



Review Paper

Catapulting scientific temper among learners by some activity-based strategies: a teacher's viewpoint

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Abstract

Science is a quest for knowledge. Exploring the existing knowledge for new construction only depends upon temperament of the learners towards science. Science in itself enfolds objectivity, verification, exploration, reliability, precision, accuracy, intellect and predictions. Meaningful learning only acquired when scientific attitude is developed among the growing lads. Three important components viz. Discourse, Argument, and Analysis must be incorporated in each student to develop the scientific temper. Application of logical-reasoning, bias-avoidance and liberal thoughts for pre-conceived notions throws open new vistas for augmenting scientific attitude among students. Inculcating these scientific qualities in learners is a great challenge for a science teacher. To meet the challenges in Science-teaching effectively, a teacher must be well equipped with innovative teaching techniques. Modern pedagogy directs towards the constructivist approach of learning involving 5Es viz. Engage, Explore, Explain, Elaborate and Evaluate which enable the learners to develop curiosity to discover the cause-effect relationships of the events happening around us. Contextually, a holistic design to teach science by teachers is the determining factor for achieving educational objectives. Hence it is imperative to innovate teaching efforts to exaggerate the conceptual learning to foster scientific skills among growing minds. This paper discusses the activity-based teaching strategies for effective learning which bring positive attitudinal outcomes necessary for developing scientific attitude in pupils. Recapitulating the ideas of scientific spirit and enquiry, it is inferred that appropriate instructions at right time with right teaching strategy assist in developing scientific attitude, evolution of creative ability and an overall enhancement in exploratory and investigative abilities among the curious learners.

Keywords: Science, scientific-attitude, activity-based teaching strategy, conceptual learning.

Introduction

Human resources are the integral wealth and heritage of a progressive nation, which can only be exploited fully when transformed into the nurtured productive minds. Resourceful teaching with organized efforts of the teachers and modern teaching techniques can make this task successful one. Progressive pedagogical approaches in the course learning has been designed innovatively for positive learning outcomes. These effective teaching techniques involves varied number of inductive and deductive approaches which direct the drift towards learner centric approach of learning¹.

It caters to the need of the current era of ICT and Scientific-technology driven society. Traditional teaching is important to bring desirable changes in attitude towards meaningful learning because what experience can give will never be equalized with the mere passive listening and rote learning².

To inculcate scientific attitude among students, the school environment, and teacher's attitude along with hard efforts are more responsible³.

Teacher as a facilitator and mentor plays a major role in showing the path to the students for their development in different dimensions like cognitive, affective and psychomotor. Monotonous lecturing without participation of students failed to achieve the learning outcome⁴.

Conceptual definition of scientific attitude: According to Gardner (1975), "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".

Dimensions of scientific attitude: Scientific attitude can be characterized in a person when he is instilled with the values like open-mindedness, inquisitiveness, objectivity in approach, critical observations, rational thoughts, believes in empirical evidences rather than any myth, believes in cause-effect relationship, follows systematic procedure to find solutions of a problem, focuses accuracy and truth and respect other's opinion as well, has intellectual honesty, matured decision making tendency. These values lay the foundation of spirit and enquiry of science among the students³.

Literature review: Activity-Based Learning Strategies (ABL), are assets of novel teaching that instructs the learners to think critically with divergent views to explore various ways to solve the problem practically. It develops self-esteem and brings about the changes in attitude with a scientific outlook⁵. A study explored the impact of ABL in mathematics achievement and found that ABL increases student's achievement in comparison to the conventional method⁶. Such strategies account for behavioral changes in pupils like scientific outlook aiming to understand daily life situations. National Policy of Education recommended for activity-oriented learning right from primary level and put forward the idea of learning according to their pace supplemented by remedial instructions wherever needed. This affirms an increase in cognitive competence and organized skills through practice⁴. Thus, infusing scientific attitude in each growing mind is the major recommendation proposed by National Policy on Education, 1986 along with other values in curriculum such as patriotism, national-integration, religious-tolerance, equality of gender, dignity of labor, modesty, sensitivity, punctuality and neatness⁴. A further study cited the improved performance of primary level students when mathematics was taught through activity-based methods². D'souza in his study advocated academic growth by ABL method. He asserted that integration of ABL and instructions provides a better learning platform as the learners gets a fair chance to relate abstract ideas and theories with concrete observations. He found that ABL eliminate rote memorization and helps in comprehending the scientific concepts underlying each event⁷.

The words quoted by Confucius, "Tell me, and I will forget, show me, and I may remember, involve me, and I will understand", explicitly illustrate the notion that learning is more efficient when learners participates actively, engage themselves in learning process and explore the conceptual framework for the topic under study and construct their knowledge on the basis of their past experiences. In another study undergraduate students were taught with ABL for evaluating the efficacy of the strategy and it was found that a strategic attempt over the monotonous method overcomes the limitations of lesson delivery. Modern pedagogical practice augments the course learning. ABL served with enough opportunities to learn beyond the classroom and improved the academic performance when taught through Games in Digital Communication course for 6th semester Engineering students¹. ABL strategies act as cornerstone in fostering creation and critical thinking among learners but Fizza, 2019 asserted that strategy even don't work if students are not motivated to follow it, therefore a high degree of motivation and reinforcement is required to participate in activity which can extract the maximum potential of the learners⁸.

As reported by other investigators, science learning is ensured when practical approach is followed. Self-initiated, cognitive-based learning assists individuals to progress with their own pace along a learning ladder.

Child move ahead step by step, where each step approves the competency required for moving to next learning step¹. ABL pedagogy is conducive in supporting and strengthening the differentiated learning whilst allowing the teacher to deal with mixed-ability classes⁹. This pedagogy is manageable where there is a dearth of teachers. The research examined the impact of ABL on learning outcomes as well as on student's non-cognitive outcomes¹⁰ and concluded that an integrated activity-based science curriculum has positive correlation in science achievement, science process skills and attitudes toward science. Appropriate teaching methodology enhances scientific skills and develop capabilities in different dimensions for conceptual learning. Achievement of learners increases when contextual teaching and learning was applied in teaching of natural science¹¹. Contextual teaching and learning open new vistas of learning and gives direction to the students to learn in better way.

In the purview of findings of previous studies, this paper discusses about the various ABL strategies applicable in participatory approach of learning that sharpens the scientific skills among learner and ensure meaningful learning. Each strategy explains its own unique pattern and guidelines to be implemented to enhance the efficiency in teaching-learning scenario. Such efforts could bring a dynamic change and development in the existing education system.

Role of a teacher in inculcating scientific attitude among students

Teacher is the torch bearer of the nation's progress who indulge himself in imbibing values like scientific attitude, curiosity, logic and reasoning etc. among learners. Effective strategy can assist in generating curiosity of the learners. Zeal aroused among them will direct their efforts for investigation, exploration and deduction. For this, a teacher uses wide variety of techniques to boost up the student's motivation towards learning. For example, Brain-storming teach the students to think differently. This meta-cognitive thinking helps in generating divergent views producing novel ideas. Reading habit of scientific literature gives an ample opportunity to get involved in some discourse. Optimal classroom learning environment would help thus enormously. Intellectual Group discussions, debate, extempore and other co-curricular activities promote any beneficial ameliorating change in the classroom for meaningful learning. Teacher motivates them to ask questions in the class. This tendency helps learners to come out with what actually is hidden within minds in quest for knowledge. A satisfactory response towards their queries develops positive attitude towards learning and it inculcates the habit of discipline while learning¹². Teacher deals with curiosity of pupils by providing them the opportunities of close observations and involvement in the experimental functions to reach their inferences. Through such practice, teacher nourishes curiosity among pupils.

Scientific method involving inductive-to-deductive and deductive-to-inductive approach of learning is imbibed by learners to explore the facts and figure in relevant field of knowledge. Self-observations, self-exploration, experiences and experimentation lead them to collect evidences for every phenomenon occurring around, thereby generating scientific temperament among them³. Freedom in thoughts and actions and active participation helps them to learn on their own. Scientific culture created in science-classroom through laboratories, field visits, science-fairs develops a strong sense and spirit of scientific environment¹³. Teacher cannot be successful in developing such scientific attitudes among the students until unless he himself does not possess attitudes. Being role model, children follow the path enlightened and guided by their teacher. Thus, it is a prime duty of teacher to adopt scientific temperament in himself first. By being democratic in nature, a teacher can create a friendly environment for fostering collaboration among the learners, thus assist in developing scientific attitude and paving a way for scientific discovery ahead.

Prime requisite for developing scientific attitude are

Divulging truth behind misconceptions: An irrational widely held belief usually misguides the learners' comprehensive ability. Nurtured young minds are being blocked by superstitions and myths prevailing in our society. Misconceptions act as hindrance in developing scientific attitudes among learners. Eradication of such false beliefs and inaccurate impressions can be achieved by systematic study of science appearing at the backdrop of concepts under explanation. Here teacher motivate the students to explore the reality of each myth before its acceptance by facilitating the learning with conceptual base and empirical evidences.

Examples citation: Scientific facts and concepts can be effectively taught through citation of readily available examples of routine life. Personal experiences during teaching process can be incorporated to arouse curiosity and enthusiasm among pupils. Mentor should be open minded, free from all biases and prejudices and should narrate live rational examples based on the scientific methods and henceforth, invite students to put forward their developed views afterwards.

Organizing science programme: Co-curricular activities in scientific field viz seminar, debates, group-discussions, educational excursions, science fairs, science exhibitions must be organized in the school every year so as to inculcate the scientific skills, temperament and aptitude among the learners. Students must be encouraged to participate actively so as to refine the knowledge of science along recent developments and technologies around the world.

Learning by doing: Self-learning skills develop when a student try to explore the things by himself. It is like a discovery method where the activity is carried out.

Project work is also one of its kind, where the assigned topic is thoroughly investigated by the student to find out the methods, issues and concerns related.

Reading scientific literature: Teacher should encourage the students to read supplementary and reference books written on scientific developments and new inventions in present era of technology. Developing a habit of reading scientific literature broadens the vision of students to explore the things with conspicuous insights.

Optimality of classroom environment: A stimulating learning environment must be provided where each child can experience growth and develop his maximum potential. The conducive environment illuminates divergent thinking in the students and augments creativity in learners. A spirit of cheerful criticism of handled methodologies, framed hypothesis and results concluded, must be encouraged by teacher to foster the investigatory habits among pupils. It will raise scientific attitude among them.

Enrichment Programmes: Implement enrichment programmes for academically advanced students to develop scientific skills relevant for a contemporary advanced nation. The gifted students are rewarded with many opportunities to develop their scientific skills viz. scientific workshops and tutorials, thematic seminars and lectures, visits and fieldtrips, summer study camps, group research, webinars, etc.

Innovative practices and instructional teaching techniques: Innovative teaching techniques retain the students' interest, develop scientific attitude and upgrade their skills thus, maximize the individual learning for each.

Activity-based learning strategies (ABL)

ABL are self-learning strategies with active participation and direct involvement of learner rather a passive listener as in lecture method. It is a learning by doing strategy when a learner grasps the content by doing some activity. It involves functions like performing, acting, demonstration, playing a game, thinking, reasoning, questioning, answering, writing, reading, operating something etc. Teacher incorporates some strategy in classroom to make students learn by their own. It is learner friendly educational tool that allows him to learn at his own pace. It provides a self-evaluation platform and reinforce them to explore the content with suitable logic and reasoning. The pioneer of the Activity-Based-Learning was Sir David Horsburgh in 1944 who arranged various teaching materials for different learning activities in his school. With the continuous development in educational technology in this digital world, numerous teaching strategies have evolved in time proving its efficacy in learning for different grades. Some of the ABL strategies can be summarized under the heads as:

Guided discovery: It is an instructional approach where teacher as a guide directs their pupils throughout the process of

discovery. Optimal environment, relevant base knowledge and required miscellaneous materials are provided to the learners to lead the progress in resolving the riddle.

Think-Pair-Share strategy: A cooperative learning strategy to attain the cognitive levels of students, involving 3 rounds as: i. Round-1: A floated question/topic by teacher instigate critical thinking among learners to explore and explain the concept. ii. Round-2: Pairing of students to exchange their ideas and clarification of the doubts. iii. Round-3: Sharing of knowledge in a group-discussion within whole class.

Dramatization: A teaching method where students use costumes, memorize dialogues and express their imaginations through actions. A novel, story or any historical event can be better taught with dramatic presentation.

Team teaching/Co-teaching/ Collaborative teaching: It is a collective instructional teaching technique where two or more teachers share the dais by working in a team for teaching a group in the class. Strategy focus on slogan of TEAM i.e. T-Together, E-Everyone, A-Achieve and M-More.

Cooperative learning: Peer-tutoring strategy where small heterogenous groups with diverse abilities work collaboratively to achieve a common goal. Students learn to listen, help, support, cooperate and reconcile differences thus succeed together in resolving any problem effectively.

Numbered-Heads-Together strategy: A diverse cooperative learning strategy in which whole class is divided into small groups. Each member in group are assigned with numbers from 1 to 5. Teacher projects a question and pupils are instructed to put their heads together within group and to discuss the topic with all concerned issues. Teacher call out any number say 4. So, all 4 numbers of the different group will be spokesperson and will explain the answer. This method ensures that all team-members in a group must know the answer as any number can be called at random.

Quizzes: An entertainment form of evaluation strategy to test the level of knowledge like contest between different teams with competitive feel where participants respond and obtained scores for their team in definite span of time decided with some preset rules for the game.

Group discussions: A Communication strategy of learning which offers an open platform for discussion under a similar objective within a group of 7 to 15 members in formal or informal structure. It promotes systematic exchange of ideas, opinions, views, comments with freedom of thought and independent views. Topic is discussed with for-and-against arguments and is finally concluded among the whole group. This strategy improves inherent linguistic skills of a learner drastically.

Educational Games: It is a Games-based Learning. A game is defined as a structured form of play. It is an interactive educational tool working on the principle of learning while playing. A variety of games with certain educational objectives are designed to make learning assured, easy and interesting, assists in developing a dynamic personality of a child. These games help pupil to gain the knowledge, to elaborate the concept and master over the content just with play way. Several educational games are available which not only provide enjoyment, but gives motivation to learn, promotes creativity, social interaction, cooperation and ego satisfaction as well. Examples are many like Casino, Taboo, Twenty Objects, Bingo, Categories, Jeopardy etc.

Brainstorming: It is primarily a discussion activity within a group having diversified spontaneous ideas on a specific theme to explore the thoughts loaded with favor of or against it. Thereafter, producing connecting linkages between the ideas to reach potential solutions within a controlled and liberal thinking environment. It is a creative technique where ideas of the team members are unified to produce new notions revolving around a decided and declared domain. Quick ideas would sow the seeds of better perceptions. All ideas are jotted down without being rebuked and are evaluated after the brainstorming session.

Role Play: It is pupil-centered participatory method where children find interest and motivation towards learning through actions and play. Pupil integrate the knowledge and passes a lesson or message to society for progress. For example, in Swachh Bharat Abhiyan the role plays by students impart message of how to recycle waste, how to keep environment clean. Thus, a team addresses an issue, explore the seriousness and concerns towards the event, seek novel creative resolutions towards problem in the form of actions and interactions. It is unrehearsed drama where all group members take different roles representing the characters of a theme/topic/content under study, uses costumes of the character, memorize dialogues and express their imaginations through dramatization.

Project Method: It is a voluntary but purposeful activity having educational value which eventuates into objective results. It is realistic, experiential learning beyond the class-walls, involves active involvement in the set task and motivates for investigation of the problem to find out the solution. It focuses on practical aspect of knowledge. Learners have freedom of thought and action and are set free to complete their project in their own way of discourse.

Experimentation: It is practical approach of learning where experiments are carried out in laboratory to study the process or phenomenon, and results are inferred by following the scientific procedure of experimentation. Experimentation process requires objectives, material needed, procedure, observation, analysis and inference.

Field work: A natural study for perceiving the available information of an event or phenomenon to collect relevant data in real-life situations. It is a study in a natural setting outside the work place, or laboratories or classrooms. Since it is done in the real world, it is a primary source of information and it reduces the chances of manipulation of the data.

Problem solving: A method of deducing solutions to the problem posed, by the application of different principles or formulas or the concepts. Students learn to explore out the causes behind the event. It augments the observation, comprehension, analysis, interpretation and subsequently assist in finding the facts lying behind. Thus, it gives a clear conceptual understanding of the topic under study and leads to construction of new knowledge.

Debates: It enunciates a formal discussion on a specific topic. It is a war of words. One person throws an argument and other one defends the issue disputed with comments and advocacies.

Jigsaw Strategy: A cooperative learning model consisting of an organized classroom activity with interdependency of the pupils to get mastery over the concept under study. Small sizes groups are given different parts of the topic to explore. Multiple tasks are accomplished by different groups at once. A complete image forms when all piece of Jigsaw Puzzle assembles together to create a final image, similarly each individual contributes his unique ideas for final group's upshot. Home group and expert group finally share to complete whole assignment collaboratively.

Discovery learning: An exploration activity to discover new things. It is inquiry-based tactical learning where students construct knowledge through discourse. The raw material required for the study is provided to the students and they try to seek answers without being assisted by teacher. Ready-made answers should not provide to the learners but they have to discover themselves only.

Concept mapping: It is a conceptual diagram delineating the relationship between concepts in hierarchical fashion with labelled arrows to link the information presented.

The one-minute paper: It is a last-minute assessment strategy after concluding the lecture. How much could learners reproduce in one minute? A timer of one minute is set. Students are asked to record their response. Their response will reflect their comprehension about the concept taught as well as build writing skills.

Quescussion: Entire discussions have to be conducted in the questions form only. Teacher projects a question and response from students must be in question form only. A student may respond only every 5th time. Statements are not allowed. If anyone makes a statement, the rest of the class is to shout "Statement".

Chain notes: A teaching strategy where teacher passes a question written on a top of paper. Paper is circulated to each student one after another. Everyone responds according to their own understanding. Thus, a Chain of responses contribute to an elaborative note and thorough understanding on the topic being taught by the teacher. Missing links will be pointed out by the teacher afterwards.

Sketch noting: Lecture notes are recorded into picture form instead of written form. Students sketch a picture which represents their learning during the class. Sketch is not drawn for quality drawing rather evaluating the imaginative ability and visualization of the taught content with different perspective.

One-sentence summary: It is an evaluation strategy involving review of content taught in the class in summarized form. It can be used at the beginning of new class as recapitulation of the topic covered in previous class, or can be used at the end of lecture to summarize or conclude the topic. One sentence summary teaches how to extract the crux in limited words, thus develops writing ability.

Conclusion

Science encompasses rational thoughts arising out of an ignited mind. Teaching-methods adopted by a teacher symbolize the quality of lesson delivered and quantum of knowledge gained. Pillars of education are laid strong only when a society embraces uninterruptedly a culture of modernization drive catapulting scientific and technological advancement. Educational reforms in 21st century is now an emergent need of hour for which various policy initiatives and planning measures have been incorporated by principle agencies under Government of India. Principles like learning without burden, learning while playing and learning by paves way for participatory mode of learning with constructivist approach for higher academic outcomes. Numerous initiatives and innovative methodologies have been put forth by SSA (Sarva Shiksha Abhiyan Scheme by Government of India) to reinforce advancement in pedagogy for learners as well as teachers. Science being a massive bedrock of cutting-edge technology harness a broader vision among growing children cherishing a spirit of scientific enquiry in them.

This will only be possible when active learning strategies will be introduced in the curriculum and a shift from teacher to learner-centric strategy is focused upon. Though many modern pedagogies have created its own way of importance and implications through times, Activity-based-learning is a variable key component of academic achievement among learners. ABL demonstrates pedagogical approaches to teaching over a much wider range of academic excellence and applicability. Learning by doing activities and hands-on-experiments is the core premise of ABL. Through ABL children act as active learners rather than passive listeners. Learning will be long-lasting as well as joyful and interesting if an optimum learning environment is provided to them.

Table-1: Examples of Few Activity Based Learning¹⁴.

Activity	Material Required	Directions to follow	Remarks
Determining Age of a Tree	Measuring-Tape, Marker, Paper	Select a tree to find an age. Wrap the tape around the trunk. Mark, measure and note the inches. The circumference of tree signifies the approximate age of the tree.	Generally, trees grow a new layer every year over the existing layer but with few exceptions like Redwood tree/Fir, which grows more layers in a one year.
Hot-Air Balloon	Empty bottle, Deflated-Balloon, Hot water	Take empty bottle. Stretch the Balloon over bottle's mouth. Heat water in a pan. Keep bottle in a hot water. Balloon starts expanding.	Air inside balloons heat up. As warm air occupies more space than cool air, it results in expansion of balloon. Warm air is lighter than cold air, balloon will fly if released from bottle.
Defy Gravity	Glass, Water A cardboard square	Fill the glass with water till its brim. Place the cardboard cover over the mouth of the glass carefully. There should be no air bubbles inside the glass. Turn the glass upside down after taking it near to the sink. Remove your hand from under the cardboard. Cardboard will stick to the glass.	As we assured that there is no air inside the glass, the air pressure outside the glass is greater than the water pressure inside the glass. The extra air pressure holds the cardboard in its place and defies gravity.
Oxygen Necessity for Combustion	Candle, Match stick, Jar	Take Candle. Place it on the table. Light the candle. It will burn continuously. Now invert the Jar over candle. Candle will extinguish after few minutes.	Candle takes away the oxygen present inside jar necessary for combustion, after which it extinguishes. This proves that oxygen is necessary for combustion.

ABL provides a platform to explore and learn, raise aptitude and skills hence focuses on self-learning skills. ABL idea is deep rooted under the notion of active participatory learning. Therefore, it should be propagated at the early primary grades so that the scientific skills can be better inculcated since the beginning of childhood stage. Conclusively, a teacher is rationalized as a catalyst all along the learning processes for improved scientific outcomes.

Recommendations: A combination of at least two methods in teaching a lesson is more advisable. Ideally, a smart teacher must use a mix-method for each lesson depending upon the topic to be taught in the class. Traditional method like demonstration and discussion when combined with innovative practices and modern pedagogies renders a greater scientific attitudinal change among learners. A curriculum shall be designed with ample scope for instilling scientific temper among the students as they move higher in their academic levels and at each level their scientific determinism further open ups with increasing complexity so forth and so on. Safe and handy materials should be provided for performing experiments and improvisation could be done if needed. Enough time must be provided for practice. Teaching must be directed over clearly defined objectives to attain the educational efficiency.

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