

Fostering Critical Thinking Skills In Elementary Science Students Through Activity-Based Teaching

¹Dr. Farah Deeba,²Dr. Muhammad Aqeel Raza,³Dr. Romena Ali,
⁴Dr. Vajiha Naz, ⁵Dr. Samina Akhtar

¹Principal / Corresponding Author's Dr. Farah Deeba Assistant Professor
Department of Education, Bahauddin Zakariya University, Multan

²Assistant Professor, Department of Education, NCBA & E Lahore, Multan
Campus

³Assistant Professor, Department of Education, NCBA & E Lahore, Multan
Campus

⁴Lecturer Education in Govt. Zainab Associate College Chowk Shaheedan,
Multan

⁵Assistant Professor, Department of Education, The Women University, Multan

ABSTRACT:

Critical thinking is one of the most, in demand skill of 21st century. To empower critical thinking in learners, activity-based teaching has emerged as a new paradigm in science education. The present work was an effort to develop students' critical thinking skills in the subject of science while integrating activity based teaching in Science classroom. For this purpose, an experimental study was conducted over 80 students of 8th class in local public sector school of Multan city. Students were divided into experimental and control group. Experimental group received intervention in form of activity based teaching while control group was taught with the same previously used traditional method. Text book of General Science was used to teach the students and critical thinking test was also made from this text book and taught units. 25 item based MCQs test was developed to assess the critical thinking of students. Pre and Post-tests were conducted which showed significant change in critical thinking of experimental group while enhancing their critical thinking. Percentage and Mean score were used as data analysis techniques. Activity based teaching proved to be a catalyst of change in students' critical thinking which was not at satisfactory level in pretest before intervention. It was concluded that various approaches of activity based teaching be used in classrooms by the teachers keeping in view the ILOs.

KEYWORDS: Critical Thinking, Activity-Based teaching, Pre and Post-test.

Introduction

In current era, critical thinking is included in 21st century skills which is crucial for students to prepare them as a productive citizen of modern times as it involves high level cognition, progressing through analyzing conflicts and challenges, having strong arguments, evaluating the situations, informed decision making and working through problem-solving (Ahmad, Deeba, & Raza, 2023; Fajari, 2020). However, majority of the countries including well developed countries have encountered the challenge of improper learning environment unable to develop the skills of critical thinking in their students. Adolescents lack critical thinking, creativity and problem solving. They are unable to draw inferences or to write a cogent piece of work. There is insufficient training of students to prepare them to think in depth of the observed phenomenon. On the other hand, diverse social changes demand

today's learners to be critical thinkers (Allen, 2021). Acharya (2017) presented a framework for critical thinking considering it as a process which makes an individual self-reflective and disciplined. Under this process, he has to monitor himself constantly and rectify on the basis of self-assessment while opting an analytical approach. In this way, he has to pass through eight stages of thinking, setting goal, asking questions, working on data, drawing interpretations and inferences, generating ideas, assumptions, finding outcome and finally coming up with a standpoint.

In view of Valdez, Lomoljo, Dumrang, & Didatar (2015) teacher should inculcate a critical attitude in students for academic goodness, value to reasoning, devotion for Math and Science, readiness to self-assessment even if the result is against themselves, inclination for finding facts and desire for precision. Literature, History and Sciences all train students to think critically. However, all disciplines which fall under Science; Physics, Chemistry, Biology and Mathematics are more supportive for critical thinking while giving opportunity in examining data, executing inferences, generating and working on ideas, and assessing claims (Romero, Quesada, & Estepa C, 2021). Then why are students' critical thinking skills are still formative? The reason behind this is our prevalent education system that promotes mere memorization rather thinking and working on ideas and projects. Otherwise, if we want to bring constructive changes in students' thought we will have to incorporate such curricular reforms that may foster critical thinking in students as its future value is undeniable. It enables students to analyze given information, work on its relevance and grasp the root cause of any issue. Science education integrates numerous skills like self-awareness, effective learning by creating the ability to plan and organize and the capability of critical thinking etc. Critical thinking and Science are extremely tangled. Therefore, teaching and learning program and environment should incorporate strategies to enhance critical thinking in students that cater diverse needs of students (Rehman, Wenlan, Mahmood, Fareed & Batool, 2023).

Critical thinking skills are thought appropriate for the students as such skills enable them to analyze logically, differentiate relevant, irrelevant and useless content (Cahyoa, Susiloa, & Sulisetijono, 2021). In current advanced world of technology and knowledge explosion, the learners should not only equip themselves with essential body of knowledge but it is necessary to enable themselves for critical and rationale thinking to have a judgment with their perception. It is prerequisite for the students to analyze and evaluate current scenario to take prudent decisions in their lives. Critical thinking encompasses interpretation, analysis, evaluation, conclusion, synthesis and even self-regulation. Therefore, it is considered as independent thinking, self-directed thinking and logical thinking as well (Yusuf, & Barlian, 2022; Jamil, Muhammad, & Qureshi, 2021). Unfortunately, our education system, promotes and prefers theoretical mindsets as students are not trained to bridge the gap between the learned concepts and real world situation. They are not optimally been facilitated with the ability to think critically while critical thinking works as intellectual process for solving problems by offering potential solutions (Alfiandra, et al., 2022). However, if students are unwilling to assess themselves on the basis of their critical thinking as they find memorization more convenient for them and if teachers think assessing and fostering critical thinking as wastage of time and resources as they have to cover the course in limited given time and they are untrained for developing critical skills, then we cannot expect school system to promote critical thinking in students (Jamil & Muhammad, 2019).

Critical thinking skills are not only for adult students, rather students be trained with critical thinking skills at an early stage of education and its foundation be laid in elementary and secondary schools and thinking process should be taken as prime goal of education. It should be cultivated for innovative talents, flexibility, persistence, reasoning, willingness when offered with multiple tasks, display of meta-cognition, clarity, accuracy, precision, relevance, depth, breadth, logic and self-correction (Ho, Chen, & Li, 2023). Allen (2021) also supports the idea that children who start to practice critical thinking in earlier grades can gain more in classroom and later on in practical life as earlier inception of learning critical thinking, causes practicing those deeper thinking skills more effectively. The problem is not that contemporary learners are incapable of evolving critical thinking at an early age, it is that much of the classroom practices does not target on critical thinking directly. Therefore, students be involved in contextual problems which may elevate their thinking as contextual learning enables

students to apply new learned knowledge and skills in real-life situations (Fitriani, Zubaidah, Susilo, & Al Muhdhar, 2020).

To develop critical thinking in elementary students, especially in Science students whose learning is meaningless without direct involvement with concepts, phenomena and theories, more innovative teaching methodologies are needed. Contrary to it, in our schools, teaching and learning are dependent on rote memorization. Therefore, unfortunately, like all other subjects even Science is taught with the help of lecture method even at elementary level. It's time to change this outdated and conventional approach of Science teachers. Our teachers will have to use unconventional and innovative teaching techniques and teaching methods and one of those unique teaching methods is Activity-Based Teaching (hereafter refereed as ABT). It is a setup designed for active and constant involvement of the students through hands-on experiments. It promotes self-learning as it is learner-centered. Students work at their own pace while engaging themselves in activity-based instruction (Iqbal & Afzal, 2022). ABT provides baseline for critical thinking in Sciences. Interactive sessions are backbone of ABT which assist a student to construct mental images. This approach of teaching is a cognition based teaching- learning process which prefers to enhance constructive learning based on philosophy of constructivism combining previous knowledge and personal experience (Anwer, 2019).

Pedagogue must work on best strategies to productively involve students in classroom as it is demand of job market which prefers competitive and passionate employees having higher order 21st century skills including creative thinking, critical thinking, decision making and problem solving. It's time to wave off lecture method in Science causing passive listening by the students. Due to conventional teaching methods, we are using students' brain as an empty vessel which is being stuffed only by knowledge. Otherwise, they have no participation in learning process. We will have to introduce brain storming, group discussion, Socratic approach, personal exploration, problem solving, critical thinking, experimentation, Heuristic method, and role playing. All of these techniques are included in ABT which can be utilized to target any skill to be learnt to deal with real life situation (Raza, Deeba, & Faqir, 2022; Zafar, & Akhtar, 2021).

ABT is suitable for all subjects. It has increased its importance for Science subjects. Science is an important field of study. One may say that science is the fundamental discipline. It makes use of symbols and numbers. Using logical numerical concepts, numbers and signs are arranged. The study of space, time, capacity, quantities, forms, and numbers, as well as how they relate to one another, might be used as a general definition of science (Golji & Dangpe, 2016). Science is the systematic study of the Physical, Chemical and Biological phenomenon around us. Therefore, science has to be explored by observation, critical analysis, experimentation and generalization and ABT techniques are most suitable for this life related subject (Ghuffran, 2014).

Activity-based learning results in high retention rates among pupils. Students are more engaged and the material is more easily understood when lessons are delivered by using an activity-based approach . Learning outcomes were shown to be more amenable as a result of activity-based instruction. Utilizing exercises is a great way to augment course information through ABT. Teachers can better convey concepts to students via the use of engaging activities. (Allen, 2021). ABT creates an effective learning environment for learning by doing with peer and group instruction. ABT is very effective for teaching Physics, Chemistry and Biology and other subjects of natural science. In an activity-based class, students are actively involved with energetic experiments while getting opportunity to relate cognitive thinking, intangible thoughts and philosophies through tangible explanations. This helps them to make deep understanding of scientific concepts. At elementary level, ABT is an effective method of teaching to clear the concept of students in the subjects of science involving learning through experiments. Students have opportunity to test theories and intangible concepts in real life for clear, solid and concrete concepts with actual observations. They are capable of applying the knowledge in real life at various situations (Noreen & Rana, 2019). ABT not only involves students vigorously but also creates a socially interactive classroom environment that ultimately provokes critical thinking as ideas are shared among students and they receive feedback over their ideas from their peers (Nwosu, Etiubon, & Ofem, 2022).

Santos, (2017) studied the teaching of Physics with activity-based learning and found that activity based learners were out performer in critical thinking skills, self-directed learning, and the capacity for interpersonal and professional competence as compared to the students learning through traditional methods. Riwanto, Ratmaningsih, & Iqbal (2019) states that students' ability to acquire and comprehend scientific concepts is considerably aided by the use of activity-based learning. Aminullah, Kang, & Saeed (2021) conclude through their study based on activity based teaching for Science subjects that in modern time of education, teachers cannot enhance skills of students until and unless they will not plan to involve students in positive academic activities. Activity based Science teaching works as an art that involves students in useful activities and bring their potentials out of them.

Jamil et al. (2021) also recommended in their study that to develop critical thinking skills in students, schools must lay stress on the execution of the pedagogy for the critical thinking as proposed by National Curriculum for Physics, Chemistry, and Biology in 2006. Refresher courses should be arranged for professional development of teachers so that they may be catalyst for students to foster the characteristics of critical thinker. They recommended it on the basis of observation method conducted in Science classes. It was concluded through their study that there was a positive impact of ABT on intellectual skills of the students in the subject of Physics and found it too much effective method to develop higher level thinking skills in the students at secondary level (Khan, Muhammad, Ahmed, Saeed & Khan, 2012). Study results by Witarsa & Muhammad (2023) confirmed that the project-based learning model proposed by them an approach of activity based teaching not only improved students' critical thinking but also the learning model worked well for developing reasoning abilities in learners which may also help them in solving various issues within society. It was concluded by Nwosu, et al. (2022) that the learners who were exposed to the activity centered method, they were found to be capable to acquire faster as compared to learners who were taught with the traditional technique. The study discloses that the activity based method has a positive impact on the students' learning outcomes especially their meta-cognition.

The capacity to apply the laws of logic and solve real-world issues is a key component of critical thinking. To cope with the situation of new and huge emerging knowledge, students should be more critical and investigator to handle difficult situation. In this scenario, there is need to change traditional method of teaching while switching over to innovative methods of teaching. Creative thinking, problem solving and decision making of students all get benefit from the critical thinking skills as it is basic building block of higher order thinking skills that must be incorporated in Science teaching and in other disciplines also. The focus of this study was on how various activities executed under activity based science instruction affect students' capacity for critical thinking in elementary Science students. The main problem is that there is almost zero concept of activity-based teaching in our schools' systems especially at elementary level. So, the major purpose of this work was to highlight the importance of introducing such amazing type of teaching that can foster critical thinking in students in a far better way. Currently, teacher is more subjugated in his class, creating environment only for knowledge acquisition. Innovative learner-centered instructional strategies which stimulate thinking skills are not integrated. Assessment also focuses on simply evoking facts and knowledge. Therefore, students exhibit a low level of critical thinking skills and students' performance in science continues to be deteriorated. Hence, there is need to explore alternative teaching approaches that may develop students' acquisition of critical thinking skills. One of such instructional strategies may be termed as ABT. So, this study was conducted to find out the improvement in learners' critical thinking skills through ABT.

Literature Review

Critical Thinking Skills

Critical thinking skills are part and parcel of our cognitive process in which these skills work as an active and organized change agent. They familiarize us with our own thinking and the world around us. They work on abstraction, logical thinking and meta-cognition. These skills are reflective and reasoned ways of thinking. When we interpret, analyze, evaluate, infer and make decision we actually are following critical thinking skills (Tuaputty, Leasa, Corebima & Batlolona, 2021). Allen (2021) further explains that critical thinking is a process based on three interconnected components; Logic,

application of this logic to present an argument and third one is an individual's willingness to use critical thinking principles in spite of falling back on previous beliefs. It is to be said that critical thinking is the ability to use the most appropriate type of reasoning in any situation (Ho, Chen & Li, 2023). Critical thinking skills encompass intricate set of competencies which empower individuals to work on information, collect data, and analyze results to engender an acceptable conclusion (Fitriani, et al., 2020). Demircioglu, Karakus, & Ucar (2022) present a comprehensive standpoint of critical thinking skills as in their view, critical thinking has the quality of social emancipation. Therefore, it presents autonomous ideas and evaluate even evidence to participate in and reflect on the social scenario. Solid argumentation is the focal point of criticism and well-versed decision. Therefore, it works on presenting arguments and counterarguments in various perspectives. In view of Jamil & Muhammad (2019) if we think meaningful, logical, draw goal-oriented inference, interpret, explain, evaluate, and decide after collecting opinions and facts and regulate ourselves, we are actually taking advantage of our critical thinking skills.

Knowledge (topic knowledge, technique knowledge, self-knowledge, and environment knowledge); dispositions (logical integrity, logical humanity, logical modesty, logical bravery, logical persistence, etc.); and skills or abilities are interlocked in spectrum of critical thinking. Critical thinking empowers problem solving as it is rooted in cognitive skills, understands the interactions of factors that influence the outcomes; and calculates various prospects and scenarios to make the right decision. Scientific communication, students' self-confidence, and motivation are also intertwined in its scope. (Razak, Ramdan, Mahjom, Zabit, Muhammad, Hussin, & Abdullah, 2022).

Critical thinking basically includes disposition and orientation, analytical and problem-solving skills, application of variety of perspectives and general awareness about one's own assumptions, capacity for meta-cognitions and set of thinking processes. It is the ability to think independently and propose solution for problems (Ahmad, et al., 2023). Critical thinking plays a vital role in learner's logical thinking, on the basis of which he makes rational decisions and perform self-examination (Lv, Chen, Zheng, & Zhu, 2022).

Characteristics of critical thinkers

Nadeak & Naibaho (2020) identified these types of critical thinkers based on initial to advanced critical thinking: unreflective thinker, challenged thinker, novice, practicing thinker, the experienced thinker, advanced practitioner, and the master thinker. They can scrutinize new information and ideas from diverse perspectives and modes of life then they pass a judgment whether it is acceptable or not (Lombardi, Mednick, Backer, & Lombaerts, 2021). A critical thinker can interpret, analyze, evaluate problems by using evidence, concepts, methodology, and criteria that can be used as the basis for making a decision. Critical thinkers are autonomous and proficient in problem-solving (Fitriani et al., 2020). They are able to make prudent and independent decisions as they are able to judge something independently and selectively on the basis of their self-reliance (Tuaputty, et al., 2021). Critical thinkers even perform well in writing activities while presenting a good write up as in form of work of art like novel, essay and research paper (Suteja & Setiawan, 2022).

Allen (2021) presents the following features of critical thinkers

- 1) They constantly improve their thinking
- 2) They are able to recognize significant differences among alternatives
- 3) They are eager and adventurous to take logical and intellectual threats as a challenge and reflect rare ideas.
- 4) They use resourcefulness and have a power of imagination while investigating complications and issues.
- 5) They are responsible of their personal learning progression.
- 6) They recognize their personal limitations
- 7) They are interested in others' ideas
- 8) They think before they act
- 9) They avoid emotionalism
- 10) They keep an open mind

- 11) They engage themselves in active listening
- 12) They are always focused

Activity Based Science Teaching and Critical Thinking

ABT has emerged as an innovative teaching method as compared to conventional lecture method. The prime objective of ABT is involving students in productive action. In ABT, learners discover, process, apply information, or can do something at the same time without listening to the lectures. ABT requires learners to discover chances for meaningful discussions and to listen, write, read and reflect on the concerns of academic topics (Mehmood, Kanwal, & Shaheen, 2021). Overall, there are three categories of activities designed in ABT, under which other various activities are further designed; Exploratory: students gather knowledge, learn about concepts and explore their skills to make concepts clear; Constructive: Experience starts in this step and students start to learn by their experiments; Expressional: After getting enough experience they become able to express their knowledge in the form of presentations (Aminullah, et al., 2021)

ABT and learning encompasses diverse interesting and workable activities including experimentation especially hands on, projects, role playing, and group discussion rather than only lecture method. It is to be believed that students should play their role in learning and engage themselves in all classroom practices rather listening passively that causes loss of attention and concentration. The idea emerged from Constructivist approach of learning which presents idea of innovative classroom in which students own their classroom and they are well-connected with each other while sharing their ideas and working collaboratively on any task. ABT is a type of teaching that engages students in various tasks and thinking about the tasks they are doing. This type of teaching scaffolds its learners while encouraging them for being connected with their peers which uplift effort and motivation (Anwer, 2019).

When students think independently to resolve issue or problem, they are capable of long-term learning. ABT is learner-centered which foster individualized-learning while keeping students at right track however, at their own pace. Their creativity is enhanced as they have to actively tackle problems via activity-based instruction in a well-nurtured shared environment. (Iqbal & Afzal, 2022). A teacher can integrate diverse activities in his science class depending on ILOs as dramatization, gamification, quizzes, group discussion, role play, simulation, brain storming problem-solving, discovery learning, projects-based learning, experimentation, concept mapping, Socratic questioning, project based learning, puzzles, case study, think pair share, minute's writing (Mehmood, et al., 2021)

Learning in science only by listening is not effective rather Science is learning by doing that creates reflection, critical thinking among learners. So, teaching of science is not effective without activities. That is why, students become more logical, critical thinkers, effective user of resources, conflict resolver and problem solver in real life. They move from imitation to innovation (Ahmad, Samiullah & Khan, 2019). Science education nurtures scientific knowledge among contemporary learners to deal with scientific phenomena effectively on the basis of which, various scientific and social problems can be resolved. Critical thinking intermingles with science education through observation and experimentation that are reflected as the key pillar of education in science subjects. However, it can be possible only through ABT and constructivist classroom environment (Jamil et al., 2021).

In activity based classroom, both teacher and student have to play their role, although student's role is more dominating and active as this set up is designed for the student. However, to enable him to play this role, teacher prepares him and trains him. Therefore, teacher is facilitator, organizer and resourceful of all this process and he has the equal value in the classroom. He has to use smart teaching strategies in classroom especially if he is teacher of Science. He is not only knowledge transmitter rather he works with students to explore and investigate the facts. He designs a stimulating environment in which he provokes the students to work on ideas to meet the challenging tasks. In this classroom, students work in small groups and help the group by sharing ideas, solving problems, relate their work, arguing to reach on a consensus and unite to achieve the main goals. Students in active learning take an active role, participate in the tasks, and reflect their learning. They advocate

their views and explain it to others, participate in group discussions and debate with their classmates. Small group discussion is more preferred than large group discussion (Allen, 2021).

To create critical thinking in students is linked with the participation of students in classroom discussion and essential part of education in science is creation of critical questioning in discussion and argumentation in students. Practical skills are interconnected with critical thinking and teaching and learning in all disciplines of Science like power of decision and solution of problems. In science education, different pedagogical techniques have been proposed to foster critical thinking like students be engaged in discussion, debate, evaluation of arguments, inquiry-based questioning, collaboration, pair share, self-evaluation, simulation, role-playing, project-oriented learning, outcome-based conversation; observation and evaluation (Jamil et al., 2021)

ABT, an active teaching technique and method, can increase learners' skill of thinking critically so that they may cope with complex situations and may make coherent conclusions. If there is no value of students' critical thinking skills, that will create hurdle in application of knowledge in daily life, problem solving and conflict resolution. They will not acquire the skills to deal with everyday problems. This will be a question mark on the effectiveness of education system. Therefore, to build critical thinking skills, teachers should present modern learning and active inquiry to explore problems. The solution to resolve the student's low critical thinking skills is application of innovative media and learning models (Fajari et al., 2019).

To ensure the critical thinking skills in students, assessment system should be effective and efficient. Assessment system should measure all the levels of three domains of Bloom's Taxonomy according to level of learning including higher-order abilities. A quality and effective assessment system should be established to assess the practical performance of the students especially in Science subjects. Formative assessment must include lab work, homework sheet, quizzes, periodical questions, observations, oral presentations, and classroom discussions (Jamil et al., 2021).

However, ABT encounter certain challenges as students of low ability feel shy to participate and thus they can lose their interest and confident students become dominant and excel in the classroom. If teachers are not properly trained and well prepared for the execution of activities then it can prove boring because of its length. Sharp students can push back other students. Most of the schools don't have financial resource to meet the criteria of active labs for experimentation, availability of artifacts and tools in classroom. Teachers avoid activities as they have to cover the course in time and they consider activities just wastage of time. Assessment system does not support any grading for marking in our examinations therefore teachers are reluctant to design and execute activities in classroom. Even to assess critical thinking there is no mechanism in our examination system or it is assessed only by practical exam in subjects of Science (Aminullah et al., 2021).

Objectives of the Study

The following were the study objectives:

To develop a test to measure the critical thinking of the students.

To test the critical thinking of the students.

To study the effect of activity-based approach of teaching on students' critical thinking

Hypotheses of Study

The following were the study hypothesis:

H1: Performance of experimental group is better than the performance of control group in critical thinking Pre-Test.

H2: Performance of experimental group is better than the performance of control group in critical thinking Post-Test.

Research Methodology

This research study was delimited to students enrolled in grade eight of an English medium Public sector school located in Multan of Province Punjab in the subject of Science. The study adopted the

quasi-experimental study design. This involves the use of an experimental group and a controlled group. Overall, there were total 50 students in class 8th of this school. These students were grouped into experimental and control groups based on their previous achievements to keep groups homogenous. The control group was introduced to the same concepts without necessarily using ABT methods as compared to experimental group which was taught with the help of ABT. Researchers taught students the same concepts in Science to the experimental group making use of ABT methods. A test to measure the critical thinking of students was developed based on the questions related to critical thinking given in the end of each unit in the text took. Pilot study was conducted on 100 students (not included in sample) to find out the item difficulty of items of test. Easy and difficult items were dropped from the test. The item difficulty range was 0.25 to 0.75. The items were arranged as easy to difficult in final format of test. Using Cronbach's Alpha, reliability of the test was found as 0.81. There were 25 MCQs in the test. Final format of the test was administered to both experimental and control groups as pre-test. Students were taught for 42 working days. The duration of test was 30 minutes for both categories of students to answer the questions under a supervised invigilation to ensure that there was no cheating during test to ensure validity of the scores of students (Sarpong, Sarpong & Asor, 2020).

Answer sheets were marked and score of each group was recorded keeping it confidential. The experimentation was started and activities were based on the human organ system, cell division, biotechnology; pollutants and their impacts on environment, habitats, chemical reactions, acids, bases, salt, and force and pressure selected from text book of General Science, a compulsory subject at elementary level covering Biology, Physics and Chemistry. After experimentation, test was administered to both experimental and control groups as post-test. Answer sheets were marked and score of each group was recorded.

Intervention

Activity Based Teaching

Sr. No.	Date	Activity	Description
1	10-01-2022	Kidney and its structure	Lecture
2	11-01-2022	Kidney and its structure	Model of goat's kidney, internal and external structure through disjoined and joined, students' practice and structure on workbook.
3	12-01-2022	Heredity	Lecture
4	13-01-2022	Heredity	Features of parents on charts by students and mentioning the characteristics overlap with parents and siblings
5	14-01-2022	Human activities' effects on environment	Lecture on different human activities as well as greenhouse effect
6	15-01-2022	Human activities' effects on environment	A greenhouse was established with help of students as a small chamber. The materials were provided by students from their homes. Students feel and observed different temperature inside and outside greenhouse effect.
7	17-01-2022	Environmental campaign	Lecture
8	18-01-2022	Environmental campaign	Walk to raise awareness through banners including materials that is polluting our environment.
9	20-01-2022	Application of chemical reaction	Lecture Students revised the topic in class as an activity.
10	21-01-2022	Application of chemical reaction	Lecture on exothermic reactions.
11	22-01-2022	Application of	In science lab., a beaker was half filled with water and a

		chemical reaction	small amount of lime was placed in it. After 20 seconds, students found heated outer shell. Its proved the release of heat in exothermic reactions.
12	25-01-2022	Properties of bases	Lecture on properties of bases.
13	26-01-2022	Properties of bases	Students observed physical properties in science lab and perform various chemical reactions of bases.
14	27-01-2022	Pressure, force and area	Lecture on pressure, force and area.
15	28-01-2022	Pressure, force and area	The researcher performs the activity in front of students. The plates should be filled with wet sand, and the surface of the sand should be level. Arrange the wedge so that the larger edge faces down on the sand in plate 1. Pick up the wedge, and make a note of the depth of the mark or pit that was produced on the surface of the sand. Flip the wedge over and position its thin edge so that it is lying on the sand in plate 2. Pick up the wedge, and make a mental note of how deep the mark or pit that was produced on the surface of the sand. The same amount of effort will increase the amount of pressure applied to the small area of sand.
16	02-02-2022	Water Pressure	Lecture on water pressure.
17	03-02-2022	Water Pressure	Activity with plastic bottle filled with water. Researcher did three holes with needle in plastic bottle. The water flowed and students observed water flow and water pressure.
18	09-02-2022	Pneumatics	Lecture on pneumatics.
19	09-02-2022		The researcher perform activity with the help of syringe with water and pull out plunger to clear the concept of pneumatics.
20	11-02-2022	Atmospheric Pressure	Lecture on atmospheric pressure.
21	12-02-2022	Atmospheric Pressure	Activity with half-filled glass water and paper.
22	16-02-2022	Physical Quantities	Lecture on physical quantities.
23	18-02-2022	Measuring Cylinder	Lecture on measuring cylinder
24	19-02-2022	Measuring Cylinder	In school laboratory, measuring cylinder were available, students visited the laboratory and practice using measuring cylinder.
25	21-02-2022	Sources of Heat	Lecture on the sources of heat
26	22-02-2022		Students brought firewood, coal and oil. It was demonstrated to generate heat in classroom.
27	24-02-2022	Thermal Expansion and Contraction of Solids	Lecture on thermal expansion and contraction of solids
28	25-02-2022	Thermal Expansion and Contraction of Solids	A spherical object made of metal that can easily pass through a ring was arranged. After heating the sphere to a high temperature, it could not pass through the ring. Because solid objects expand when heated.



29	02-03-2022	Thermal Expansion and Contraction of Solids	An empty flask was arranged form school laboratory. It was filled halfway with water and its mouth was closed with rubber stopper. A U-shaped glass tube's shorted limb through the plug. Water level in the glass tube was noted. Flask was heated. It was noted that water level raised in flask. Then it was allowed to cool flask. The students observed decrease in water level on cooling.
30	03-03-2022	Application of Expansion and Contraction of Solids	Lecture on application of expansion and contraction of solids.
31	03-03-2022	Application of Expansion and Contraction of Solids	A test was conducted on the topic for the purpose of assessment for learning.
32	09-03-2022	Peculiar behavior of Water	Lecture on peculiar behavior of water.
33	11-03-2022	Lenses	Lecture on lenses.
34	12-03-2022	Lenses	Students observed the working of lenses for different typed and angles.
35	17-03-2022	Power Plant Generator	Lecture on power plant generator.
36	18-03-2022	Power Plant Generator	A test was conducted on the topic for the purpose of assessment for learning.
37	23-03-2022	Energy Sources to Generate Electricity	Lecture on energy sources to generate electricity.
38	25-03-2022	Energy Sources to Generate Electricity	A test was conducted on the topic for the purpose of assessment for learning.
39	28-03-2022	Problems involved in Generating Electricity	Lecture on problems involved in generating electricity.
40	31-03-2022	Problems involved in Generating Electricity	A test was conducted on the topic for the purpose of assessment for learning.
41	04-04-2022	Electronic System	Lecture on electronic system.
42	07-04-2022	Electronic System	Electronic equipments were observed by students. Discussion was done on this topics and students did questions.

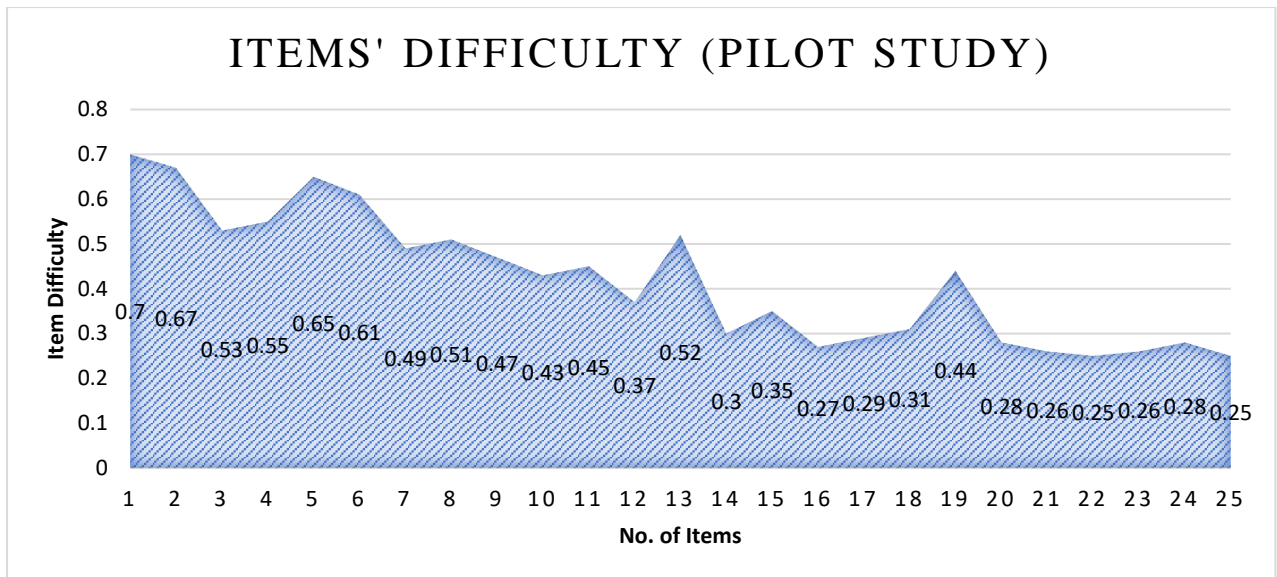
The above table shows the date wise activities performed by students of experimental group with the help of teacher. There are 42 activities, first activity is related to Kidney and its structure and last activity is related to electronic system.

Data Analysis and Results

Graph 1

Pilot Study

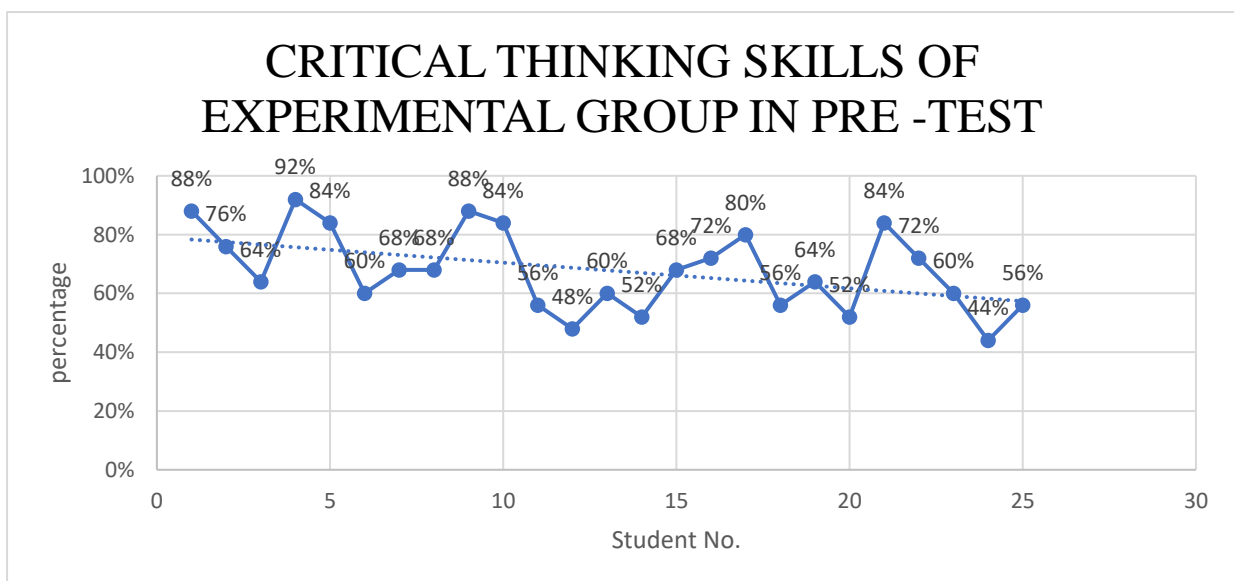




The above graph shows that items difficulty of the items of the test that varies from 0.25 to 0.70 Item No. 1 shows maximum value that is 0.70 and item No. 25 shows minimum value that is 0.25.

Graph 2

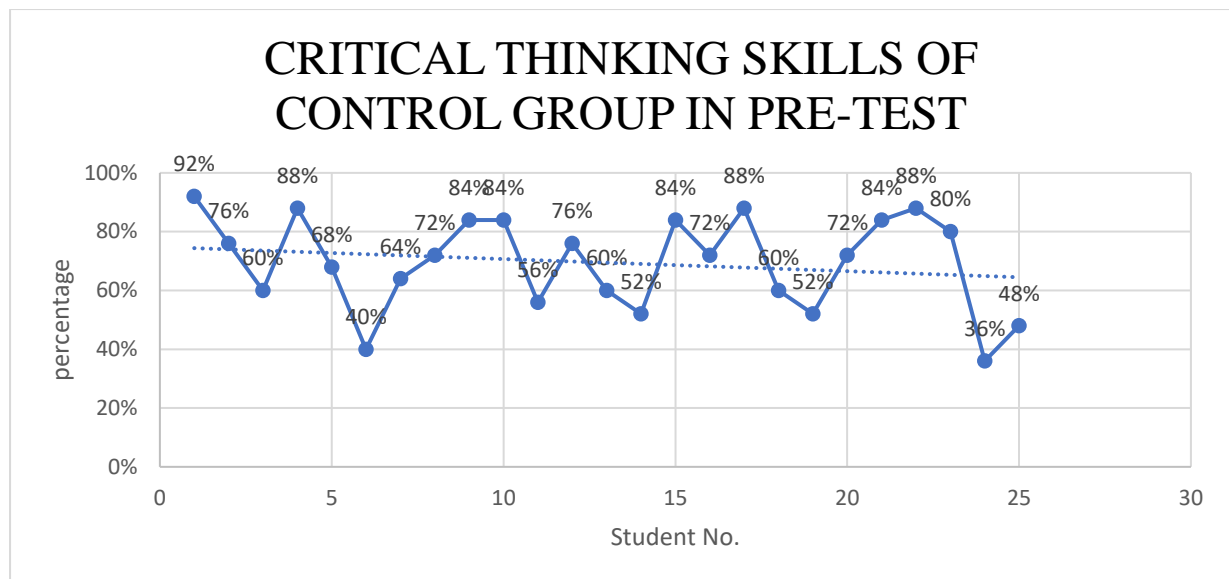
Critical Thinking Skills of the students of Experimental Group in Pre test



The above graph shows that the total mark of the students in pre-test (Critical Thinking Skills) of experimental group and the student No. 4 obtained the highest marks (92%) and Student No. 24 obtained the lowest marks (44%).

Graph 3

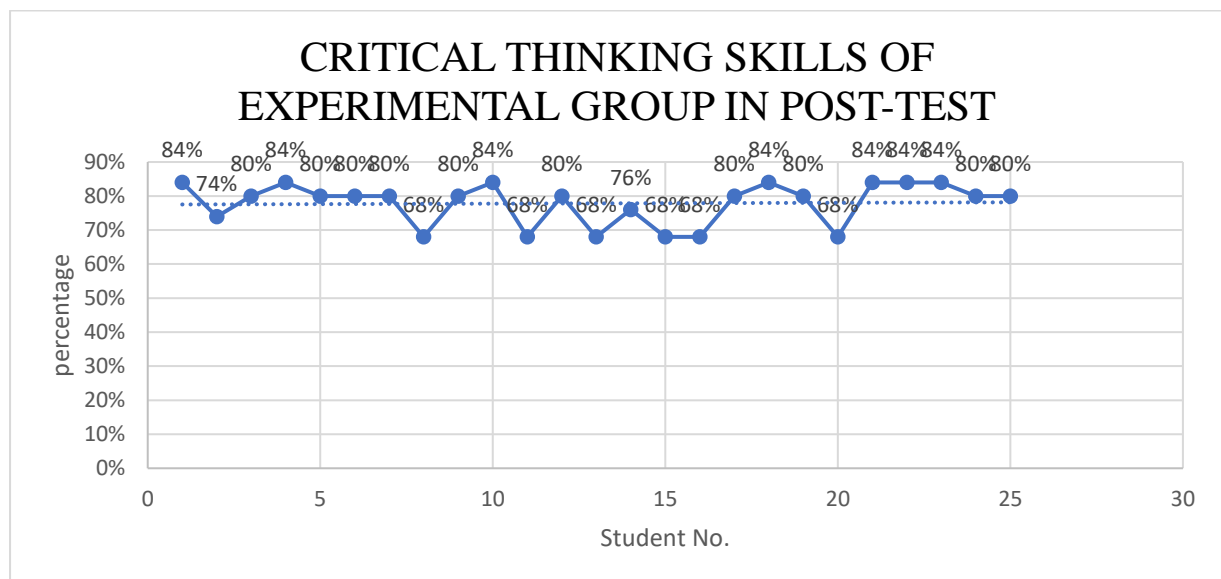
Critical Thinking Skills of the students of Control Group in Pre test



The above graph shows that the total mark of the students in pretest (Critical Thinking Skills) of control group and the student No. 1 obtained the highest marks (92%) and Student No. 24 obtained the lowest marks (36%).

Graph 4

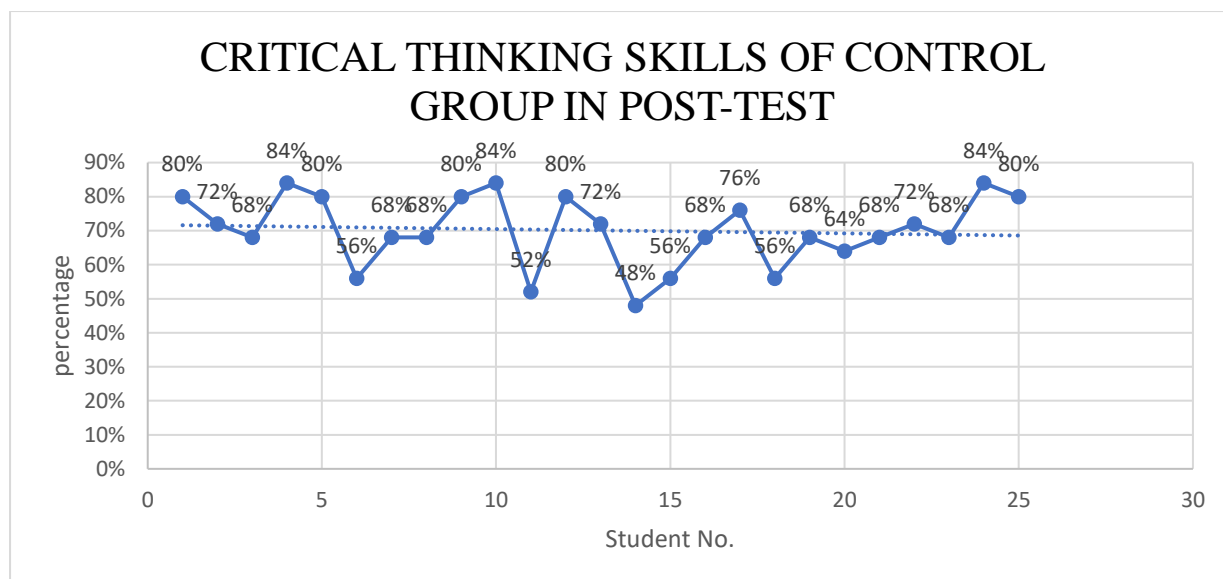
Critical Thinking Skills of the students of Experimental Group in Post test



The above graph shows that the total mark of the students in posttest (Critical Thinking Skills) of experimental group and the student Nos. 1, 2, 4, 9, 10, 18, 22 and 23 obtained the highest marks (84%) and Student Nos. 8, 11, 13, 15, 16 and 20 obtained the lowest marks (68%).

Graph 5

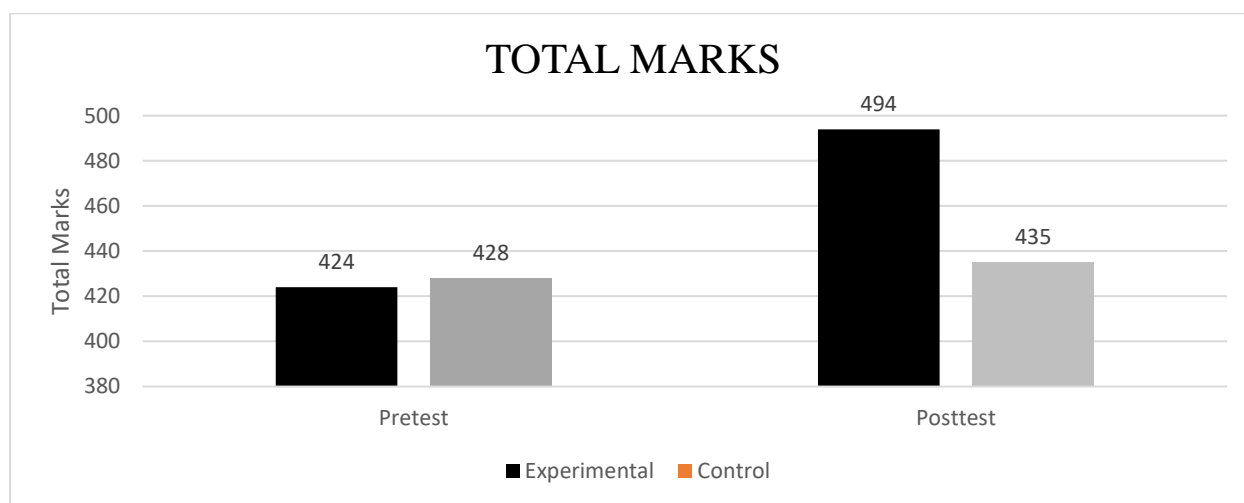
Critical Thinking Skills of the students of Control Group in Post test



The above graph shows that the total mark of the students in post-test (Critical Thinking Skills) of control group and the student Nos. 4, 10 and 24 obtained the highest marks (84%) and Student No. 14 obtained the lowest marks (48%).

Graph 6

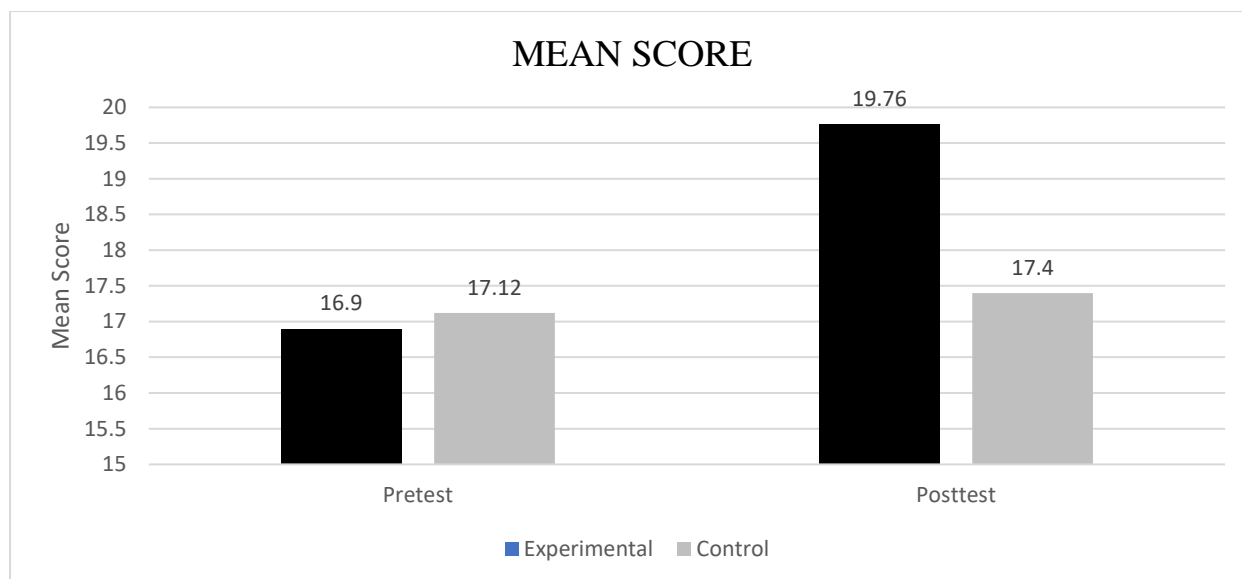
Total Score of Experimental and Control Groups in Pretest and post-test



The above graph shows the total marks experimental and control groups in pretest and posttest. The total marks of experimental group and control group are 424 and 428 in pretest and 494 and 435 in posttest respectively.

Graph

Mean Score of Experimental and Control Groups in Pretest and post-test



The above graph shows the mean score experimental and control groups in pretest and posttest. The mean score of experimental group and control group are 16.9 and 17.12 in pretest and 19.76 and 17.4 in posttest respectively.

Discussion & Conclusion

The present study was conducted to find effect of ABT on students' critical thinking skills to foster critical thinking in elementary level students in subject of Science. After experimentation, significant improvement occurred in students of experimental group as compared to control group which were taught with conventional lecture method. In post-test, by integrating ABT students' score in critical thinking test of experimental group was far better than their pre-test scores. Even Mean score of critical thinking test was also improved. The study concluded that ABT proved to be a cause of increase in students' critical thinking. Results are in line with study result by Puspita and Aloysius (2019) whose study participants also showed improvement in post-test of critical thinking test and an increase in the average score of student's critical thinking skills was also revealed after analysis. They concluded that problem-based learning, an approach of ABT proved workable to develop critical thinking in students. Yaki (2022) also found significant difference of performance in science critical thinking test after treatment in experimental group. Lapuz & Fulgencio (2020) mirrored a significant change in students' critical thinking and majority of their participants were improved in their critical thinking. Rashid and Qaisar (2016) also found that Mean scores of students showed an improvement in their critical thinking skills as they improved in all intellectual standards and it can be considered an evidence of the effectiveness of the intervention. Valdez, et al. (2015) revealed after analysis a significant change in Mean score of experimental group after introducing ABT to the Science students as compared to control group which shows that experimental group's critical thinking improved. Khan, et al. (2012) concluded that ABT method is more effective than the classical method of teaching in developing critical thinking in students in terms of Physics.

The emphasis in 21st century learning has switched over to acquisition of competencies to infer, analyze, deduce, interpret, and draw a conclusion as well as apply these skills to solve problems in real-life situation while skipping mere memorization and passive listening of lecture. Science teaching and learning augment students' critical thinking skills preparing them for practical life. Still educationists and researchers feel a mismatch between the skills acquired in the classroom and the skills required in the job market. Use of innovative teaching strategies by the school authorities and teachers is still deficit. To foster critical thinking skills in students of Science, new, self-reliant learning approaches like ABT in various forms be introduced. Although, critical thinking is not limited to any discipline like only Science rather it serves as a means of improvement in thinking by avoiding irrational and illogical thoughts (Rashid & Qaisar, 2016).

Recommendations

Following recommendations were made on the basis of findings.

- 1) ABT should be adopted in science subjects at elementary level.
- 2) Teachers be trained on regular basis to train themselves for various form of ABT
- 3) School management should assist educators to practice ABT.
- 4) Teacher should give enough freedom to students for doing different activities at their own and teach students through different activities.
- 5) Teacher must be equipped with the advanced skills of executing various forms of activity-based approach in classroom
- 6) Students' critical thinking be assessed on regular basis

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