strengthened the concepts that the video had highlighted by asking questions and explaining the concept
- Life experiences - food absorption from the digestive system was associated with cytoplasm exchange
- Hands-on experience equated to swelling of whole grams soaked in water overnight
- Multidisciplinary outlook was missing in discussed but, the teacher associated the knowledge of prokaryotic and eukaryotic cells gained previously by the students with the present learning and kept reinforcing their relationship
- Concept-specific vocabulary was reinforced
- Division of labor among cell organelles was equated to the human values of sharing responsibility, cooperation, and collaborating among ourselves

Analysis of Observation 4

Grade: VII

Topic: Physical and Chemical change

- The students and teacher shared a very comfortable close relationship discussing with a free mind
- The positive mindset was seen in the way the students participated in answering and the discipline they portraited while taking part in the discussion indicated the teacher's ability
- Introducing the topic through vocabulary was a good brainstorming exercise that created a learning environment and engrossed in discovering the concept even though it was rediscovering
- The teacher ensured all student's participation and analysed the answers logically for students' understanding
- Students' involvement and enthusiasm ensured that they were learning
- Hands-on /life experience was missing in the transaction could be a possibility thatit be planned for her next class
- Physical and chemical changes in our body, in the surroundings, and the environment along with this universe could have been a good life experience education for a better life, sustainability, and awareness

Analysis of Observation 5

Grade: VIII

Topic: Microorganisms: Friend And Foe

- The previous knowledge of the cell and its structure from their grades was used asscaffolding
- Many students enthusiastically took part in answering the questions while theteacher stressed upon learning new vocabulary about the topic
- Basic salient features of each of the microorganisms or microbes were discussedabout their existence, habit, and habitat developing previous knowledge
- Teacher practiced critical thinking and brainstorming for enhancing inquisitivenessamong students but not all students were anxiously involved
- Association to life experience with hands-on experience and multidisciplinaryoutlook were missing
- Ethical and humane values were touched upon through the discussion of theenvironmental factors and associating them with being friends or foes
- Actual concept of microbes being friends or foes was still to be discussed whichwould be a continued session for the next
- Rediscovering and reinventing was not a part of the strategy planned for thistransaction

4. RESULTS AND DISCUSSION:

"Math and Science are the life blood of the future" ***- Bob Becker***

Upper primary level begets bifurcation along with laying the foundation in each of the disciplines taught in the school curriculum. Laying a broad spectrum as foundation for education is the toughest job for teachers in shaping the futuristic students whose learning depends on concept clarity, critical thinking, inquisitiveness, research ability, multidisciplinary and multilingual skills developed during this stage. Shouldering responsibility, every teacher should develop concepts clarity for transaction, acquire good knowledge of recent developments and research in thy field, command over the language used for transaction along with passion towards discipline and patience for teaching. Binding the enthusiasm and energy of students towards learning concepts is a challenge for teachers which should not become limitation. The prescribed curricular books are just a guideline to bring students of a similar age and

understanding an equal learning platform as the curriculum developed is according to students' mental age. There is neither a pedagogy perfect for any discipline nor any specific method of teaching to ensure every student's learning. (Pal, Yash, and et, 1962)

The concept clarity attained by the teacher plays an important role in teaching as it drives the teachers' mind to change and challenge transactions in the class according to the students' ability allowing adoption of new methods of transaction such that students learn enthusiastically and joyfully by changing their thought process, proving learning has occurred. The difference between pre-service learning and in-service experience is the maturity in transaction. The teachers should be open to learning themselves so that lifelong learning is inculcated, practiced, and promoted as role models. The freedom to develop strategies for the transaction and the different styles of pedagogy used by the teacher help in manipulating the class environment, binding the enthusiasm of the students, and developing inquisitiveness in them. The students' attentiveness depends on the teacher's ability to develop learning experiences enjoyable and meaningful. It is very monotonous for the teachers also to keep teachtheing same concept with the same strategy as the curriculum changes once in a decade or two. The teacher teaching at the same level, the same lesson, reaches an unchallenged and unmotivated zone unless life is put into their teachings and transaction methods. (***Archer E. James 1966***)

Teaching fraternity is the heart and soul of the learning process while taught absorbs the teachings with heart and soul for learning. Teachers are the ones who must take the initiative to stop rote learning and marks-oriented attitude in students as well as parents while enhancing the importance of learning and understanding concepts, bringing clarity tconceptspt along with their application. Use of technology, synergy in curriculum, multilingual and multidisciplinary aptitude along with a light but a tight regulatory framework to ensure efficiency, integrity, and transparency in the education system at all levels should be adopted so that the desired improvement and desired outcome can be achieved by every country out of education that is provided to the citizens, thereby ensuring the development of the country and sustainability for the residence. (Ministry of Human Resource Development, 2020) (**NEP 2020**)

Focus on continuous review of progress with providing space for improvisation at the earliest, should be an integral part of teaching-learning, minimizing misconceptions and mistakes. Incorporating new research in their specific field, and keeping themselves and students updated on the latest is the requisite of every teacher. Every teacher can be in touch with the most recent developments, discoveries, and inventions in their discipline to be used for an open discussion with the students that would keep thee students abreast and enlighten the inquisitive minds along with critical thinking and reasoning ability. Teachers have learned - is history, teachers are teaching
- is present, but the fact of the matter is that teachers are teaching – to create the future. Their futuristic approach and open-mindedness in rationally analyzing the thoughts and ideas of their students are of paramount importance. (**NEP 2020**) Every teacher has the responsibility of raising the mental level of the students from the previous class they have arrived to the next class they will be promoted, sothat the education of the student goes on smoothly unhindered for learning and education. Teaching-learning should not always be confined to a classroom decorum of discussion, demonstration, and lecturing Teacher's connection with the students should evolve away from classroom, to playgrounds, library, garden, nurseries, swimming ppools or any other place where learning in a multidisciplinary aspect can occur. Such situations can develop the understanding of the students better as there is no bondage to the classroom nor any tense situation as forced learning. It is the teacher who can create such an environment so that the students are free-minded and learning theconcepts without any hindrance.

It must be planned with a multidisciplinary aptitude and attitude especially in the disciplines of Sciences and Mathematics, along with life experiences, at playgrounds, while playing games, at the swimming pool, or the garden… any place which raises a question in the students' mind and the teacher is present there to clarify the concept, can be converted into a learning spot. Indulgence and involvement in teaching-learning in such methods opens the students' aptitude for learning in every situation which is going to be a blessing for acquiring and accumulating knowledge.

Learning becomes enjoyable, experiential, and motivational under an unconditional and supportive environment. Teachers also find support in each other that can brighten their horizons for teaching-learning. Concept learning along with the support of the sports teachers and language teachers for teaching Science in school can bring in a welcome change helping in engaging the student along with an ability to develop research ability and new knowledge.

In-service training for discipline-specific teaching, interdisciplinary aptitude along with interlinking of different disciplines for learning the concepts better equips teachers for appropriate transactions in class. Just like the wishes of every parent that their children should have a better living than them, every teacher's wish should be that their students acquire more knowledge than them. Keeping their teachings

open-ended - leading to questions and inquisitiveness - for the world to benefit from the young minds creating new knowledge – is a responsibility to be shouldered by the teacher.

Observation number	**Main Findings**	**Analysis**	**Implication And Suggestions**
1	Transaction limited to classroom approach	Scarcity of space	Playground activity providing space and better environment
	Emphasis on Making notes	Emphasis should befor Understanding	Attaining concept clarity
	Lack of integration	involving physical educator	Interdisciplinary and Holistic
2	Transaction limited to classroom approach	Inappropriate Learning environment	Incorporated an Garden/Nursery visit
	Hands-on experiencefor home assignment	Class task given in the form of independent enquiry	Guided Hands-on experience for better understanding
	Transaction limited to Discussion	Lack of Experiential learning	Happiness of learning through rediscovering
3	Transaction through Video presentation	Engaging visual activity for students	Enhancing spatial intelligence
	Working on board	Attracting the students' attention towards transaction	Enhanced Visual and Contextual learning
	Transaction through explanation	Association to Life experiences were missing	Illustration of life examples
4	Transaction through Explanation	Real life examples were missing	Association to Life experiences were missing
	Transaction through Demonstration	Hands-on experiences were missing	Emphasis on Experiential learning for concept clarity
	Transaction limited to textbook content	Interdisciplinary aspect was missing	To incorporate awareness on environment and sustainability
5	Stressed on New Vocabulary	Learning specific Scientific Terminology	Development of new knowledge
	Transaction through Questioning	Brainstorming and critical thinking	Enhanced Inquisitiveness

	Association and application of learning	Retention of learned content	Association to real-life experience

Table 1.1 Tabular Representation of Major Findings

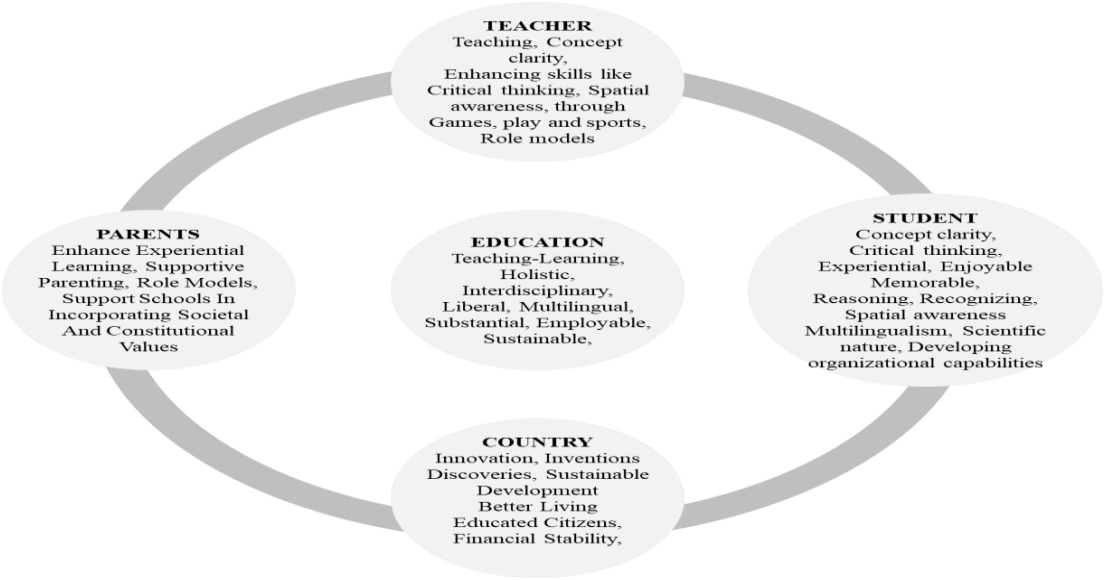
CONCLUSION AND IMPLICATION:

"When a student recognizes they don't know something, It should be a transition to knowing, Not a Termination of thinking." - Connie Hamilton

Hamilton's quote is so very apt for teaching-learning. The first step in learning is to understand what is learning and how to learn - which supports learning to occur. Thesecond step is to recognize the concepts not understood or difficult to learn. Under normal circumstances, students do recognize the concepts posing difficulty for learning, but instead of seeking help from the teacher to understand and clarify the concepts,they refrain from learning and forgo answering a such question during examination or byheart only for marks and forget. As teachers, clarifying the misunderstood concepts either during class or after analyzing the assignment sheets is of utmost importance, as it is a pathway for the transition of knowledge from unknown to the known, from not knowing to know, but not the termination of thinking or the thought. Teaching to achieve concreteness of concepts for clarity and meaning should encourage application of the concepts in multidisciplinary situations for better understanding, while practicing incognito abstraction for higher knowledge. Abstract concepts remain abstract unless concreteness is achieved during classroom transactions. They remain in the memoryand becomes a learning outcome only when it is attached to the thinking and application providing a joyful and meaningful experience. Concept clarity and understanding, appropriate analysis, and utilizing of the knowledge is the concreteness of the abstractum - which is to be achieved during the foundation years of schooling in every discipline (Pal, Yash and et, 1962)

Figure 1 The Responsibilities - Stakes holders of education

Science and Mathematics are usually presumed to be difficulty, either due to the difficulty in understanding or just because the students have heard from their surrounding elders who have found it difficult in understanding the discipline and have just had a blocked mind for learning these disciplines. Any which way, the need of the hour is to bridge the gap, clear the block, and emphasis learning for the betterment of the students as well as the development of the disciplines. (***Novak, Joseph D 1966***)



Incorporating the goals of SGDs like multidisciplinary, multilingual, life skills and humane values into education not only for learning and behaviour but for employment into the upcoming fields of employment as necessitated by the change in society. Thy importance caters to the new work requisites in the emerging multidisciplinary fields. Education system including all its stakeholders, i.e., teachers and parents - who should be striving to encourage inherent learning into the students – the fundamentally receiving stakeholders, for their betterment as learners, who thereby are playing a pivotal role in the country's development, leading to a holistic version of the Education System, every country needs to provide for its future citizens.

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Declarations:

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2. The authors have no relevant financial or non-financial interests to disclose
3. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript
4. The authors have no financial or proprietary interests in any material discussed in this article
5. The submitted work is original and has not been submitted or published anywhere else.
6. Informed consent was obtained from all individual participants included in the study
7. The participant has consented to the publication of this work
8. The Unscheduled Observation was conducted in the natural school environment with the permission of the researcher's School, the School Principal, the concerned subject teacher, and the learners without causing any hindrance either to the working of the school, class, or the subject involved in the study

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