EFFECT OF COGNITIVE ACTIVATION ON THE ACADEMIC ACHIEVEMENT OF ELEMENTARY LEVEL STUDENTS

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AUTHOR'S DECLARATION

I, Mr Nauman Sadeeque Reg. No. 189-FSS/PHDEDU/F-20 as a student of PhD Education at International Islamic University, Islamabad do hereby declare that the thesis entitled "EFFECT OF COGNITIVE ACTIVATION ON THE ACADEMIC ACHIEVEMENT OF ELEMENTARY LEVEL STUDENTS", submitted for the partial fulfillment of PhD Education is my original work, except where otherwise acknowledged in the text and has not been submitted or published earlier and shall not in future, be submitted by researcher for obtaining any degree from this or any other university or institutions.

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The thesis titled "EFFECT OF COGNITIVE ACTIVATION ON THE ACADEMIC ACHIEVEMENT OF ELEMENTARY LEVEL STUDENTS" submitted by Mr. Nauman Sadeeque Reg. No. 189-FSS/PHDEDU/F-20 in partial fulfillment of PhD degree in Education has been completed under my guidance and supervision. I am satisfied with the quality of student's research work and allow her to submit this for further process as per IIUI rules and regulation.

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ABSTRACT

This study examined the effect of the Cognitive Activation Method (CAM) on the academic achievement and retention level of elementary-level students in General Science. The main objective of the study was to determine the comparative effect of the Cognitive Activation Method (CAM) and the Lecture Method (LM) on the academic achievement and retention level of elementary-level students in General Science. The design of the study was true experimental and pretest posttest equivalent group design was used to conduct the research. Boys Elementary School Palhatar was selected as the sampling frame, and 60 students of grade 8 were randomly chosen as a sample of the study. The pretest was conducted one week prior to the start of the experiment. Based on the pretest scores, students were divided into a control group (30 students) instructed through Lecture Method and an experimental group (30 students) instructed by using Cognitive Activation Method. The treatment period was eight weeks followed by a posttest. The data were analyzed using SPSS version 25. Descriptive statistics (Mean and SD) were applied to calculate academic achievement of the elementary level students in General Science, while inferential statistics (Independent-samples t-tests, paired-samples t-tests, and partial eta squared) were used to compare group differences. Findings revealed that experimental group performed significantly better than the control group in both achievement and retention measures. The effect sizes were large (ηp^2 values between .38 and .41), highlighting the strength of CAM's impact. Subgroup analyses indicated that low achievers benefited the most, followed by medium achievers, with high achievers also improving though with smaller relative gains. It is concluded that CAM is a more effective instructional method than LM for improving both achievement and retention in General Science. Based on these conclusions, it is recommended that CAM be integrated into teacher training programs, science curricula be revised to include cognitively engaging tasks, and supportive educational policies be promoted to strengthen elementary science education. These findings carry broader implications for teacher professional development and curriculum reform, particularly in contexts where traditional lecture-based instruction still predominates.

Keywords:*Cognitive Activation Method, Lecture Method, General Science, retentions*

CHAPTER 1
INTRODUCTION

1.1 Background of the study

Education serves as a foundational pillar for both individual advancement and societal development. It equips learners with essential cognitive and social skills that enable them to think critically, solve problems, and engage meaningfully in the world around them. Among the many factors that influence educational outcomes, the methods used to deliver instruction play a pivotal role. In the educational context, the present study explores the comparative effect of the Cognitive Activation Method (CAM) and LM on the academic achievement of elementary-level students in General Science. CAM is an instructional approach designed to engage students in higher-order thinking through cognitively stimulating tasks. By investigating, how cognitively engaging teaching strategies impact academic performance, the current study aims to provide practical insights for science teachers, curriculum developers, and teacher educators (Alarifi, 2023).

In modern educational settings, the landscape of science instruction is being reshaped by innovative teaching methodologies. Education can generally be categorized into informal and formal modes. While informal education occurs through family, community, and self-directed learning, formal education is delivered in structured institutions with accredited curricula. The current study is situated within the context of formal science education, where methods such as CAM are gaining recognition for their ability to promote inquiry-based learning and student engagement. By focusing on CAM within formal classroom settings, current research seeks to provide empirically grounded guidance for improving teaching practices and student outcomes in General Science (Obidovna, 2023).

In modern classrooms, science instruction is being reshaped by innovative methods that promote active learning. Among these, the Cognitive Activation Method (CAM) is recognized for fostering inquiry, critical thinking, and student engagement. Unlike traditional lecture-based teaching, CAM relies on cognitively challenging tasks, questioning, and dialogue that enhance comprehension and long-term retention. The effectiveness of any teaching method depends largely on the teacher’s role. When educators employ strategies like CAM, they move beyond rote delivery to create interactive learning environments that motivate students and improve achievement in science (Lombardi *et al.,* 2021).

Science education plays a crucial role in nurturing curiosity, creativity, and scientific literacy among young learners. At the elementary level, one key objective is to connect students' prior knowledge with new concepts so they can develop logical reasoning and problem-solving skills. The Cognitive Activation Method (CAM) supports this process by promoting inquiry, encouraging conceptual conflict, and fostering active dialogue. When effectively implemented, CAM enables learners to construct knowledge meaningfully and develop the habits of scientific thinking. In this way, it not only improves immediate academic achievement but also lays the foundation for higher-order thinking skills that are essential for future learning in science and other disciplines (Nurbavliyev *et al.,* 2022).

Lipowsky (2015) highlighted the challenges of directly measuring cognitive activation, which often requires indirect indicators such as analyzing lesson materials or observing teaching practices. Two key methods are used in research: the examination of instructional content and the analysis of classroom interactions via recorded lessons. These indicators include presenting cognitively demanding tasks, clarifying conceptual distinctions, prompting students to explain reasoning, and integrating prior knowledge into new learning experiences. These instructional elements are foundational to CAM and are associated with improved student performance (PISA, 2020).

The Cognitive Activation Method (CAM) is a structured teaching approach that promotes deep thinking, inquiry, and active student engagement. It consists of three main components. The first is challenging questions, where the teacher introduces thought-provoking problems, encourages student inquiry, and asks open-ended, cognitively demanding questions (Lipowsky *et al*., 2009). The second component focuses on activating prior knowledge, fostering in-depth learning, and creating cognitive conflictteachers explore students' preconceptions, ask them to justify their reasoning, and present surprising facts that challenge their assumptions (Barenthien *et al.,* 2023). The third component involves instructional dialogue, in which teachers facilitate meaningful discussions among students, encouraging them to respond to each other's ideas and learn from their mistakes. These elements make CAM highly relevant for science education, where conceptual understanding and critical thinking are essential (Wen, 2021).

CAM is particularly critical for teaching science at the elementary level because science education requires more than factual recall. it involves developing inquiry skills, logical reasoning, and conceptual understanding from an early age. Young learners often hold misconceptions about scientific phenomena, and CAM effectively addresses these through strategies that activate prior knowledge, generate cognitive conflict, and encourage reflective dialogue. By fostering curiosity, problem-solving, and deeper engagement, CAM helps students build a strong foundation in scientific thinking. The steps of the CAMmake it an ideal method for creating active, student-centered science classrooms that support long-term academic achievement of the elementary level students (Shanta & Wells 2022).

Research on CAM often focuses on the role of Pedagogical Content Knowledge (PCK) in shaping cognitively stimulating classroom interactions. While many studies have analyzed instructional tasks, fewer have relied on video evidence of actual teaching. This methodological gap limits our understanding of how CAM operates across different contexts and subjects. Moreover, most studies have centered on mathematics and physics, with science education in general requiring further exploration (Pozo-Rico *et al*., 2023).

Hardy and Stern (2006) argue that student-led inquiry is only effective when supported by structured guidance. Even at the primary level, when appropriate scaffolding is provided, cognitively engaging instruction becomes feasible. Activities such as guided experiments can promote CAM in early grades, but care must be taken to avoid overwhelming students. The Cognitive Activation Method aligns with the constructivist shift in education, moving beyond rote learning to active, reflective, and student-centered teaching (Barenthien *et al*., 2023).

Fortsch (2016) in the Prow study used video analysis to trace the development of cognitive activation in biology instruction. Results showed a strong link between teachers' PCK and the successful implementation of CAM strategies. Other studies further confirm the relationship between CAM, student engagement, and academic outcomes. Constructivist approaches like those used by Ewerhardy *et al*. in Grade 4 science classes have demonstrated improvements in students' conceptual understanding, showing the value of strategies that promote reflection, debate, and contextual learning (Steffe & Ulrich, 2023).

The evolving landscape of education demands innovative approaches that foster deeper cognitive engagement and active learning among students. The shift toward constructivist paradigms highlights the importance of teaching methods that not only transmit knowledge but also stimulate critical thinking and problem-solving skills. Understanding how pedagogical content knowledge and cognitive activation influence student outcomes is essential for improving instructional quality across disciplines, particularly in science education. The current study aims to address these gaps by exploring effective teaching strategies that promote meaningful learning experiences. The following section, "Rationale of the Study," will elaborate on the specific motivations and context driving the current research, underscoring its significance in contributing to contemporary educational practice and theory.

1.2 Rationale of the study

The current study aims to compare the effectiveness of the Cognitive Activation Method and the Lecture Method in enhancing students' academic achievement in General Science. By examining the Cognitive Activation Method in comparison to the traditional lecture method, the current research aims to provide evidence-based insights into effective instructional strategies for teaching General Science at the elementary level in Pakistan.

In contemporary education, the effectiveness of teaching methods plays a critical role in shaping students' academic performance, particularly in science where critical thinking and conceptual understanding are essential. While traditional lecture-based teaching remains prevalent, it often fosters passive learning, which can hinder student engagement and limit deeper comprehension of scientific concepts. In contrast, the Cognitive Activation Method emphasizes stimulating students' cognitive processes through thought-provoking questions, problem-solving tasks, and active participation, thereby promoting a more profound grasp of complex scientific ideas.

This research is especially significant in the context of developing countries, where educational stakeholdersincluding instructors, head teachers, curriculum developers, and educational authoritiesmust increasingly focus on the cognitive aspects of knowledge acquisition. The findings of this study are expected to inform and support efforts to improve teaching practices by integrating cognitive activation strategies in science education.

Furthermore, the study aspires to contribute to the development of innovative teaching approaches that enhance science education. Science education is vital, as it equips students with the skills necessary to understand and engage with complex scientific phenomena. By exploring effective pedagogical methods, this research will support the continuous evolution of science teaching to meet the demands of a rapidly changing world, ensuring students are prepared with critical thinking and problem-solving abilities essential for their academic and future success.

The Cognitive Activation Method (CAM) is grounded in the principles of constructivism and cognitive psychology, emphasizing the active involvement of students in the learning process through tasks that challenge their thinking and promote meaningful engagement. Unlike traditional lecture-based approaches, CAM encourages students to confront cognitive conflicts, reflect on their prior knowledge, and construct new understanding through dialogue and problem-solving.

Several studies have explored the effectiveness of CAM in improving student outcomes. For instance, Klieme *et al*. (2009) found that cognitively activating instruction significantly enhances students' conceptual understanding in mathematics and science. Similarly, Baumert *et al*. (2010) emphasized that high-quality cognitive activation correlates positively with students' long-term achievement. However, most of these studies have been conducted in Western contexts and secondary education settings, leaving a gap in understanding CAM's effectiveness at the elementary level, particularly in developing countries.

Moreover, Lipowsky *et al*., (2009) supports the effectiveness of CAM in increasing student engagement and motivation, other studies highlight challenges in its implementation, such as teachers' limited training and curriculum constraints. These contradictions indicate a need for more context-specific investigations that account for local educational realities.

Few studies use experimental or quasi-experimental designs to establish causal links between CAM and academic achievement. Additionally, there is limited research that examines CAM’s impact across diverse disciplines, especially in science education at the elementary level.

Given these gaps, the present study aims to contribute to the literature by evaluating the effectiveness of CAM in comparison to traditional lecture methods in the teaching of General Science at the elementary level in Pakistan. Through an experimental design, the study not only assesses student achievement outcomes but also explores CAM's applicability in a context where teacher-centered approaches still dominate classroom instruction.

Globally, research in science education has increasingly highlighted the limitations of teacher-centered instruction and the benefits of active learning approaches. Studies in countries such as Finland, the United States, and Singapore demonstrate that student-centered, cognitively oriented teaching methods foster deeper understanding, problem-solving skills, and long-term retention of scientific knowledge (Freeman *et al*., 2014). These global trends underscore the shift from rote learning and passive reception toward active engagement and higher-order thinking.

In contrast, science classrooms in Pakistan remain largely dominated by the traditional Lecture Method, where students assume a passive role in the learning process. Research evidence shows that this reliance on lecture-based instruction leads to low participation, superficial understanding, and poor achievement in science (Shah *et al*., 2012). Recent Pakistani studies further confirm that constructivist and activity-based methods significantly improve student learning outcomes compared to traditional instruction (Salmachanna & Karim, 2023). This mismatch between international best practices and local classroom realities highlights the urgent need for empirical research in Pakistan on alternative instructional strategies.

Unlike the traditional Lecture Method, which often encourages passive learning, the Cognitive Activation Method actively engages students in inquiry, problem-solving, and higher-order thinking, making it particularly necessary for improving science education outcomes in Pakistan’s elementary classrooms

In Pakistan, the Lecture Method (LM) continues to dominate classroom practices, particularly in science teaching, where students are often passive recipients of information. This approach has been criticized for encouraging rote memorization and providing limited opportunities for critical thinking and problem-solving. In contrast, the Cognitive Activation Method (CAM) emphasizes inquiry, higher-order questioning, and student engagement with cognitively demanding tasks. As international research indicates, CAM fosters deeper conceptual understanding and stronger retention of knowledge. Therefore, it is necessary to compare CAM with LM in the local context to provide empirical evidence on which approach better serves the learning needs of elementary-level students.

1.3 Problem Statement

In many developing countries, including Pakistan, the teaching of General Science at the elementary level continues to rely greatly on the Lecture Method. While widely practiced, this traditional approach often results in passive student engagement and limited conceptual understanding, particularly in science education where active learning is essential. Although international and national studies highlight the benefits of constructivist and activity-based approaches, such as improved science achievement and deeper learning, local classrooms remain largely teacher-centered and ineffective in promoting higher-order thinking skills(Fırat, Koksal & Bahşi, 2021). More recent studies in Pakistan also demonstrate that constructivist and activity-based approaches yield better science achievement compared to traditional methods (Noureen, & Karim, 2023).Despite these findings and global shifts toward constructivist and cognitively oriented models of instruction, science classrooms in Pakistan remain dominated by outdated, teacher-centered practices that are ineffective in developing higher-order thinking skills. This persistent reliance on the lecture method poses a significant barrier to achieving the goals of modern curricula. To address this gap, it is essential to empirically examine alternative instructional strategies that actively engage learners. The Cognitive Activation Method (CAM), grounded in cognitivist learning theory, offers such an approach by stimulating students' thinking processes, encouraging participation, and fostering deeper conceptual understanding. Moreover, limited research in Pakistan has tested the comparative effectiveness of CAM against the lecture method in science education. Therefore, this study seeks to investigate the effect of the Cognitive Activation Method on the academic achievement of elementary-level students in General Science, compared to the Lecture Method.

1.4 Objectives of the Study

The objectives of the study were:

1. To determine the effect of Lecture Method on the academic achievement of

elementary level students in General Science.

2. To examine the effect of Cognitive Activation on the academic achievement of elementary level students in General Science.
3. To compare the effect of Lecture Method and Cognitive Activation Method on the academic achievement of elementary level students in General Science
4. To determine the effect of Lecture Method on the academic achievement of lower, medium and higher achievers in General Science.
5. To examine the effect of Cognitive Activation Method on the academic achievement of lower, medium and higher achievers in General Science.
6. To compare the effect of Lecture Method and Cognitive Activation Method on the academic achievement lower, medium and higher achievers in General Science.
7. To compare the retention level of elementary level students in General Science treated with Cognitive Activation Method and Lecture Method.

1.5 Research Hypotheses

Following were the research hypotheses of the study:

$H_0$1: There is no significant effect of Lecture Method on the Academic Achievement of elementary level students in General Science

H_{02}: There is no significant effect of Cognitive Activation Method on the academic achievement of elementary level students in General Science

H_{03}: There is no significant difference between the effect of Cognitive Activation Method and Lecture Method on the academic achievement of elementary level students in General Science

H_o4: There is no significant effect of Lecture Method on the academic achievement of lower achievers in General Science.

$H_0$5: There is no significant effect of Lecture Method on the academic achievement of medium achievers in General Science.

$H_0$6: There is no significant effect of Lecture Method on the academic achievement of higher achievers in General Science.

H_o7: There is no significant effect of Cognitive Activation Method on the academic achievement of lower achievers in General Science.

$H_0 8$: There is no significant effect of Cognitive Activation Method on the academic achievement of medium achievers in General Science.

$H_0 9$: There is no significant effect of Cognitive Activation on the academic achievement of higher achievers in General Science.

$H_0 10$: There is no significant difference between the effect of Lecture Method and Cognitive Activation Method on the academic achievement of lower achievers in General Science.

$H_0 11$: There is no significant difference between the effect of Lecture Method and Cognitive Activation Method on the academic achievement of medium achievers in General Science.

$H_0 12$: There is no significant difference between the effect of Lecture Method and Cognitive Activation Method on the academic achievement of higher achievers in General Science.

$H_0 13$: There is no significant difference between the academic achievements of the students of control group in posttest and retention test.

$H_0 14$: There is no significant difference between the academic achievements of the students of experimental group in posttest and retention test.

$H_0 15$: There is no significant difference between the academic achievementsof control and experimental group in retention test.

1.6 Significance of the Study

The present study is significant for teachers, curriculum developers, policymakers, and researchers. For teachers, the findings provide practical evidence that the Cognitive Activation Method (CAM) is more effective than the traditional Lecture Method (LM) in enhancing students' academic achievement and retention in General Science. This study guides that teachers can improve classroom engagement and learning outcomes by integrating cognitively demanding tasks, guided inquiry, and thought-provoking questions into their practice.

For curriculum developers, the study highlights the need to embed CAM-based strategies in textbooks and teacher guides so that elementary-level science curricula foster inquiry, problem-solving, and deeper conceptual understanding rather than rote learning.

The study is also valuable for teacher training institutions, as it suggests that pre-service and in-service teacher education programs may include modules on cognitive activation strategies. Training teachers in these approaches will prepare them to move beyond lecture-dominated instruction and adopt methods that support diverse learners, especially low and medium achievers who benefited the most from CAM in this research.

For policymakers, the results provide insights for aligning classroom practices with the objectives of the Single National Curriculum by promoting learner-centered instructional strategies and supporting teacher capacity-building initiatives. Finally, this study contributes to the limited local literature on CAM in Pakistan and opens new avenues for researchers to explore its effects in mixed-gender contexts, in other science disciplines, and over longer instructional periods.

1.7 Delimitations of the Study

The study was delimited to:

1. The District Kotli AJ&K
2. Government Boys Elementary School Palhatar Kotli Azad Kashmir
3. The students of 8th class
4. Following three chapters of General Science (SNC, 2022) of Azad Jammu and Kashmir textbook Board, printed in 2023;
    1. Ecology
    2. Chemical Reactions
    3. Force and Pressure

1.8 Operational Definitions of Key Terms

Academic Achievement: Academic Achievement refers to the degree to which the students fulfilled specified educational objectives, whether they are of a short-term or long-term nature. The determination of achievement can be quantified through the evaluation of students' grade point averages, whereas for academic institutions, indicators of achievement may be assessed through their respective graduation rates. In this research, the performance metrics derived from pre-test and post-test assessments will serve as the operational definition of Academic Achievement.

Lecture Method: The Lecture Method, often referred to as the traditional pedagogical approach, constitutes a teaching strategy wherein an educator guides students through techniques of memorization and recitation, consequently neglecting the cultivation of critical thinking, problem-solving, and decision-making competencies. This conventional method of instruction is characterized by a predominant focus on the educator, rendering the approach teacher-centered.

Cognitive Activation Method: Cognitive Activation fundamentally pertains to the instruction of students in strategies that promote deeper cognitive engagement, enabling them to devise solutions while emphasizing the processes employed to arrive at those conclusions, rather than merely fixating on the final answer. Cognitive Activation is recognized as one of several instructional practices that facilitate the enhancement of scientific literacy.

1.9 Conceptual framework

The conceptual framework of the study is given below:

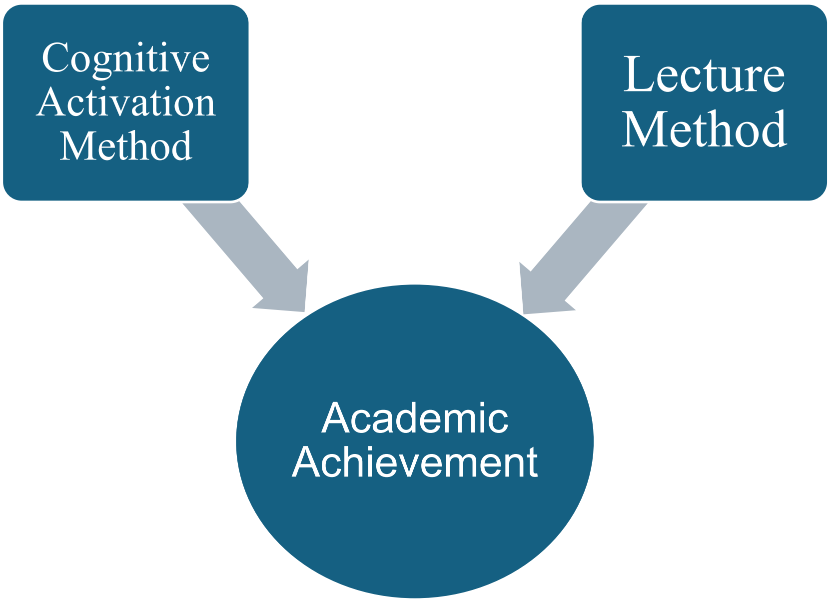

Figure 1.1 Conceptual Framework of the study

The above figure indicates the entire process of the experiment. The CAM and LM were the independent variable and academic achievement is the dependent variable of the study.

CHAPTER 2
REVIEW OF THE RELATED LITERATURE

This chapter provides a refined review of related literature on the Lecture Method (LM) and Cognitive Activation Method (CAM), critically analyzing their theoretical underpinnings, empirical evidence, and practical implications for elementary education. Unlike descriptive reviews, this chapter adopts a critical lens by synthesizing agreements, contradictions, and gaps in prior studies. Particular emphasis is placed on the Pakistani context, where teacher-centered methods remain dominant, and the need to explore CAM experimentally is urgent. The detail description of the works of the researchers on the topic and related topics of Cognitive Activation is given below;

2.1 Science Education

Science education at school level could be beneficial only when students realized its value in their personal lives. Students might lose interest in science education if is not enthusiastic enough or does not concern them. If positive responses are needed about science education, then the issues for woman, extremely religious people, with cultural capitals and the people who have their roots outside the west should be taken into notice and systematically resolved. A great subject for science educators is that students are much involved in practical science work in their lives than school science lessons. Science museums, botanical gardens and zoos give an up list to science education (Rottman & Nokes-Malach, 2023).

2.1.1 Function of Scientific Education

The main function of scientific education is to create sound minds and the ability to make tough decisions and objective choices. This view of science education is not understood by the society that's why they do not get fully benefited by technology. The scientific knowledge tries to struggle with the three mutually contradictory requirements. On one side, it wants to present the main laboratory power that is offered by science a combination of the excitement of gaining new knowledge as well as exploring the microscopic material world. The mechanism of science teaching is to make students rely on rigid and extended science education in which they learn without questioning. Because of this foundational concept, it is impossible to get cultural benefits from science and technology (Cooper, 2023).

2.1.2 Sources of Science Education

Science is also available in bookish form for small as well as adults. Two-third of the life of every student is spent outside the classroom where they are impressed by the scientific processes but the teachers ignore this aspect completely or take it as a misconception while it can be helpful in building students' interest and mental capabilities. This source could be helpful in clearing science concepts. Newspaper, magazines, multichannel TV, internet are the great resources of attractive and complete science education (Cheung & Tai, 2023).

In a study made, it was shown that science museum visits can be helpful in clearing the misconception and building new concept about some phenomenon like force and motion etc. Students also get the opportunity to explore science as they cannot do in their laboratory due to security issues for example combustion experiments, rocket launching, ecological surveys, observing the open night sky. Is not still unknown how these activities improve student's scientific approach. Science museums, industries, zoos and botanical gardens offer the golden chances to students to see and complete yesterday's and today's science in daily use. Aircraft, Heavy machinery and other collection and their related stories help students to understand their use and importance of science and the social enterprise in which people are involved (Muktiarni, Rahayu & Maryanti, 2023).

2.1.3 Science Education and our life

The education that tends to increase the knowledge of people about scientific processes and elements is called science education. It mainly concerns general public, small and adult. This field consists of scientific information, social science and teaching methodology. Science education is meant to make students understand scientific truths through course study. Its curriculum standards include physical, life earth and space science. Through science education, a person becomes able to think his personal knowledge or experience with natural activities of life. It makes one to develop a logical thinking approach (Klopfer & Aikenhead, 2022).

The luxuries, curriculum and educators in science education are also related to science. Science has made a great cultural change in the world. If a man of past could possibly see his future, he would say that this world is none he knows about. Science has changed all the fields of life. For example; change in

1. Our lifestyle and houses

2. Personal relations
3. Our dressing and health
4. Habits, values and rituals
5. Political change (Treagust & Won, 2023).

2.1.4 Educational Objectives of science education

The major purpose of education is to bring out a thought of justice in human beings. Education system should be so established that could modify human mentality and attitude, getting them out of injustice, Chios and worldly temptations. Following main aims are given by National Education Policy 1998-2010;

- To acknowledge students by Quranic beliefs for gaining science education.
- To benefit traditional education by the use of science.
- To make students aware of importance, achievements and effects of science education.
- To create a professional approach in students.
- To make people appreciate everyday use of science.
- To teach students structure and scope of science education.
- To develop more productive future citizens (Worner *et al*., 2022).

2.1.5 Cognitive Activation in Science Education

Most studies examining cognitive activation in science instruction and its effects on student achievement and interest have focused on fifth grade and higher. To the best of our knowledge, no research has yet explored the use of cognitive activation in kindergarten or compared its application between kindergarten and elementary school.When educators express interest for the subject matter and use creative methods to convey information, students are supposed to motivate to learn and excel in their studies. Regular assessments help identify student strengths and areas for improvement, allowing educators to adjust teaching methods to meet specific learning needs and provide timely feedback. In addition to academic knowledge, effective teaching methods help develop essential life skills such as communication, collaboration and adaptability.

Access to quality education reduces inequality and promotes social mobility. Empowering minds through a comprehensive science education lays the foundation for a future where curiosity inspires discovery, critical thinking drives innovation, and a scientifically literate society navigates the complexities of an evolving world. If these tasks were achieved, cognitively activated teaching in primary schools would already be possible (Schumacher, & Stern, 2023).

Research predominantly employs two distinct methodologies for the measurement of cognitive activation. Firstly, the pedagogical practices may be examined indirectly through an analysis of the materials and tasks that educators implement within the classroom context. Conversely, it is also feasible to conduct a direct analysis of the instructional process, for instance, through the video documentation of the course, which can subsequently be evaluated utilizing a coding manual or an observational protocol tailored to the course. However, the research did not incorporate video documentation of the instructional sessions, opting instead for an analysis of the educator's instructional tasks (Pacaci *et al*., 2024).

In addition, students and schools completed questionnaires, respectively, providing information on student backgrounds and attitudes, school management, and school climate. And the following points are found to be true in general. Teachers have great experience with these methods as confirmed by research. A good teacher is the one who does not waste a single minute of class and keep them busy. Time management is very important. A wise teacher must notice the student's learning time. Training techniques and systems ought to energize students. Teachers are a key piece of advancing learning among students. For them, it is essential to guarantee that the training strategies utilized are useful to the students. For instance, in the event that students can learn better by directing notes, at that point the educator ought to give notes. Individuals equipped with scientific literacy can critically assess information, engage in meaningful dialogue about pressing global issues such as climate change, and make decisions that contribute positively to society (Asmara *et al*., 2024).

2.1.6 The Challenge of Strengthening Science Education

As for as Science education is concerned at school levels its very challenging especially in underdeveloped regions. If a country wants to make progress in the technology-based markets, highly qualified scientist and technicians are needed. If a science education is not made compulsory at the primary level, the youngsters cannot do much science. The scale of this problem and its causes are summarized in a report by Roberts, 2002. It is noted that lesser woman opt science subject, students have poor experience of science education, lack of less qualified science teachers and people unaware of science carriers. The government's ten years 'Science and Innovation Investment Framework 2004-2014 (Suwono *et al*., 2023).

2.1.6.1 Lack of professional Science Educators

The strategy guides about the curriculum issues and shortage of professionals but it provides no solution. Most of the science education research work is completed at secondary level but primary level also includes similar problems. 'Science education is needed for citizenship'. It should be designed to enhance children's curiosity about the material world around them explore the important ideas about science framework. There are three ways in which scientific ideas and knowledge is very important;

1. Firstly, in practical life to identify the elements of a healthy life style
2. Secondly in civic life to take part in decision making like the future map of electric supply
3. Thirdly in economic life to respond optimistically toward the

Science based changes (Otten *et al*., 2024).

2.1.6.2 Lack of Scientific Attitude

If the main purpose of science education is to produce a large no. of scientists and technicians then youngsters having aptitude of science should be brought forward. They should be given a separate scientific environment and specialized science education. Such people share the need of broad science education. But there is no reliable compass to identify these people. Some of them show their interest in science education in the beginning but fades away latterly. Some find it interesting lately. Young people take interest in broadly based education based on a range of transferable abilities. So, they resist everything that comes in their way of choice. The solution to this problem is to provide best science education for citizenship at every level (Muyunda *et al*., 2023).

If that education system would have been challenging enough then student's creativities, lateral thinking and abilities could get exposed easily. In this way young people would be encouraged toward science related career paths. Now what are the factors that could help in promoting science education at a high level for everyone in future? The audio-visual aids and the teaching method make a student able to indulge in his studies should be noted. This diversity should be met by special teaching ways. The curriculum should be turned into science education for citizenship. The learning should closely match to this aim. Moreover, highly qualified, enthusiastic teachers and sufficient studying environment should also be provided (Kougias *et al*., 2023).

2.2 Teaching of Science

Teaching plays a central role in shaping student learning outcomes, particularly in science education, which requires not only content knowledge but also critical thinking and inquiry. Research highlights that effective teaching integrates subject mastery, pedagogical skills, and classroom management (Aguilera & Perales, 2023). However, effectiveness is often mediated by the instructional method employed. Traditional methods like lectures emphasize coverage and efficiency, while contemporary approaches such as CAM emphasize student engagement, reasoning, and retention. Therefore in researcher's point of view, this duality underscores the ongoing debate over which teaching strategies best support long-term academic achievement.

Teaching constitutes the fundamental concern of education, which has a direct influence on the manner in which students acquire knowledge. In light of the existing diversity and escalating expectations surrounding education, a transformative change in educational delivery is imperative; this change needed for transformation necessitates the implementation of a more student-centric approach to learning and instruction, the integration of adaptable learning pathways, and the acknowledgment of learning opportunities that arise beyond the traditional curriculum. The influence of teaching on student performance, as well as the presence of professional competencies encompassing skills, knowledge, qualifications, and ongoing professional development, under marks that the caliber of educators is pivotal to the successful attainment of the Education for All (EFA) objectives. There exists a compelling necessity to cultivate a more expansive vision of educational objectives to enhance national capacity and to foster the essential competencies required by all learners through the renewal of curricula tailored for emerging knowledge-driven societies throughout the world (Urishov, 2023).

The essential traits of an effective teacher include a strong grasp of their subject matter, relevant teaching experience, formal training, certification, and robust academic skills. Another perspective on effective teaching emphasizes the importance of cognitive resources, suggesting that a teacher's knowledge, skills, and attitudes play a pivotal role in determining teaching quality. Enhancing these aspects should be a central focus for educational institutions. For instance, in the United States, the "No Child Left Behind" Act, enacted in 2001, aimed to improve the academic performance of specific student groups, including English language learners, students receiving special education services, and children from economically disadvantaged or minority backgrounds (Ssemugenyi, 2023).

Many studies have been conducted on instructional methods, and it has been concluded that variables associated with teacher competency, such as subject knowledge, pedagogical skills, and classroom management, play a significant role in enhancing student academic achievement.Teachers implement strategies to reward outstanding performance, and students need to work durable to pick up. High school student's generally feel right to the superior category and flush people; they know the desire to have a fine livelihood. Educational researchers analyzed many factors to explain why some students performed better on standardized tests and achieved higher levels of academic achievement. Science is a unique subject because it creates professionals instead of future citizens. It makes such a curriculum whose components can easily understand who are at distance. And along it subject becomes valuable and meaningful. It mainly consists of assessment system which requires low level cognitive recall (Aguilera & Perales, 2023).

A series of studies performed in 1970's to found out the qualities of effective taeching . " Effective Teaching Research"shows that the old beliefs about good teaching methods are accurate. And the following points are found to be true in general. Teachers have great experience with these methods as confirmed by research. A good teacher is the one who does not waste a single minute of class and keep them busy. Time management is very important. A wise teacher must notice the student's learning time. Training techniques and systems ought to energize students. Teachers are a key piece of advancing learning among students. For them, it is essential to guarantee that the training strategies utilized are useful to the students. For instance, in the event that students can learn better by directing notes, at that point the educator ought to give notes (Al-Seghayer, 2023).

Teaching General Science focuses on helping students comprehend the natural world by developing their scientific knowledge, skills, and attitudes. The primary objectives include enabling students to grasp scientific ideas, principles, and processes; promoting curiosity through inquiry, exploration, and experimentation; linking scientific theories to practical, real-life situations; and fostering analytical thinking by teaching them to evaluate data, form hypotheses, and draw logical conclusions (Windschitl, 2023).

Teaching General Science is fundamental to education, as it cultivates critical thinking, curiosity, and an understanding of the natural environment. It plays an essential role in building scientific literacy, empowering individuals to make well-informed choices in both personal and societal contexts. By incorporating inquiry-based learning, science education develops vital competencies such as observation, analysis, logical reasoning, and problem-solving. These abilities are adaptable to various disciplines and pivotal for solving practical challenges, including those abilities related to environmental conservation and technological advancements (Southeastern Oklahoma State University, 2023).

Additionally, science education bridges different domains of knowledge by incorporating concepts from life sciences, physical sciences, and earth sciences. This interdisciplinary method aids students in grasping intricate systems and understanding the interconnectedness between human actions and natural ecosystems. It also equips learners with the knowledge required for STEM careers, which are increasingly significant in the modern, technology-focused world (Somerville, 2022).

Beyond career readiness, science teaching fosters informed and responsible citizenship. Individuals equipped with scientific literacy can critically assess information, engage in meaningful dialogue about pressing global issues such as climate change, and make decisions that contribute positively to society. Furthermore, science education inspires creativity by enabling learners to formulate and test hypotheses, conduct experiments, and interpret data, which are essential components of innovation. These approaches make science accessible and relevant, encouraging curiosity and a lifelong passion for learning. Ultimately, teaching General Science establishes the groundwork for continuous education and thoughtful decision-making throughout life (Alhomairi, 2024).

2.2.1 Critical Perspective on teaching General Science

Although the literature affirms the centrality of effective teaching in shaping scientific understanding, much of the existing research remains descriptive, emphasizing teacher qualities and classroom practices in isolation. What remains less explored is how specific instructional methods interact with these teacher competencies to influence deeper learning outcomes such as achievement and retention. While the Lecture Method continues to dominate due to its efficiency and familiarity, its emphasis on coverage often undermines critical inquiry and long-term understanding. Conversely, contemporary methods such as CAM align more closely with constructivist principles by actively engaging learners, yet their effectiveness in resource-constrained and exam-driven contexts like Pakistan remains insufficiently examined. These contradictions highlight the need for experimental studies that move beyond generalized claims about "good teaching" to rigorously evaluate how distinct pedagogical approaches affect learning in elementary science classrooms.

2.3 Methods of Teaching General Science

Some Instructional models are old but, in this century, their use is increased. Here some traditional and modern models will be discussed in detail;

2.3.1 Problem Solving Method

Science is a fundamental component of school education. However, traditional teaching methods have been criticized for their inability to promote critical thinking and create a well-rounded learning environment for students. Science education should aim to build scientific process skills in children, such as observation, measurement, classification, information processing, interpretation, critical thinking, problem-solving, analysis, synthesis, and conclusion-drawing. It is also important to emphasize that creativity plays a vital role in this process. Through the problem-solving method, students learn by actively engaging with challenges. They are encouraged to observe, comprehend, analyze, interpret, identify solutions, and apply their knowledge, which leads to a deeper understanding of concepts. This approach not only enhances scientific process skills but also fosters brainstorming techniques to grasp scientific ideas effectively (Akben, 2020).

While the problem-solving method has been widely appreciated for cultivating higher-order thinking and creativity, it is not without challenges. Research indicates that although students gain deep conceptual understanding through this approach, it can be time-intensive and demanding in terms of teacher expertise and classroom resources. In under-resourced schools, teachers often struggle to balance syllabus coverage with the open-ended nature of problem-solving activities. Compared with traditional lecture-based instruction, which ensures content delivery but fosters passive learning, problem-solving offers richer engagement but risks inconsistency in outcomes if not well-structured. In contrast, methods such as activity-based learning provide more guided interaction, though sometimes with less emphasis on independent reasoning. Within this spectrum, the Cognitive Activation Method (CAM) can be seen as integrating the strengths of problem-solving, encouraging reasoning and active engagement, while offering structured cognitive tasks that help teachers manage time and resources more effectively.

2.3.2 Observation Method

In this approach, students acquire knowledge through observation. While it may not be categorized as a distinct method for teaching science, nearly all scientific learning begins with observation. Students observe their surroundings in various settings, such as small groups, school laboratories, their homes, or gardens. This process naturally engrains conceptual understanding in their minds. Developing students' observational skills significantly strengthens their mental capabilities, as relevant experiences are systematically organized and internalized. Science, being a subject of wonders, enables learners to reason based on established facts and formulate concepts about newly observed phenomena (Kraus, 2024).

Although the observation method is foundational to scientific inquiry, its effectiveness depends on how observations are structured and interpreted. On the other hand, without guided questioning or opportunities for reflection, students may remain at the level of surface noticing rather than deeper cognitive engagement. Compared with lecture-based methods, which provide direct content delivery but limit experiential learning, observation allows students to build knowledge firsthand. However, unlike problem-solving approaches, it may not always encourage reasoning beyond what is seen unless accompanied by critical discussion. In this respect, the Cognitive Activation Method (CAM) provides a more balanced strategy: it builds upon observation as a starting point but extends learning by requiring students to analyze, explain, and apply their observations in cognitively challenging tasks, thereby transforming passive noticing into active knowledge construction.

2.3.3 Laboratory Method

This method is widely regarded as a practical and reflective approach to teaching science, allowing students to gain hands-on experience with phenomena related to their studies. Students can engage individually or in small groups, exploring and manipulating various variables under investigation. The level of control students have over their exploration may differ significantly. In this approach, learning is achieved through active participation rather than passive observation of experiments. When children carry out tasks themselves, the experience leaves a lasting impression on their minds. This approach is psychologically effective as it fulfills the natural desire for activity, expanding students' interests. Through laboratory activities, they develop numerous virtues and gain immense personal satisfaction from practical experience (Trevisan *et al*., 2023).

The laboratory method is highly valued for making science tangible and memorable, but its effectiveness is often limited by the availability of resources, teacher expertise, and time. Compared to lecture-based teaching, laboratory activities promote deeper understanding and skill development. However, they can be costly, time-intensive, and sometimes impractical in overcrowded or underfunded schools. Unlike the problem-solving method, which emphasizes independent reasoning, laboratory tasks may become mechanical if not coupled with critical reflection. CAM can complement the laboratory approach by embedding cognitive challenges and structured questioning into practical activities, ensuring that hands-on work also stimulates higher-order thinking.

2.3.4 Demonstration Method

Demonstration Method prompts students to move from concrete to abstract, because they critically observe the content, and through this process, they acquire many other things, such as critical thinking skills, reasoning skills, and questioning skills, so we can say that this approach in short is based on what works. This is true that lectures and demonstrations have some limitations such as sometimes concepts are not clear to students and those approaches are the student-centered approaches are successful which are not student-centered. Students face laboratory skills, lack of training in these methods (Kucharska & Erickson, 2023).

Demonstrations are powerful for simplifying complex phenomena and making abstract ideas visible, which is especially valuable in resource-limited contexts. Yet they risk becoming teacher-dominated if students remain passive observers rather than active participants. Unlike laboratory or problem-solving methods, demonstrations do not always foster hands-on engagement or independent reasoning. Still, they often surpass lectures in stimulating curiosity. CAM addresses this limitation by transforming demonstrations into interactive experiences, encouraging students to analyze, question, and discuss what they observe, thereby turning passive viewing into active cognitive processing.

2.3.5 Lecture-Cum-Discussion Method

This method integrates the Lecture Method with the Discussion Method, fostering positive verbal interactions between teachers and students. The teacher delivers a lecture and then allocates approximately 10 minutes for class discussions. During this time, students can share their opinions, comments, and experiences, as well as raise questions or express difficulties in understanding parts of the lecture. The teacher addresses these queries, clarifying doubts and enhancing comprehension. This strategy is vital for capturing students' interest and assessing their understanding of key concepts. It is a dynamic, interactive process where both teachers and students engage in asking and answering questions, making the learning experience more effective (Zulyusri & Santosa, 2023).

The lecture-cum-discussion method represents a practical compromise between teacher-centered and student-centered instruction. Its major strength lies in encouraging dialogue after content delivery, which can improve comprehension and retention. However, the limited time often allotted for discussion may prevent deeper exploration of concepts, especially in large classes. Compared with pure lectures, this approach offers more interactivity, but it still risks maintaining teacher dominance. CAM moves beyond this limitation by embedding questioning and cognitive conflict throughout the lesson rather than reserving interaction for the end, thereby sustaining student engagement and reasoning during the entire instructional process.

2.3.6 Lecture Method

The Lecture Method, also referred to as the authoritarian method, is deeply embedded in educational practice due to its simplicity, cost-effectiveness, and ability to address large groups (Zhao *et al.*, 2023). It allows teachers to deliver significant amounts of information efficiently. However, critics emphasize its limitations: it promotes passive learning, discourages critical inquiry, and often results in short-term memorization rather than lasting understanding (Yuldashev, 2021). In Pakistan, the lecture method continues to dominate elementary classrooms, partly due to overcrowded classes, limited resources, and examination-driven teaching (Fatima & Ahmed, 2023). These realities make the lecture method a pragmatic choice; y*et al*so highlight the urgent need to test alternatives that encourage deeper learning and retention(Zhao *et al*., 2023).

Looking the other side of everything, has negative effects. Same case with Lecture Method it has also some disadvantages which are as following. Like a road if it will be one way there will be difficulties for people. Same situation with lesson if it will be one way there will be no interest. Everything in the world can get success if it will be two ways. Those who are against Lecture Method; it is their strong argument against Lecture Method. Students have no way without accepting it. Because they have to take passing grade, it has seen most in most of institutions in our country that these students who are not agree with teacher's statements, sometimes have less grades or even they failed in these subjects. It also be said it is like authoritative method of teaching. Students are not free in thinking and questioning. Students want to talk about something but they can do that, having confusion in their mind. Lecture Method is a one-way teaching process and also a passive experience. Students do not learn by their personal experience. They are imposed to listen what are being taught in class. They have no choice in learning process. They cannot evaluate the contents critically (Yuldashev, 2021).

In some cases, lecture is not useful for teachers and professors as well. All human beings are not same in nature. Some are expert in any field but maybe he does not quality of another field. To convey messages to the people requires best skills of speaking. All teachers and lectures are not same in terms of speaking skills in front of large gathering. If a teacher is expert in his subject, knows up and downs of his subject, but he is week in speaking ability in front of public? He might not be able to prepare his lesson not because he does not knowhis subject but because of the way he does not know to convey his message properly (Macharia, 2024).

Despite the difficulties which are face in Lecture Method, there are some alternatives which can be adopted which are as: Discussions: Many universities and colleges arrange discussion forums for students with the assistance of teachers, with the aim of allowing students to share their ideas with each other in an open manner and to be able to articulate their views well. They can clear up misunderstandings about classroom lectures. The power of students in discussions is less than that of lectures, because a forum has at least 10 to 20 students, while lectures have up to 300 students, forming a large class. In these forums, they can ask each other question about the course. If they have any questions later, they are free to ask the teacher again in class (Korkmaz & Mirici, 2023).

2.3.7 Cognitive Activation Method

Cognitive activation is one of the dominantvaluefeatures of teaching learning process. By activating the cognition of the student an instructor may achieve the learning products easily.The cognition is considered very crucial in every type of education, but for the teaching of science subjects its significance is beyond the imagination. Lipowsky (2015) pointed out that it is not possible to check whether the cognition of the students is activated or not. Numeroussigns are needed to capture this construct. He introduced three key elements of Cognitive Activation: (i) Challenging Questions, (ii) Prior knowledge/ideas, in-depth learning opportunities and cognitive conflicts (iii) Instructional Dialogue. He argued that cognition of the students can be activated by implementing these strategies.

2.3.7.1 Phases of Cognitive Activation Method

Key elements of Cognitive Activation Method are given below;

2.3.7.1.1 Challenging Questions

The first element of Cognitive Activation Method is the challenging questions. The basic purpose of this phase is to grasp the attention of the students and to make them ready for the further joinery of the lesson. This phase is further divided into three sub stages as described below;

Challenging phenomena at the beginning: At this sub stage the teacher introduces a challenging or fascinating problems or tasks at the beginning of the lesson. The teacher may show them a picture, model and video or talk about the incredible facts about the topic of that particular day.

The questioning of the students is supported: The teacher offers the students time and opportunities to ask their own questions. Teacher motivates the students to be the part of the lesson by asking the questions. The students are encouraged to ask the questions.

The teacher asks cognitive activating questions: At this sub stage the teachers ask the questions in order to activate the cognition of the students. These questions require the answers more than yes or no. The teacher will ask the students to think and then answer the questions. At this phase the students are asked to think deeply rather than to give spontaneous response.

2.3.7.1.2 Prior knowledge/ideas, in-depth learning opportunities and cognitive conflicts

It is the second phase of Cognitive Activation Method. The purposes of this phase are; to link the prior knowledge with new one, to provide the students the opportunities of in-depth learning and to generate the cognitive conflicts among them. This phase is further divided into three sub phases as described underneath;

The prior knowledge and the ideas of the learners are explored: At this sub stage the teacher asks the students to make assumptions or encourages the kids to express their doubts.

In-depth learning opportunities: The teacher tries to understand the thinking of the learners by asking how they came up with specific answers or by asking to justify their answers.

Cognitive conflicts are generated: At this phase the teacher confronts the learners with facts, observations or phenomena which contradict their responses.

2.3.7.1.3 Instructional Dialogue

Third and final stage of the CAM is "Instructional dialogue". At this stage the students and teacher discus the ideas and errors together. This phase if further subdivided into two stages which are given below;

Discuss ideas together: The teacher encourages the exchange among the learners by asking them to relate their contributions to each other. The teacher also guides the students to discuss their assumptions.

Discussing errors: The teacher picks up mistakes of the learners and uses them in the further course of the lesson.

2.4 Critical Comparison of Teaching Methods with the CAM

Different instructional strategies are used in science education at the elementary level, including the lecture method, activity-based teaching, and inquiry-oriented approaches. While each has its benefits, a comparative evaluation reveals that the Cognitive Activation Method (CAM) offers a more comprehensive and cognitively engaging approach, especially for improving conceptual understanding in General Science (Skulmowski, 2024).

2.4.1 Lecture Method Compared to CAM

The lecture method is commonly used due to its simplicity and efficiency in covering content within limited time and resources. However, it largely promotes passive learning, where students mainly listen and memorize information without deep mental involvement. This method often limits students' capacity for critical thinking and concept application.

In contrast, CAM encourages active cognitive engagement by incorporating challenging questions, thought-provoking tasks, and structured classroom discussions. Instead of simply transmitting information, CAM requires students to process, analyze, and reflect on content. This route makes it more effective for subjects like science, which demand understanding beyond memorization (Betto *et al*., 2023).

2.4.2 Activity Method Compared to CAM

Activity-based teaching focuses on learning by doing, aiming to make lessons interactive and enjoyable. Though it helps improve student motivation and interest, the method sometimes lacks the cognitive depth needed for robust learning outcomes, particularly when activities are not carefully aligned with conceptual goals.

CAM, while also engaging students in tasks, ensures that these activities are intellectually demanding and directly tied to key learning objectives. It promotes meaningful engagement by building on students' prior knowledge, confronting misconceptions, and guiding them through higher-order thinking processes. Therefore, CAM provides a more intellectually rigorous experience than typical activity-based approaches (Li *et al*., 2023).

2.4.3 Inquiry-Based Learning Compared to CAM

Inquiry-based learning allows students to explore concepts by posing questions, conducting investigations, and drawing conclusions. While this method fosters curiosity and a scientific mindset, it can be challenging for students, especially in under-resourced classrooms or where learners have limited background knowledge. Without sufficient support, students may become confused or fail to construct accurate understanding.

CAM addresses these limitations by offering structured inquiry rather than leaving students to discover everything independently. It integrates cognitive scaffolding, prompts for reflection, and teacher-guided discussions to keep students focused and cognitively engaged. This balance between student-centered inquiry and guided instruction makes CAM particularly suitable for science education in diverse classroom settings (Yulianti, 2024).

2.5 Empirical Studies on Cognitive Activation Method

Research consistently demonstrates the strengths and limitations of both methods. Baumert *et al*. (2010) and Hardy *et al*. (2011) showed that CAM strategies significantly improve conceptual understanding and problem-solving. Similarly, Seidel & Shavelson (2007) confirmed that cognitively engaging instruction yields stronger outcomes than lectures. In contrast, studies in South Asia reveal that lecture-based instruction persists because of its practicality (Iqbal & Amin, 2022). Pakistani studies, such as Aslam & Afzal (2021), observed that CAM-trained teachers reported greater student curiosity, achievement, and retention. However, some findings are contradictory: in under-resourced classrooms, implementing CAM can be challenging due to teacher workload and large student numbers. These tensions justify the present study's experimental design.

2.5.1 Empirical Studies on CAM in Developing Countries

In recent years, empirical evidence from developing regions has increasingly affirmed the positive effects of cognitive activation or active learning on elementary students' academic achievement. While much research originates from Western contexts, growing scholarship in South Asia, Africa, and Latin America provides contextually relevant insights that strengthen the rationale for this study.

2.5.1.1 Empirical Studies in Pakistan

Several studies demonstrate the potential of inquiry-based and activity-based pedagogies in enhancing cognitive and academic outcomes. Awan, Kanwal, and Qamar (2021) examined guided-inquiry methods among elementary students from low-socioeconomic backgrounds in Islamabad and found that such approaches significantly fostered creativity. Similarly, Ahmad, Samiullah, and Khan (2019) used a quasi-experimental design to show that activity-based teaching improved science comprehension among eighth-grade students. Additionally, Batool and Akhtar (2020) revealed a strong positive relationship between eighth graders' cognitive engagement and mathematics achievement in Lahore that deeper strategic engagement correlated with better performance.

2.5.1.2 Empirical Studies in India

India's experience with Activity-Based Learning (ABL) offers a well-documented model of cognitive activation in elementary schooling. Originating in the

1940s and institutionalized across various states, ABL emphasizes hands-on experiments and student autonomy. Implemented through programs like Sarva Shiksha Abhiyan, ABL has fostered joy and sustained engagement in learning by encouraging learners to complete small, interactive milestones.

2.5.1.3 Empirical Studies in Bangladesh

While specific empirical studies in Bangladesh on cognitive activation at the elementary level were not located in the recent literature, active learning initiatives in neighboring developing contexts suggest similarly positive outcomes. Including this observation flags a gap and a potential research opportunity.

2.5.1.4 Empirical Studies in Nigeria

A quasi-experimental study by Oribhabor (2020) assessed the impact of an activity-based teaching method on secondary school students' mathematics achievement. Results showed a significant improvement in academic performance compared to traditional lecture methods. Though conducted at the secondary level, these findings indicate that activity-based strategies can be effective across different education stages in Nigerian contexts.

2.5.1.5 Empirical Studies in Latin America

Latin America has contributed notable evidence of active and playful learning models enriching student engagement. The Education for Sharing (E4S) framework, operational across Mexico, Argentina, Guatemala, and Ecuador, integrates play, reflection, and action to enhance cognitive, social, and emotional development. Teacher feedback indicates improved engagement and cognitive awareness; for example, in Chihuahua (Mexico), 84% of participating educators noted a significant spike in student interest. While these studies focus on engagement and reflective capacities, they underscore the broader spectrum of cognitive activation beyond academic scores.

2.6 Cognitive Activation strategy during Instructions

Because cognitive activation has been shown to support the development of mathematical literacy, the quality teaching methods promote numerous learning skills. Active learning methods such as interactive discussions, practical applications and practical experiences can enhance the retention of knowledge. There are many types of education; one of them is informal education, which includes learning from family members, attending community events, attending workshops or seminars while participating in interests, or through hands-on learning, acquiring knowledge through online resources and social interaction. Effective teaching methods can meet these different needs and ensure that students master and understand the material more thoroughly. Empowering minds through a comprehensive science education lays the foundation for a future where curiosity inspires discovery, critical thinking drives innovation (Sultana, 2024).

The most frequently used strategy by teachers was asking students to explain their problem-solving methods, with over 80% of students reporting that their teachers did this regularly. A significant number of students mentioned that their teachers posed questions that encouraged them to apply their knowledge in new situations or explore different contexts. This suggests that teachers value deeper conceptual understanding over mere surface-level knowledge or memorization. However, fewer than half of the students indicated that teachers often asked them to independently determine the procedures for solving problems related to complex concepts. Elementary school students can also use experimental situations to activate children's cognition. However, structure and support are also necessary here to avoid placing an undue burden on the children (Loughland *et al*., 2024).

Because cognitive activation in learners cannot be directly observed or measured, various indicators are necessary to assess this concept (Lipowsky, 2015). Research generally employs two approaches to measure cognitive activation. One method involves analyzing teaching materials and tasks used by educators in the classroom, which provides an indirect way to assess cognitive activation (Krauss *et al*., 2013). The other method involves directly examining the course, for example, by recording the class and evaluating it with a coding manual or observation protocol. Both approaches require specific indicators, which can be identified in teaching activities that have a strong potential for cognitive activation. These indicators include: assigning challenging tasks, creating cognitive conflict, highlighting differences in ideas, concepts, explanations, and solutions related to the content, connecting to prior knowledge, fostering thoughtful discussions, and encouraging students to articulate or explain their thoughts and ideas (Senden *et al*., 2023).

2.6.1 Cognitive Activation by Tasks and Repetitions

High cognitive activation involves teaching students' strategies that promote deeper thinking, encouraging them to focus not only on finding solutions but also on understanding the methods they used to reach the answer. Complex tasks are those that actively engage students in the learning process, connect to real-life situations, and accommodate a range of ability levels. Educational and psychological research highlights the critical role teachers' play in enhancing student learning. The approach teachers take in delivering lessons and how they present the material are key factors contributing to students' success, with both students and teachers serving as crucial tools in the learning process (Van der Heiden, & Janssen, 2022).

Factors such as a person's experience, abilities, and prior knowledge will inevitably influence the perceived cognitive demands posed by the problems (and tasks) the person faces. Acquiring different types of knowledge requires different types of cognitive processes, and it can be assumed that some processes are more complex than others. However, task difficulty does not solely depend on the types of cognitive processes elicited by the task. Cognitive activation is a key dimension of teaching quality and a condition for students to construct knowledge. Additionally, it demonstrates that students are engaging in higher-order thinking and need to provide reasons for their answers. Cognitive activation is a complex construct, and given that different learners have different experiences and abilities, certain situations that require higher-order thinking for some students may not always be as challenging for others (Tabari *et al*., 2023).

The cognitive processing, and the national curriculum, as well as national tests, implicitly indicate the level of cognition that Swedish and Norwegian teachers are expected to achieve in their teaching. The Norwegian junior high school language arts curriculum stipulates that students should be able to compare and interpret different types of literary texts and reflect on aspects such as purpose, content, and literary devices. The Swedish Curriculum expresses similar ideas but is less detailed, merely stipulating that students should read and analyze different types of texts. In essence, the behaviorist paradigm lays the groundwork for the cognitive approach, which in turn provides a foundation for the constructivist perspective accordingly, the cognitive approach does not repudiate dismiss behaviorism Although the Swedish curriculum implicitly states that one of the purposes of reading literature is to learn how to analyze, understand and interpret literary texts, this is not reflected in the knowledge requirements. In Sweden and Norway, national tests are used to measure and assess students' reading comprehension skills in contradiction of prospectus objectives (Fukunaga, 2023).

Consequently, the task of categorizing these theories within this framework presents significant challenges. Certain theories may simultaneously belong to multiple classifications in divergent manners. For instance, Bruner's theory of Discovery Learning is frequently regarded as a cognitive framework in some literature, while other sources classify it primarily within developmental or constructivist paradigms. Conversely, although Albert Bandura is predominantly categorized as a behaviorist, he himself critiques the tenets of behaviorism. This inherent complexity in classification is to be expected (Khezrlou, 2024).

2.7 Cognitive Activation Processes

Following are the elements of cognitive process

Attention: It is the power of concentration upon some stimulus which constitutes the focus of consciousness. In other words, it is a title designed to respond to a stimulus. Suthers defines attention as the limits of perceptual processes and production of answers. The process of data processing begins with attention. External stimuli are initially captured by the sensory register, where they are transferred to short-term memory without alteration, as they are directly received from the environment. Stimuli that do not capture attention are discarded. In this sense, attention plays a crucial role in deciding which information progresses to short-term memory and which does not. Individuals possess the capability to focus their cognitive resources on specific sources of information (Vasconcelos, Zollo, 2023).

Perception: This refers to the process of interpreting stimuli received through the sensory organs or transforming sensory signals into meaningful experiences. During perception, the type of stimulus that is selected for further processing is determined. Because each person organizes signals in their own way, individuals perceive stimuli differently. A person can only transfer information from environmental stimuli into memory that they are able to perceive (Abramski, 2023).

Repetition: Information is retained through repetition, which helps prolong its stay in short-term memory. The extended retention occurs because the information is encoded before being transferred to long-term memory, preventing it from being lost. A stimulus or event typically elicits a response. Perception is an active and selective process, and how an individual perceives a particular stimulus depends on their preparation and guidance (Demirbas & Demir, 2023).

Coding: Much of the information from our environment is initially stored temporarily and not encoded. Encoding involves associating information in short-term memory with long-term memory. Those who encode information in long-term memory are expected to assign meaning to the message. Each person encodes information in the way that best suits their individual situation. There are four essential elements that enrich the encoding process by adding meaning to the information (Al-Obaydi, 2023).

Storing: Anderson and Ball presented a model to explain how accumulated information is stored. This model suggests that messages are organized based on speech units, such as subject-verb structures, rather than solely on perceptions. Information is stored in long-term memory, but it is categorized into different types, including episodic memory, semantic memory, and procedural memory, ensuring correct retrieval when needed.

Retrieving: Retrieval is the process of searching for, discovering, and activating information stored in long-term memory. Finding appropriate clues during this process is essential to retrieve stored information. Ashcraft argued that true forgetting does not occur in long-term memory; rather, forgetting happens when retrieval fails. Executive cognition refers to one's awareness of cognitive abilities and the strategies they use to process information. This awareness helps learners understand their own cognitive strengths and weaknesses. A student with strong executive cognition recognizes how their mind works and is not only focused on the material they need to learn but also aware of their learning strategies and cognitive limitations(Siregar, 2023).

Executive control processes explain the answer to the question of why some people learn and remember more than others. Executive control is the name of the system that controls all cognitive processes of an individual. The system controls two basic aspects of learning. The first is about the motivation process. Motivational processes consist of situations over which an individual has conscious control, such as intending or aiming to obtain something. The second one consists of all processes related to data processing. Executive cognition is said to have two functions. The first is implementation condition information. For example, what you learn in school is implemented at home (Wilkey, 2023).

2.8 Cognitive Activation and students' related factors

Cognitive activation in the classroom does not operate in isolation; its effectiveness is shaped by a range of student-related factors. Elements such as prior knowledge, learning attitudes, motivation, family background, and peer influence play a critical role in determining how learners respond to cognitively demanding tasks. Students who bring stronger cognitive readiness and supportive environments are more likely to benefit from challenging questions, instructional dialogue, and problem-solving opportunities. Conversely, some other factors related to cognitive activation are given below:

2.8.1 Cognitive Activation Perspective of Learning

Another dimension of complexity involves the number of knowledge elements and their connections required to solve the task, which is mainly described by three levels: facts, relationships and general concepts of science and mathematics. Students' cognitive level and concept teaching can use the competency model of the National Junior High School Natural Science Education Standard Assessment Project for science teaching. Dimensional cognitive processes describe the four levels of cognition required by students to solve a given task. Therefore, in our current study, we focus on instructional practices that stimulate students to engage in more cognitive analysis to gain conceptual understanding. Teaching practices that are considered to be cognitive activation or lead students to act at least on a constructive level can be used to indirectly describe cognitive activation. For example, such teaching practices that are thought to promote cognitive activation in students include setting challenging tasks, inducing cognitive conflict, confronting students with opposing ideas or interpretations, making connections with prior knowledge, and promoting communication among students (Sadr, ZHossieni & Masjedi, 2023).

The inherent necessity of communication explains the longstanding interest of scholars and researchers. The formations of the individuals' collective consciousness are fundamentally determined 'according to a system that arises from their union and changes according to their behavior in the expanse of space and according to the means of communication. The social nature of human being basically influences the need to communicate with others. Connecting and interacting socially with others is an essential and indispensable aspect of human existence and self-actualization. The importance of verbal communication has been further reinforced by educational studies across various disciplines. Most researchers have emphasized the importance of mastering communication competencies, and the direct link between these competencies and proficiency in verbal communication skills. There is no path to general existence and communication, in particular, without possessing communication competencies (Mungan, 2023).

Upon examining the Western literature to understand the mechanisms of verbal communication and explore ways to develop it, the researchers have observed the paradigm shift brought about by cognitive psychology after the dominance of behavioral theory in the educational field. The behavioral theory had focused on mechanical interactions and measuring outputs, while falling short in comprehending mental processes. Active students show up behaviorally. For the constructive mode, the learner must produce additional output "beyond what is provided in the learning material." In order to achieve interaction, discussion or dialogue must take place among the least constructive learners. Furthermore, they believe that higher modes lead to increased learning and a deeper understanding of the content. Therefore, making a general determination of the degree of cognitive activation is complex, if not impossible (Nguyen, 2023).

2.8.2 Cognitive Activation Approaches of Learning

The investigation into the mechanisms by which individuals acquire knowledge and the enhancement of learning efficiency is rooted in a substantial historical context. A plethora of theories and methodologies have emerged within this domain, profoundly influencing educational practices aimed at optimizing learning outcomes. Educators typically categorize learning theories into three foundational paradigms. It would be erroneous to regard these three paradigms as mutually exclusive alternatives or to assess them in isolation when undertaking a classification. The concepts and principles of behaviorism, cognition, and constructivism exhibit considerable overlap across various domains (Min, 2023).

Consequently, the task of categorizing these theories within this framework presents significant challenges. Certain theories may simultaneously belong to multiple classifications in divergent manners. For instance, Bruner's theory of Discovery Learning is frequently regarded as a cognitive framework in some literature, while other sources classify it primarily within developmental or constructivist paradigms. Conversely, although Albert Bandura is predominantly categorized as a behaviorist, he himself critiques the tenets of behaviorism. This inherent complexity in classification is to be expected. It is indeed impractical to formulate assertions regarding cognitive approaches without reference to behaviorism, nor to do so concerning constructivism without acknowledging cognitive perspectives. In essence, the behaviorist paradigm lays the groundwork for the cognitive approach, which in turn provides a foundation for the constructivist perspective accordingly (Li *et al*., 2023).

Furthermore, the constructivist framework is predicated upon the principles established by the cognitive approach. From the behaviorist standpoint, learning is contingent upon stimuli and the responses elicited by those stimuli, with a pronounced emphasis on observable and quantifiable behavior. As the discourse transitioned from behaviorism to cognition, inquiries regarding the presence of cognitive processes in behavioral acquisition emerged. Similarly, science acts as a reformer of societies. Scientific education is very effective in development of techniques that could meet the population's needs. Taking a step toward the country development by the use of science, in 1979, Pakistan Government dictated the science education as a main factor in nation development. It provides a base for research and development of science and knowledge. It also included that economic and national potential of country totally depends on the quality of science education taught in our country. Science can offer maximum contribution only if people are highly educated with science and technology (Kirschner *et al*., 2023).

2.8.3 Cognitive Activation as a Feature of Instructional Quality

Active students show up behaviorally. For the constructive mode, the learner must produce additional output "beyond what is provided in the learning material." In order to achieve interaction, discussion or dialogue must take place among the least constructive learners. Furthermore, they believe that higher modes lead to increased learning and a deeper understanding of the content. Mayer (2004) has criticized being merely behaviorally active and called for a more advanced model. This route is consistent with a goal of the National Education Standards to focus on learning core ideas and general principles that lead to conceptual understanding. Active students show up behaviorally. For the constructive mode, learners must generate additional ideas and output beyond the concept (Frommelt *et al*., 2023).

2.8.4 Cognitive Activation and Concept Framing

Cognitive activation is a key dimension of teaching quality and a condition for students to construct knowledge. Additionally, it demonstrates that students are engaging in higher-order thinking and need to provide reasons for their answers. Cognitive activation is a complex construct, and given that different learners have different experiences and abilities, certain situations that require higher-order thinking for some students may not always be as challenging for others. Therefore, making a general determination of the degree of cognitive activation is complex, if not impossible. Acquiring different types of knowledge requires different types of cognitive processes, and it can be assumed that some processes are more complex than others. However, task difficulty does not solely depend on the types of cognitive processes elicited by the task. There are other influencing factors (e.g., text structure, density of distractors in the text, and plausibility of distractors). Therefore, cognitive activation and difficulty are not synonymous (Sanfo & Malgoubri, 2023).

Students' cognitive level and concept teaching can use the competency model of the National Junior High School Natural Science Education Standard Assessment Project for science teaching. Dimensional cognitive processes describe the four levels of cognition required by students to solve a given task: representation, selection, organization, and integration. Another dimension of complexity involves the number of knowledge elements and their connections required to solve the task, which is mainly described by three levels: facts, relationships and general concepts of science and mathematics (Sigurjonsson, 2024).

To achieve this goal, we assume that instruction should stimulate students to act at least in accordance with constructive patterns. Conceptual and deeper understanding of the content will develop as students must perform more cognitive analysis. Therefore, in our current study, we focus on instructional practices that stimulate students to engage in more cognitive analysis to gain conceptual understanding (Prediger *et al*., 2024).

2.8.5 Cognitive Activation and pupil ability

PISA defines competencies in terms of proficiency, with proficiency levels outlining the skills students are expected to demonstrate and the tasks they are capable of completing (OECD, 2014). Test questions that focus on simple tasks, which involve familiar contexts containing all relevant information, are placed at the lower proficiency levels. In contrast, more challenging questions, requiring students to develop models for complex situations, identify constraints, and define assumptions, are categorized at higher levels (El Haj Chapelet & Moustafa, 2022).

A student assigned to a particular proficiency level not only shows the knowledge and skills specific to that level but also possesses the abilities required at lower levels. Based on these proficiency levels, students are classified into low, medium, and high ability categories. In England, 17% of students are considered low ability, 42% medium ability, and 41% high ability. As illustrated in Table 1, differences were observed among the ability groups regarding the frequency with which teachers reported using various cognitive activation strategies. On average, high-ability students were given cognitive activation tasks more often in mathematics classes compared to low- and medium-ability students, with low-ability students engaging in cognitive activation tasks the least.

The most significant differences were in the following strategies: Teachers asked questions for which there was no immediately obvious way to find the answer. Twenty percent of high-ability students said their teachers frequently used this strategy in their math classes. Research predominantly employs two distinct methodologies for the measurement of cognitive activation. Firstly, the pedagogical practices may be examined indirectly through an analysis of the materials and tasks that educators implement within the classroom context. Conversely, it is also feasible to conduct a direct analysis of the instructional process, for instance, through the video documentation of the course, which can subsequently be evaluated utilizing a coding manual or an observational protocol tailored to the course. Nonetheless, the research did not incorporate video documentation of the instructional sessions, opting instead for an analysis of the educator's instructional tasks. This latter finding is indeed unexpected (Vilotijevic & Mathot, (2024).

2.8.6 Cognitive Activation and pupil attitudes to learning

PISA discovers an extensive variety of student features toward school and learning, behaviours, motivations and beliefs. Students get much spare time to explore different situations; this strategy improves their physical and mental abilities. Teachers design the activity and students get a chance and time to understand objects and materials by their own previous knowledge. And students would also be able to build better relationships, questioning, and identification and understanding skills.

Teacher's work in this phase is to facilitate or coaching. For mental reconstruction of students, teacher might guide them by questioning, explaining and giving hints. This scheme does not mean one can include explaining learning. To sum up, it can be considered that recent biology teaching is mainly at a low level in terms of cognitive activation. According to the definition of cognitive activation, which includes its three key elements, cognitive activation instruction should lead students to take action on a constructive or communicating plane (Tshering *et al*., 2024).

Motivation to learn mathematics is typically measured through intrinsic motivation (driven by student interest and enjoyment) and instrumental motivation (viewing mathematics as a useful tool). The OECD found that students who lack interest and enjoyment in mathematics often perform worse than those who are intrinsically motivated. The same trend applies to instrumental motivation, with students who believe that learning math will help them improve their future math marks showing better performance. Students in the UK do not exhibit particularly high levels of intrinsic motivation for studying mathematics but display stronger levels of instrumental motivation.

Activation appears to be a key teaching strategy positively linked to math achievement for all student groups, regardless of ability or socio-economic background. This action supports the idea that teaching practices which encourage students to think critically and reflect on math problems, while allowing them to choose their own methods for tackling problems with no clear solution, promote critical thinking in mathematics and can lead to better performance. To offer these opportunities, teachers need to design mathematical problems that can be solved in multiple ways and may require varied solutions depending on the context. Such freedom in learning also requires a classroom environment where discussing different solutions is encouraged, and where students are asked to explain and justify their approaches, supporting their development (Al-Obaydi & Ugla, 2023).

2.8.7 Cognitive Activation and family background

This section examines the relationship between cognitive activation and mathematics achievement among students from various family backgrounds based on PISA 2012 data. PISA gathers information from students about their family backgrounds, which is then used to construct a measure of economic, social, and cultural status (ESCS index). In this report, students are categorized into three groupslow, medium, and high ESCS based on their responses. The ESCS index combines different aspects of family backgrounds, including students' answers about their parents' education, background, and family possessions. This index reflects various social factors, such as economic disadvantage and the value families place on education and educational resources (Kramarz *et al*., 2023).

As previously mentioned, all students benefited from cognitive activation strategies in mathematics lessons, but students with lower and medium ESCS marks seemed to benefit the most from increased cognitive activation. This finding is particularly significant, as earlier analysis of PISA 2012 data from England showed that students with lower ESCS marks typically had lower average math performance (Wheatear *et al*., 2013). Additionally, as noted earlier, students with lower ability reported that their teachers used cognitive activation strategies less frequently. Given the evidence that these students stand to gain the most from such strategies, teachers working with lower ability students should encourage practices such as summarizing, questioning, clarifying, and predicting to help them effectively solve fundamental mathematical problems (Amalina & Vidákovich, 2023).

2.8.8 Cognitive Activation and Thoughtful Discourse

Jatzwauk (2008) said that specifically asking students to give short answers in biology teaching does not stimulate thoughtful discussions. To sum up, it can be considered that recent biology teaching is mainly at a low level in terms of cognitive activation. According to the definition of cognitive activation, which includes its three key elements, cognitive activation instruction should lead students to take action on a constructive or interactive level. Although the Swedish curriculum implicitly states that one of the purposes of reading literature is to learn how to analyze, understand and interpret literary texts, this is not reflected in the knowledge requirements. In Sweden and Norway, national tests are used to measure and assess students' reading comprehension skills against curriculum objectives (Quabeck *et al*., 2024).

Teaching practices that are considered to be cognitive activation or lead students to act at least on a constructive level can be used to indirectly describe cognitive activation. For example, such teaching practices that are thought to promote cognitive activation in students include setting challenging tasks, inducing cognitive conflict, confronting students with opposing ideas or interpretations, making connections with prior knowledge, and promoting communication among students.

Although the Swedish curriculum implicitly states that one of the purposes of reading literature is to learn how to analyze, understand and interpret literary texts, this is not reflected in the knowledge requirements. In Sweden and Norway, national tests are used to measure and assess students' reading comprehension skills against curriculum objectives (Norte & Morell, 2024).

2.8.9 Cognitive Activation and Developing Communication

Philosophers have realized because long that 'man is by nature a social creature' Sociologists later on pointed out that the shaping of an individual's social identity. The formations of the individuals' collective consciousness are fundamentally determined 'according to a system that arises from their union and changes according to their behavior in the expanse of space and according to the means of communication. The social nature of human being basically influences the need to communicate with others. Connecting and interacting socially with others is an essential and indispensable aspect of human existence and self-actualization. The inherent necessity of communication explains the longstanding interest of scholars and researchers. They have tried to understand its mechanisms and have explored ways to enhance its effectiveness, particularly among those engaged in learning and education Communication for them is not merely a cornerstone of a successful society being the most powerful motive of interaction between individuals and groups, but it is also the core of the success and sustainability of the learning and teaching process. Communication contextualizes the transformations brought about by the industrial, technological, and digital revolution (Cruz *et al*., 2022).

The importance of verbal communication has been further reinforced by educational studies across various disciplines. Most researchers have emphasized the importance of mastering communication competencies, and the direct link between these competencies and proficiency in verbal communication skills. There is no path to general existence and communication, in particular, without possessing communication competencies. These competencies can only be attained through mastering the skills of verbal communication (Bamicha & Drigas, 2022).

Upon examining the Western literature to understand the mechanisms of verbal communication and explore ways to develop it, the researchers have observed the paradigm shift brought about by cognitive psychology after the dominance of behavioral theory in the educational field. The behavioral theory had focused on mechanical interactions and measuring outputs, while falling short in comprehending mental processes. This scheme explains the tendency of teachers to rely on repetition and rote learning. They discourage creativity in learners due to the modeling of expected answers, and the reliance on punishment and reward, which limits the individual's autonomy in constructing their own learning (Gabard-Durnam & Tottenham, 2022).

2.9 Theoretical Foundations of Cognitive Activation

Cognitive activation theories are frameworks used to understand how cognitive processes are activated, organized, and utilized in various tasks and situations. Here are some prominent theories in this field:

2.9.1 Adaptive Control of Thought-Rational (ACT-R)

This system incorporates an ACT-R-like production framework and modules based on statistical learning, which are used to process and filter external inputs to reduce the computational load. In the ACT-R production system, information chunks are matched with those in a buffer (working memory) to achieve set goals. Each chunk has a numerical value called activation, and the chunk with the highest activation among the matching ones is selected (Reinhold *et al*., 2024).

This process can be altered by randomly modifying the activation values of the chunks or by introducing randomness into the selection process by allowing partial matches that are sufficiently close to perfect. The ACT-R Reference Manual provides further details. A key feature of the activation mechanism is that frequent use of a chunk increases its activation value, which makes it more likely to be selected again. While this structure can be beneficial, it may also cause the system to focus on certain environmental elements, creating a feedback loop of increasing activation values. This report aims to analyze how the ACT-R activation equation behaves under various parameters and stimulation levels, helping SS-RICS developers gain insights into the impact of specific parameter choices and the behavior of the baseline activation terms in ACT-R (Kaup *et al*., 2024).

The ACT-R activation equation can be conceptualized in multiple ways depending on the desired level of detail. Referring to the ACT-R Reference Manual (5, p. 218), the activation of a block (A) can be represented as the sum of the baseline component (B), the extended component (S), and a component for partial matches (P) and noise. When a perfect match is not required, a partial match value is used, indicating the closeness to an ideal match. Spreading activation reflects the connections between blocks in the buffer and represents the contribution of associative memory to recall efforts (Houcan & Xiangang, 2024)

The baseline component consists of a stable part (often set by the modeler to reflect baseline strength) and a dynamic function that changes based on how frequently the block is used while in working memory. This function may include a refraction term to decrease the likelihood of the block being used repeatedly in quick succession. These baseline activation terms are designed to replicate human cognitive processes during task performance. To aid SS-RICS developers in modifying ACT-R's structure, this report explores the behavior of the baseline activation term under different strengths and activation modes. The following section will introduce several baseline activation equations used in ACT-R and compare them with new equations developed for this study (Yang & Stocco, 2024).

2.9.2 Schema theory

Schema theory, a key area in cognitive science, focuses on how the brain organizes and constructs knowledge. A schema is a structured set of knowledge related to a specific topic or event, formed based on past experiences, and can be applied to guide current understanding or behavior. The key aspects of this theory include: Patterns are flexible they evolve and adjust in response to new experiences and information, supporting the concept of developmental plasticity. Schemas shape how we interpret new information; with their influence often being quite significant (refer to the work of Brewer and Treyens for examples). Schemas store both declarative ("what") and procedural ("how") knowledge. Declarative knowledge refers to knowing facts, such as understanding how something exists or works, while procedural knowledge pertains to knowing how to perform tasks, sometimes without being able to consciously explain how it is conducted (Wang & Yin, 2023).

Declarative schemas can be imagined as containing "slots" for specific attributes and values. For instance, a house can be described through its materials (e.g., wood) and components (e.g., rooms). These materials and parts are the slots of the house schema, while wood and rooms represent the corresponding values. Some slots may have fixed values (e.g., the primary purpose of a house is residence), though a house could also serve different purposes, such as a museum or a place of worship.

Additionally, schemas can have hierarchical relationships, where parent schemas pass down or inherit characteristics from child schemas (Lyu & Fang, 2023).

2.9.3 Theory of Cognitive Development

Piaget investigated the origins of cognitive structures and the processes involved in learning and knowledge construction. Originally trained as a biologist, Piaget shifted his focus to understanding how humans interpret their surroundings and experiences. The key concepts of his cognitive theory were influenced by biological principles. If positive responses are needed about science education then the issues for woman, extremely religious people, with cultural capitals and the people who have their roots outside the west should be taken into notice and systematically resolved. Piaget suggested that intellectual and cognitive development mirrors biological behavior, requiring adaptation to environmental demands (Rochat, 2024).

Piaget conducted numerous experiments to understand how children think. He believed that children actively engage with their environment, seeking out stimuli rather than passively accepting them. They naturally explore and interact with the world around them to make sense of it (Bransford, Brown, & Cocking, 2000; Fox, 2001). Piaget's work primarily focused on learning mechanisms in the context of the natural sciences, rather than on the types of logic employed by learners (Booth, 1994; Fosnot, 1996). He argued that human cognitive development follows a biologically determined maturation process, progressing through distinct stages that are sequential and interdependent. Each stage marks the acquisition of specific skills and reflects qualitative changes in cognitive abilities (Fosnot, 1996; Gillani, 2003; Jarvis, Holford, & Griffin, 2003; Piaget, 1970). Piaget believed that cognitive change occurs through a balance of adaptation, organization, and growth—an ongoing dynamic interaction during development (Dawkins *et al*., 2024).

When faced with a new learning experience, an individual applies prior knowledge to make sense of the new situation. If the new experience conflicts with existing understandings, it can disrupt mental schemas, creating a state of imbalance. To restore equilibrium, the individual must modify or reorganize their schemas through adaptation. The scientific knowledge tries to struggle with the three mutually contradictory requirements. On one side, it wants to present the main laboratory power that is offered by science a combination of the excitement of gaining new knowledge as well as exploring the microscopic material world. This process of reorganizing schemas involves two mechanisms: assimilation and accommodation. Assimilation involves incorporating new information into existing cognitive structures, while accommodation involves altering or restructuring those structures to better fit new information. The learner's internal, self-regulating behaviors help compensate for these cognitive disruptions (Chiari & Morais, 2024).

In Piaget's theory, the concept of schemas plays a central role in explaining cognitive development. A schema is a mental framework used to organize and represent patterns of events or abstract concepts. Schemas can be thought of as a series of interconnected "index cards" that represent environmental patterns within the mind. These schemas are continuously reorganized as the individual encounters new learning experiences. There are three processes involved in acquiring or modifying schemas: (1) Accumulation, where new information is integrated into existing schemas without altering them; (2) Tuning, when new information challenges existing schemas, requiring adjustments to better align with the experience; and (3) Restructuring, which occurs when an entirely new schema is formed to accommodate experiences that the original schema could not process (Matthews, 2024).

2.9.4 Social Cognitivism Theory

Piaget explored learning through the concepts of contradiction and equilibrium, whereas Vygotsky emphasized the significance of dialogue in the learning process. A notable distinction between their perspectives is that Piaget focused on the progression of logical thinking, while Vygotsky delved into areas such as categorical perception, logical memory, conceptual thinking, and self-regulated attention. Piaget believed that development must precede learning, but Vygotsky challenged this view, suggesting that social learning often drives development. Vygotsky's socio-cognitive model highlights the influence of culture on cognitive growth. His research emphasized the interplay between individuals and society, demonstrating how social interactions and language contribute to learning and cognitive development (Cong-Lem, 2023).

Instruction rooted in cognitive principles should be authentic and engaging. Teachers are encouraged to create dynamic classroom environments that inspire children's natural curiosity and exploration. Through such experiences, students actively construct their own knowledge by assimilating and adapting information. Teaching should be tailored to accommodate students' unique needs, interests, and backgrounds. Instead of focusing solely on teaching specific skills, educators prioritize creating meaningful learning environments. From a cognitive perspective, as learning involves receiving, storing, and retrieving information, it is vital for teachers to carefully select instructional materials, appropriate tasks, and learner-specific strategies to enhance processing efficiency. Effective instructional materials should incorporate demonstrations, examples, and constructive feedback to help students build embodied mental models (Graham *et al*., 2023).

2.10 Key proponents of Cognitive Activation Method

Theoretical foundations of the CAM lie in the thoughts of the following proponents:

2.10.1 Jean Piaget

Jean Piaget is widely recognized as a foundational figure in constructivist learning theory. He introduced the idea that cognitive development occurs in distinct stages namely, the sensorimotor, preoperational, concrete operational, and formal operational stages. According to Piaget, learning involves the active construction of knowledge through interaction with the environment. A central concept linked to Cognitive Activation is cognitive conflict or disequilibrium, which arises when students are presented with new information that contradicts their prior understanding. The Cognitive Activation Method (CAM) intentionally creates such situations, through thought-provoking questions, unexpected scenarios, or conceptual puzzles, to stimulate deeper thinking and foster conceptual growth. Piaget strongly advocated for active learning, where learners engage with materials and ideas directly, which closely aligns with CAM's emphasis on inquiry-driven and student-centered science instructions (Nurhasnah *et al*., 2024).

Piaget's theory posits that learners actively construct knowledge based on their experiences and mental interactions with the environment. A central tenet of this theory is the idea of cognitive conflict or disequilibrium, which arises when learners encounter new information that challenges their existing schemas. In CAM, this conflict is deliberately introduced through challenging questions, real-world problems, or conceptual dilemmas to provoke curiosity and stimulate deeper cognitive processing. Piag*et al*so emphasized active learning, where learners are not passive recipients of information but actively engage with ideas, materials, and tasks to build their own understanding (Erawati & Adnyana, 2024).

CAM's theoretical basis integrates multiple perspectives. Piaget emphasized that learning occurs when students encounter disequilibrium, forcing them to reconstruct mental schemas. CAM creates such conditions through thought-provoking tasks. Vygotsky emphasized scaffolding and social dialogue, which CAM implements through guided discussion and peer exchange. Dewey highlighted the importance of learning through authentic experiences, a principle reflected in CAM's emphasis on real-world problem solving. While these theories converge on the value of active learning, contradictions remain: Piaget stresses individual cognition, while Vygotsky underscores collaboration. CAM attempts to bridge these tensions by balancing individual reasoning with social interaction (Celik *et al*., 2023).

2.10.2 Lev Vygotsky

Lev Vygotsky developed the idea of the Zone of Proximal Development (ZPD), which refers to the gap between what a learner can accomplish alone and what they can achieve with appropriate assistance. This idea plays a crucial role in the Cognitive Activation Method (CAM), where scaffolding strategies and guided interactions are employed to help learners tackle complex tasks. Vygotsky emphasized the importance of social interaction and language in the learning process, asserting that cognitive development is largely shaped through social experiences. In CAM, meaningful conversations between teachers and students, as well as among peers, are used to collaboratively build knowledge. This above-mentioned process enhances students' cognitive engagement and supports the development of higher-order thinking skills (Souza, 2023).

Vygotsky's sociocultural theory highlights the role of social interaction and language in cognitive development. Central to this theory is the concept of the Zone of Proximal Development (ZPD), which refers to the difference between what a learner can do independently and what they can do with appropriate support. CAM incorporates this principle by using scaffolding, support provided by teachers or peers to help students engage in tasks slightly beyond their current ability. Instructional dialogue, peer discussions, and teacher questioning in CAM are designed to facilitate learning within the ZPD, making the method inherently collaborative (Yıldız, 2025).

2.10.3 John Dewey

John Dewey, a key figure in progressive education, highlighted the importance of learning through real-life experiences and reflective thinking. He believed that education should involve learners in authentic problem-solving situations that provoke inquiry and encourage thoughtful reflection core principles that align closely with the Cognitive Activation Method (CAM). CAM engages students in tackling relevant challenges, thinking critically about their learning process, and transferring their understanding to new situations. Dewey was also a strong proponent of student-centered education, where learners actively build their own understanding rather than passively absorb information. This approach forms a foundational element of CAM's instructional philosophy (Malik & Behera, 2024).

Dewey's educational philosophy promoted learning through experience and emphasizes the importance of reflection in the learning process. CAM draws on Dewey’s ideas by encouraging students to engage with authentic, real-life problems, reflect on their learning processes, and apply their knowledge to new contexts. This reflective engagement helps learners consolidate their understanding and develop higher-order thinking skills. Dewey’s advocacy for student-centered learning also aligns with CAM’s focus on empowering learners to take an active role in their educational journey (Kurniawati, 2024).

2.11 Significance of Cognitive Activation

A research report from ETS shows that complex academic tasks are crucial in the teaching and learning process as they help students improve their abilities as they reflect more on their real-world connections, which is a good way to relate knowledge to the real and natural world. Get in touch. Students' cognitive level and concept teaching can use the competency model of the National Junior High School Natural Science Education Standard Assessment Project for science teaching. Dimensional cognitive processes describe the four levels of cognition required by students to solve a given task: representation, selection, organization, and integration. Another dimension of complexity involves the number of knowledge elements and their connections required to solve the task, which is mainly described by three levels: facts, relationships and general concepts of science (Rosyidah, 2024).

Conceptual and deeper understanding of the content will develop as students must perform more cognitive analysis. Therefore, in our current study, we focus on instructional practices that stimulate students to engage in more cognitive analysis to gain conceptual understanding. However, research by Jatzwauk (2008) shows that specifically asking students to give short answers in biology teaching does not stimulate thoughtful discussions. To sum up, it can be considered that recent biology teaching is mainly at a low level in terms of cognitive activation. According to the definition of cognitive activation, which includes its three key elements, cognitive activation instruction should lead students to take action on a constructive or interactive level of the students (Kasapi, 2024).

Studies on cognitive activation in education typically examine how pedagogical content knowledge (PCK) influences cognitive activation in the classroom and its effect on student performance or engagement. The formations of the individuals' collective consciousness are fundamentally determined 'according to a system that arises from their union and changes according to their behavior in the expanse of space and according to the means of communication. The social nature of human being basically influences the need to communicate with others. Connecting and interacting socially with others is an essential and indispensable aspect of human existence and self-actualization. The essential role of communication helps explain the enduring interest of scholars and researchers. In studies like the Trends in International Mathematics and Science Study (TIMSS) and the Teaching Quality and Mathematics Comprehension in Different Cultures projects, a positive correlation between cognitive activation was observed (Khudhair *et al*., 2024).

2.12 Academic achievement

Academic achievement refers to the extent to which students attain their educational goals, often measured through test scores, grades, and overall performance in learning tasks. It reflects not only the mastery of subject matter but also the development of skills such as critical thinking, problem-solving, and application of knowledge in real-life situations. Academic achievement is influenced by multiple factors including teaching methods, classroom environment, student motivation, parental support, and socio-economic conditions. In education, it serves as a key indicator of learning outcomes and effectiveness of instructional strategies, making it central to evaluating both student progress and the quality of educational systems.

2.12.1 Academic Achievement of Elementary level students

Teachers implement strategies to reward outstanding achievement, and students need to work durable to pick up. High school student's generally feel right to the superior category and flush people; they know the desire to have a fine livelihood.

Educational researchers analyzed many factors to explain why some students performed better on standardized tests and achieved higher levels of academic achievement. As a result, data was collected from many sources and analyzed by hundreds of people. These data confirm or question the bond between students' SES and their successful scholastic success (jadallah *et al*., 2023).

Improving scholastic execution requires instructors at all levels to assume a compelling job. In a meta-examination dependent on a huge number of studies, Heidi brought up six "street signs" for greatness in instruction;

- The educator is the most impressive expert in the learning cycle.
- Teachers need to have order, impact, administration, care and energy to effectively partake in the training and learning measure.
- Teachers should be aware of the thoughts and information on every understudy. They know to develop important and significant encounters dependent on this information. Instructors have an abundance of information and comprehension of the substance, and can give them important and suitable criticism. Thusly, every understudy bit by bit enters the course level (Alam *et al*., 2023).

Teachers need to comprehend the learning aim and achievement measures of the course. They likewise need to realize how well they satisfy these guidelines for all students. Given the hole between students' present information and comprehension, they realize what to do straightaway. They additionally know the achievement models of where are you going", "where are you going" and "where are you going straightaway. Teachers need to transform from a solitary plan to numerous thoughts. They have to associate and grow these thoughts with the goal that students can manufacture and reconstruct information and thoughts

2.12.2 Factor effecting academic achievement of elementary level students

The difference in personal academic performance is related to the difference in intelligence and personality. The IQ test shows that students with higher intellectual abilities and due diligence (related to effort and sense of accomplishment) be likely to do good results in studious environment. A current study shows that psychological (measured by typical intellectual input), in count to intellect and neatness, also has an important impact on academic performance. Following are some key factors that affect the academic achievement of elementary level students:

2.12.2.1 Home Environment

The atmosphere of children with squat socioeconomic status is described by fewer chats between parents. They read the least. Compared with the environment of children with high SES, there are very few incidents of mutual concern, so that children and adults focus on the same object or event. In contrast, the language experienced by babies belonging to families with higher SES is more child-oriented. At 10 months, children with higher SES listened to more than 400 words more than children of the same age with lower SES. The language ability changes drastically with the change of SES. Children from squat revenue in have more media entrance rights in the bedroom, although compared with high-income children; they have less access to convenient play equipment. Eventually, this was will lead youngsters from lower financial foundations to be off guard when contrasted and their companions under states of physical movement

2.12.2.2 Parental Interactions

The house is viewed as the establishment of learning and training. To accomplish great scholarly execution, it is significant for guardians, kids and other relatives to help and improve the family learning condition. For instance, when students experience issues in a specific subject, the guardians are answerable for giving assistance. This assistance may take various structures, for example, private coaching, or they can show their kids themselves. They give innovation and other learning materials at home to improve youngsters' scholarly presentation. Guardians assume a significant job in controlling kids' development (Gu *et al.*, 2024).

The number of languages that SES inputs from parents seriously affects the type of parenting style. This structure also affects the family's choice of do. The poles methods determine the trend and idea of vocal interaction connecting parents and children. For pattern, parents with upper SES lean to be extra steadfast or more relaxed parenting methods. These parents asked their brood more untie problems and encouraged their children to improve their speech skills. In contrast, parents with low SES tend to be more demanding and easier to control (Khuma & Utete, 2023).

2.12.2.3 Extra-curricular Activities

The arranged extracurricular exercises have framed a positive relationship with high scholastic execution. These measures incorporate expanding participation, school support, post-auxiliary training, and diminishing dropout rates and sorrow.

Likewise, positive improvement results were found among youngsters identified with arranged extracurricular exercises. Secondary school sports are related with acceptable scholastic execution, chiefly among urban youth, despite the fact that interest in sports is related with expanded liquor utilization and secondary school students' forcefulness and truancy. There is a hopeful connection between scholarly execution and interest in extracurricular exercises, and it isn't in every case clear to follow this relationship. Also, there are many separated components that can control the connection between scholarly accomplishment and support in extracurricular exercises (Ribeiro *et al*., 2024).

2.12.2.4 Neighborhood Influence

Neighborhood components can help clarify contrasts in perusing execution at school, particularly when youngsters enter a higher evaluation. Although children with low SES will grow up in a poor community environment, as the reading ability of peers with higher SES increases, their learning ability will further decline. The general condition wherein youngsters grow up adds to the distinction in perusing between kids with high and low SES. In any case, these local characteristics are not restricted to trash or refuse in the city (Ruffini, 2022).

These individuals may incorporate the accompanying people: selling or utilizing drugs in the city, breaking or taking in the zone, violations of hostility in the region, empty houses in the region, and that it is so sheltered to play close by. Kids with low SES may experience childhood in such a local situation than their friends with high SES. The people group's help to the school and the poor state of being close to the school are additionally identified with youngsters' perusing. Therefore, it is more difficult to develop reading skills (Troller-Renfree *et al*., 2022).

2.12.2.5 School (Peer) Influence

The uniqueness of the school, including the uniqueness of students and instructors, can lead to inconsistent appraisal among children with soaring and low SES. For paradigm, peers play a vital part in swaying pre mature evaluation talent. Lower SES and a small number of peers have lower reading gain. The quantity of youngsters beneath grade and the quantity of low-pay peers are frequently identified with significant accomplishments and development rates. Compared with children with higher SES, peers with lower SES are apt to boast insufficient expertise and smaller quantity financial funds. This scheme creates it thorny for brood to develop appraisal skills. Students with lower SES are more liable to lack skilled tutors, which are related to the fact that their reading growth rate is much lower than that of their counterparts with higher SES (Brouwer *et al*., 2022).

2.12.2.6Influences on Nonverbal Behaviour

Students with high parental SES are bound to show more separation practices than their friends with low SES. In this structure, withdrawal practices incorporate self-prepping, shaking with close by things, and outlining when the individual is talking. In contrast, engagement behavior consists of many nonverbal behaviors, such as head nodding, raising eyebrows, laughing and staring at each other. These gestures indicate interest in a partner.Participants with lower SES tended to communicate more participation behaviors with dialogue partners, while participants with higher SES showed more disengagement behaviors. The author pointed out that as SES increases, the ability to meet individual needs will increase. This communication may bring a greater sense of freedom. Because they are unlikely to need their support in the future, individuals with higher SES have difficulty getting to know their dialogue partners (Almeida & Buzady, 2023).

2.13 Effect of Cognitive Activation on the Academic Achievement

Zhao (2017) emphasizes that academic performance as the level of students' proficiency in academic knowledge and skills, which is demonstrated through examinations after structured learning. In the Chinese education system, universities often categorize students based on their academic performance.

Liu (2019) emphasized that academic performance, particularly in school-administered examinations, plays a pivotal role in shaping students' future prospects. He described academic performance as a concentrated representation of students' learning efforts, a reflection of their cognitive abilities, and an indicator of their learning progress and proficiency. Within the framework of China's student evaluation system, academic performance remains the primary criterion for university admissions and the central focus of student learning objectives. Numerous researchers highlight the critical role cognitive abilities play in the learning process. Consequently, teaching practices emphasize fostering and leveraging students' cognitive abilities to enhance academic outcomes (Reeder & Rico Mendez, 2022).

Although there is a strong connection between cognitive ability and academic achievement, current research struggles to accurately model how cognitive ability influences academic outcomes. Cognitive abilities play a vital role in students' learning processes, involving not only individual abilities but also the interaction between them. While many researchers have demonstrated a significant effect of cognitive ability on academic performance, the intricate mechanisms underlying this relationship remain poorly understood (Feraco, 2023).

The significance of cognitive abilities in learning is often limited to the specific parameters defined by researchers, which typically focus on one or more abilities selected by them. Beyond these parameters, cognitive abilities may function in ways that are less predictable. The inconsistency in the scope of studies on cognitive abilities has led to a lack of consensus among scholars about how and why cognitive abilities influence academic achievement. Furthermore, much of the existing research has primarily examined the effect of individual cognitive abilities, with limited exploration of how multiple cognitive abilities work together to impact academic performance (Mammadov, 2022).

This study builds upon the classification of cognitive abilities proposed by Woo and Lin (2000), focusing on five categories: information processing, logical reasoning, working memory, thinking transformation, and representation. Through extensive research, the researcher can arrive at scientifically validated conclusions and developed testing methods for these distinct cognitive abilities. Additionally, a software system was designed to measure these five abilities, with over two million students from mainland China assessed, resulting in normative data tailored to current cognitive ability evaluations in the region. The reliability and validity of this assessment system have been thoroughly tested, demonstrating its accuracy in evaluating students' cognitive abilities (Karakoç *et al*., 2022).

Despite these findings, other researchers suggest that cognitive ability alone is not the primary determinant of academic performance. Academic outcomes may also be influenced by broader aspects of students' overall learning conditions. However, limited research has explored the interaction between cognitive ability and academic achievement. This study addresses the gap by incorporating students' self-monitoring as a moderating variable to investigate how cognitive ability affects academic performance under the influence of self-monitoring (Huang *et al*., 2022).

While the connection between students' cognitive abilities and academic performance is well-established, understanding the intricate mechanisms underlying this relationship remains a challenge. Research consistently shows a clear link between cognitive abilities and academic achievement, yet the specific processes that mediate this ability influence are still not fully understood. Cognitive abilities are often studied within predefined parameters set by researchers, focusing on particular aspects of cognition. However, beyond these parameters, cognitive abilities may function in ways that are difficult to predict. As a result, scholars have yet to reach a consensus on this matter, leaving it open for further investigation for the entire process of teaching (Korous *et al*., 2022).

Research highlights a significant correlation between attention and academic performance, with correlation coefficients ranging from .4 to .5. However, Zhang (2008) reported a correlation coefficient of approximately .3 between logical reasoning ability (LRA) and performance in Chinese and mathematics, while the correlation between attention and these subjects was found to be insignificant. These findings suggest that cognitive abilities can have an indirect effect on academic performance. Nevertheless, they do not provide a definitive explanation of how individual student factors contribute to academic achievement (Liu *et al*., 2024).

2.14 Limitations of Cognitive Activation Method in Prior Studies

Although the Cognitive Activation Model (CAM) offers a strong theoretical basis for enhancing student learning, prior studies have reported several limitations in its classroom application. Cognitive activation strategies require high levels of teacher expertise, as instructors must design challenging tasks and manage discussions effectively. Teachers often struggle to balance syllabus coverage with the time needed for extended cognitive engagement. Moreover, CAM does not always yield consistent results across diverse classrooms; students with limited prior knowledge or language proficiency may find it difficult to benefit from cognitively demanding tasks. Large class sizes further complicate implementation, as individualized attention is reduced and student disengagement becomes more likely. These limitations indicate that while CAM is theoretically sound, its successful application depends on teacher training, supportive environments, and contextual adaptation (Paurowski *et al*., 2025).

2.15 Previous Research Findings on Cognitive Activation Method

Numerous studies have demonstrated the beneficial effects of the Cognitive Activation Method (CAM) on students' academic achievements. For instance, Baumert *et al*. (2010) observed that when mathematics teachers used cognitively challenging tasks and encouraged active classroom discussions, student performance significantly improved. This positive impact is also evident in science education, where CAM not only helps students grasp subject content but also promotes critical thinking and scientific reasoning skills.

In countries like Pakistan, where many schools face resource constraints, research by Rahman (2018) and Tariq and Malik (2020) stated that employing CAM strategies can enhance student involvement, deepen their understanding of concepts, and raise academic success in General Science.

Additional research by Klieme *et al*. (2006) highlighted that teaching practices involving high cognitive demands, coupled with effective classroom management, contribute to better learning outcomes across disciplines. Similarly, Seidel and Shavelson (2007), through a comprehensive review of teaching effectiveness studies, found that teaching approaches focused on cognitive engagement generally yield stronger improvements in student achievement compared to traditional methods.

Specifically in science classrooms, Hardy *et al*. (2011) demonstrated that CAM techniques applied in physics education led to notable improvements in students' conceptual grasp and their ability to solve problems, emphasizing the importance of supportive dialogue and scaffolding. Furthermore, a study by Aslam and Afzal (2021) in rural Punjab schools reported that teachers trained in CAM observed greater student curiosity, participation, and retention compared to conventional lecture-based instruction.

The focus of CAM on intellectually stimulating, student-centered tasks is consistent with international recommendations advocating a shift from rote memorization to deeper learning. This is further supported by OECD (2015, 2018) reports, which link cognitively activating teaching methods with higher student performance in global assessments such as PISA, particularly in science and mathematics.

2.16 Recent Pakistani Studies on Academic Achievement and Teaching Approaches

Noor, Parveen & Ehsan (2024) investigated the effectiveness of cooperative learning on academic achievement among ninth-grade students at the elementary level. The researchers used a pretest, posttest control group design, comparing the outcomes of traditional lecture-based teaching with cooperative group learning. The analysis revealed that there was no statistically significant difference between the two approaches in terms of academic achievement. These findings suggest that while cooperative learning can be an engaging method, it does not always guarantee superior academic results in comparison to traditional methods in the Pakistani context.

Ahmad, Zulfiqar & Bajwa (2024) explored the impact of Problem-Based Learning (PBL) on mathematics achievement among elementary school students in Multan. The study employed a quasi-experimental design with pretest–posttest, comparing an experimental group taught with PBL strategies to a control group taught through traditional methods. Findings revealed that students exposed to PBL showed significant improvement in mathematics performance. Additionally, female students demonstrated greater academic gains than male students, highlighting gender-based differences in responsiveness to PBL strategies. This study underscores the potential of PBL as a transformative teaching method in Pakistani classrooms.

Sarwar & Ullah (2023) conducted a qualitative investigation into motivational factors contributing to low achievement in general science among elementary school students in Lahore. Through interviews with 15 general science teachers, the study identified barriers such as lack of student interest, limited practical engagement, and insufficient motivational strategies. The researchers proposed incorporating contextualized teaching practices, student-centered activities, and teacher motivational strategies to enhance science learning outcomes. This study highlights the critical role of motivation in shaping academic achievement in science subjects.

2.17 Research Gap

Despite extensive international evidence supporting the effectiveness of the Cognitive Activation Method (CAM), there is a lack of empirical studies in Pakistan that experimentally compare CAM with the Lecture Method (LM) at the elementary level in General Science. Most local studies have focused on cooperative learning, motivational strategies, or inquiry-based approaches, but not specifically on CAM. Moreover, little attention has been given to retention levels and the differential effects of CAM on low, medium, and high achievers. This gap provides the rationale for the present study.Although the Cognitive Activation Model (CAM) has been widely discussed in international literature as a means of fostering higher-order thinking and improving student outcomes, research on its practical application within Pakistan remains scarce. In particular, there is a noticeable absence of experimental investigations that examine the role of CAM in the teaching of science at the elementary level. Most local studies in Pakistan have focused on general teaching methods, cooperative learning, or motivational strategies, without exploring the specific impact of cognitively activating practices. This gap limits the understanding of how CAM can be adapted to local classroom realities, such as large class sizes, varying student preparedness, and resource constraints. The present study seeks to address this gap by experimentally investigating the effect of CAM on the academic achievement of elementary science students in Pakistan, thereby contributing both to theory and practice.

2.18 Summary of Reviewed Studies

A synthesis of key reviewed studies indicates consistent patterns in the effectiveness of active and cognitively engaging pedagogies compared to traditional lecture-based instruction. For example, Shah and Rahatullah (2012), in a quasi-experimental study with Grade 8 students in Pakistan, reported that the Lecture Method led to passive learning, low participation, and poor retention of concepts. Similarly, Ahmad, Samiullah, and Khan (2019) employed an experimental design and found that students exposed to activity-based teaching significantly outperformed those taught through conventional lectures. Extending this evidence, Ashraf and Rauf (2020) observed that lecture-driven instruction in Punjab schools was associated with weaker reasoning skills, while Mahmood and Iqbal (2021) demonstrated that activity-based approaches improved middle school students' problem-solving abilities.

International research also aligns with these findings. Oribhabor (2020) in Nigeria reported that activity-based instruction yielded better mathematics achievement than lecture-based teaching. In Latin America, the Education for Sharing (2021) initiative demonstrated that play-based and cognitively activating strategies enhanced student engagement, reflection, and social development. Local correlational work by Batool and Akhtar (2020) further emphasized that higher levels of cognitive engagement were strongly linked with better mathematics achievement among Pakistani students. Finally, Noureen and Karim (2023) confirmed that constructivist instructional strategies significantly improved science achievement, underscoring the advantages of student-centered learning models in Pakistan.

Overall, these studies collectively highlight two important trends: first, the persistent limitations of lecture-based instruction in promoting meaningful learning; and second, the potential of cognitively activating approaches such as CAM to enhance achievement, reasoning, and engagement. Yet, despite international and local evidence supporting active learning, there remains a notable lack of experimental research on CAM in Pakistani elementary science classrooms, which this study seeks to address.

CHAPTER 3
RESEARCH METHODOLOGY

This chapter outlines the research design, population and sample, research instruments, data collection procedures, and data analysis methods used in the study. It also details the construction of the Subject Achievement Test, lesson plans, and the experimental procedure

3.1 Research Design

The true experimental design was utilized in this study. Gay (2009) emphasizes that such a design is well-suited especially for the experimental research, as it permits the manipulation of the independent variable to assess its influence on the dependent variable

Table 3.1

Research Design of the study

Groups	*Pre-test*	*Independent Variable*	*Post-test*
R	O1	T1	O2
R	O3	T2	O4

Where;

R= randomly selected participants

O1 and O3 = Pre-test

T1= Treatment group with Cognitive Activation Method

T2= Treatment group with Lecture Method

O2 and 4 = Post-test.

3.2 Population

All 6,972 Grade 8 students of District Kotli constituted the targeted population of the study (DEO Office Kotli, 2024). The accessible population comprised 63 Grade 8 students of Government Boys Elementary School Palhatar, District Kotli.

Grade 8 students were selected because they are at a crucial stage of cognitive development and formal learning (Rabillas *et al.*, 2023). Studying the impact of the Cognitive Activation Method (CAM) on their academic achievement aligns with the study's objective to compare the effectiveness of CAM and the traditional Lecture Method in enhancing learning outcomes in General Science.The study was conducted in District Kotli, Azad Jammu and Kashmir (AJ&K). Although the study was conducted in a single school, this institution was considered representative of the broader educational context in District Kotli, where the lecture method predominates and resources are limited. The school's demographic profile, including its rural setting, socio-economic diversity, and adherence to the Single National Curriculum, closely mirrors that of many other government schools in Azad Jammu and Kashmir. The school was selected through a random process from the list of government schools provided by the District Education Office, which ensured that the choice of institution was unbiased. As the selected school was a boys-only institution, the sample was restricted to male students.Therefore, findings from this school can be cautiously generalized to similar contexts across the region.

3.3 Sampleand Sampling Technique

Government Boys Elementary School Palhatar was randomly selected as the sampling frame. Out of 63 students 60 students were selected randomly through lottery method. Each student's name was written on a slip of paper, and 60 slips were drawn without replacement. This method was chosen due to its simplicity, transparency, and appropriateness for a relatively small and manageable population. After administering a pretest to all selected students, two equivalent groups (control and experimental) were formed based on their pretest scores to ensure comparability before the intervention.

The sample size of 60 was considered sufficient for the experimental study based on the accessible population and practical feasibility. Based on Cohen's (1992) power analysis framework, a study aiming to detect a medium-level effect (effect size d =.5) with 80% power at a 5% significance level typically requires at least 52 participants. The detailed composition of the study sample is presented below:

Table 3.2

Sample of the Study

No.	*Experimental Group*	*Control Group*	*Total*
01	30	30	60

3.4 Research Instruments

Subject AchievementTest and Lesson Plans were developed by the researcher to conduct the experiment, as given below:

3.4.1 Subject Achievement Test (SAT)

The Subject Achievement Test (SAT), carrying a total of 100 marks, was prepared by the researcher based on three selected chapters from the Grade 8 Science textbook. This textbook follows the syllabus of the Single National Curriculum (SNC) 2022, recommended by the Azad Jammu and Kashmir Textbook Board and published in 2023. The SAT was specifically developed to assess students' academic achievement in General Science, aligning closely with the instructional objectives and content of the selected chapters. The test items were constructed following a Table of Specification to ensure comprehensive coverage of key concepts and alignment with the Single National Curriculum (SNC 2022).The SAT was chosen as the primary instrument because it provides an objective and quantifiable measure of student learning outcomes, which is essential for evaluating the effectiveness of instructional strategies in an experimental study.

3.4.1.1 Selection of Units from General Science

To ensure the unbiasness, following three units from the textbook of textbook of General Science of grade 8 were selected randomly;

Ecology: This chapter contains the following topics;

- Oxygen Cycle
- Carbon Cycle
- Relationship between oxygen and carbon cycle
- Global warming
- Effect of Global Warming
- Energy Flow in an Ecosystem
- Change in an Ecosystem
- Effect of Population of different Ecological Relationship
- Positive behaviour for preservation of Environment

Chemical Reactions: This chapter contains the following topics;

- Chemical Reactions
- Rearrangement of Atoms in Chemical Reactions

- Changes in Chemical Reactions
- Application of Chemical Reactions
- Application of Endothermic Reactions
- Chemical Bonds and its types

Force and Pressure: This chapter contains the following topics;

- Force
- Balanced and Unbalanced forces and the effect of Unbalanced forces
- Density, Floating and sinking objects in terms of density
- Pressure, Force and Area
- Pressure of Liquid and Air
- Effect of force in the presence of air pressure

3.4.1.2 Construction and marks distribution of Subject Achievement Test

The subject achievement test of 100 marks was prepared by the researcher from three selected units of science textbook of grade 8. The Subject Achievement Test was constructed according to a detailed Table of Specification (TOS), which ensured proportional representation of content areas and cognitive levels. The complete Table of Specification is provided in Appendix D.

The marks distribution of the test items is given below;

Table 3.3

Marks Distribution of the Subject Achievement Test

No.	*Item type*	*No. of items*	*Marks of each item*	*Total Marks*
01	MCQs	33	01	33
02	Blanks	34	01	34
03	True/False	18	01	18
04	Match the columns	15	01	15
05	Total	100	01	100

3.4.1.3 Marking of the Subject Achievement Test

The SAT was marked as per the scheme of District Elementary Board Kotli. Each correct answer was awarded one (1) mark, while zero marks were given for incorrect answers. The total score was calculated by summing up the marks for all correct responses.

3.4.1.4 Validity of the Subject Achievement Test (SAT)

To validate the SAT following procedure was adopted;

1. The researcher aligned the SAT proportionally with the table of specification.
2. The researcher obtained the feedback from the experts of the Department of Education, Physics, Chemistry and Biology University of Kotli Azad Kashmir. Based on expert feedback, the description of the research instruments has been revised to provide greater clarity and depth. Enhancements include a more detailed account of the development process of the Subject Achievement Test.
3. The researcher consulted Head examiners of General Science of BISE Mirpur.
4. The researcher modified the SAT according to the opinions of the above-mentioned notables.

3.4.1.5 Pilot Testing of the Subject Achievement Test

For pilot testing, the Subject Achievement Test (SAT) was administered to 20 Grade 8 students at Government Boys Elementary School, Gulhar Sharif.

3.4.1.6 Reliability of the Subject Achievement Test

The Kuder-Richardson Formula 20 (KR-20) was used to calculate the reliability of the SAT, as the difficulty level of the test items was consistent. The reliability coefficient for the multiple-choice questions (MCQs) was.78, for fill-in-the-blanks.82, for true/false items.81, and for matching items.79. The overall reliability of the SAT was.80. This consistency across item types demonstrates that the SAT provided stable and dependable measures of students' academic achievement.

3.4.2 Development of Lesson Plans

Lesson plans were the key components of the study. It was a comparative study between two teaching method. Thirty-two lesson plans were prepared for each of the methods.The treatment period was eight weeks. The detailed description of the lesson plans is given below:

3.4.2.1 Lesson plans for Experimental Group (CAM)

The researcher developed 32 lesson plans for experimental group from three selected chapters of General Science textbook published by Azad Jammu and Kashmir Textbook Board Muzaffarabad in 2023. These lesson plans were based on the Cognitive Activation Method. The detail description of the Cognitive Activation Method introduced by Lipowsky (2015) is given below:

Steps	Subcategories of Cognitive Activation	Examples Items
	Challenging questions	
A	A1 Challenging phenomena at the beginning	The teacher will introduce stimulating or fascinating problems/tasks at the beginning of the lesson.
	A2 The questioning of the students is supported	The teacher will offer the students time and opportunities to ask their own questions.
	A3 The teacher asks cognitive activating questions	The questions will be asked by the teacher require more than just yes/no answers and will not just ask for memorized knowledge. The questions will not be answered spontaneously and make the learners think.
	Prior knowledge/ideas, in-depth learning opportunities and cognitive conflicts	
B	B1 The prior knowledge and the ideas of the learners are explored	The teacher will ask for the assumptions or encourage the kids to express their doubts
	B2 In-depth learning opportunities	The teacher will try to understand the thinking of the learners by asking how they came up with specific answers and/or by asking to justify their answers.

	B3 Cognitive conflicts are generated	The teacher will confronts the learner with facts, observations or phenomena that contradict learners' expectations
	Instructional dialogue	
C	C1 Discuss ideas together	The teacher will encourage the exchange among the learners by asking them to relate their contributions to each other
	C2 Discussing errors	The teacher will pick up mistakes of the learners and uses them in the further course of the lesson.

PISA (2020) recommended the use of "Cognitive Activation Methodfor the teaching of science subjects.

3.4.2.2 Lesson plans for Control Group (LM)

Theresearcher developed 32 lesson plans for control group form three selected chapters of General Science textbook published by Azad Jammu and Kashmir Textbook Board Muzaffarabad in 2023. These lesson plans were based on the Lecture Method. The key phases of the lesson plans are given below:

1. Objective
2. AV aids
3. PK test
4. Announcement of the topic
5. Presentation
6. Recapitulation
7. Closure
8. Home work
9. Departure

3.4.2.3 Validity of the Lesson plans

The lesson plans of CAM and LM were validated by the faculty member of Department of Education, Physics, Chemistry and Biology of the University of Kotli Azad Jammu and Kashmir who were PhDs in their respective subjects.

3.5 Procedure of conducting experiment

Following procedure was adopted to carry out the research;

3.5.1 Ethical Consideration

The researcher got the permission from District Education Officer Kotli Azad Kashmir for conducting the experiment at Government Boys Elementary School Palhatar. The researcher also got the permission of the District Education Officer Kotli, Head teacher parents and guardians of the students (Sample) and took an assurance from them that the children should not take leave from school during experiment. The students were properly made known about the experiment and the researcher also discussed the significance of their role in the experiment. The researcher assured the school administration that the data will only be used for the research purpose and remains confidential. During the experiment the researcher kept in touch with the parents, teachers, and Head teacher and to handle any unexpected situation. The permission letter from DEO Kotli has been added in the Appendix.

3.5.2 Conduction of Pretest

The Subject Achievement test was taken as pretest, one week before the start of the experiment. The pretest helped the researcher in formulating two equivalent groups. The pretest also gave the academic achievement of the both groups before the treatment. The pretest also located the similarities and differences among the students.

3.5.3 Formation of Control and Experimental Groups

Sixty students were first chosen randomly through the lottery method, after which a pretest was conducted. The pretest scores were used to create two comparable groups so that both had nearly the same level of academic ability prior to the treatment. The groups were then randomly designated as control and experimental. This approach ensured fairness by combining random sampling with score-based matching, thereby reducing bias and meeting the standards of a true experimental design.

3.5.4 Formation of the sub groups (Lower, Medium and Higher Achievers)

First of all, the marks sheets SAT (pretest) were arranged in ascending order.After that top 25% of the students were placed in higher achievers' group, similarly bottom 25% students were placed in lower achievers' group, whereas rest of the 50% were placed in medium achievers' group. This formation is suitable do the experimental study(Cohen *et al*., 2018).

3.5.5 Treatment

The treatment period lasted for eight weeks. The students in the control group were taught using the Lecture Method, whereas the students in the experimental group were taught using the Cognitive Activation Method.

3.5.6 Controlling Internal Validity Threats of the Experiment

To control the threats of internal validity of the experiment following measures were taken;

Selection Bias: To control the selection favoritism, the participants were randomly assigned the groups: control and experimental group. No preference was given at the time of formation of groups. Furthermore, the age, learning style and age of the student were not taken into consideration and students were assigned the groups purely by chance.

Maturation: The maturity of the students may affect the results of the posttest. This threat may rise if the results of the posttest are higher due to the maturity rather than due to the treatment. To control this threat the duration of the experiment was kept just eight weeks, which was no sufficient for the development of the maturity level of the grade 8 students.

Testing Time: Testing time is another threat which occurs if the same SAT is given to same group of the participants with in a short period of time. The results of the posttest may improve if the students check the correct answers after the pretests and they may remember them. This memory may help them in getting good grades in the posttest. To control this effect the duration of eight weeks was given between pretest and posttest. This is enough time to forget the items of the pretest for the students of grade 8. Moreover, the students were unaware of the composition of the posttest. This threat was also condensed by changing the order of the test items in the posttest.

Unexpectedness: This threat may arise when the responses of the participants change due to an unpredicted event during the treatment period. To control effect of this threat, the experiment was conducted under well-planed and controlled conditions. Moreover, there was no such an event was observed during the course of experiment. So, this threat was controlled successfully.

Morality: The morality is another threat which may occur when the students of both groups may not have the chance of being evaluated on the identical bases. To control this threat the students of both the groups were evaluated on the same criteria that is they were awarded one mark for the correct answer and zero mark for the wrong answer. Furthermore, the students of both the groups were not allowed by the school administration to remain absent during the experiment, so getting equal chance of the treatment in reduced the effect of morality in this respect.

3.5.7 Controlling External Validity Threats of the Experiment

To control the threats of external validity of the experiment following measures were taken:

Instrumentation: This threat may happen if the instrument is not developed appropriately. To control this threat the SAT was constructed under the supervision of the experts. Additionally, before the implementation in the experiment pilot testing was also conducted and reliability of the SAT was also calculated which was satisfactory. Hence this threat was effectively controlled.

Locality: This threat may occur; is the participants of groups are selected from the different localities. To control this threat the participants for both the groups were selected from the same school, moreover the participants were also belonged to the local community and they are supposed to have same kind of mentality. Hence this threat was controlled effectively.

Grouping: This threat may come across, if the grouping of the students may not be made on the basis of equality. To control this threat, 30 students were assigned experimental group and 30 were placed in control group. Moreover, the division of the students wastaking place on the basis of the marks of the pretest. Hence the students of both groups own same competencies. In this way the threat of the grouping was controlled.

Treatment period: Another threat may happen, if treatment period for both the groups may not be same. To control this threat, both groups were treated for eight weeks. In this way the threat of being treated unequally was controlled.

Teacher's Qualification, Experience and Training: Thisthreat may come across, if the qualification and experience of the teachers are different for both groups. In order to control the effect of teacher's qualification, experience and training, the researcher himself taught both groups. Before starting the experiment, the researcher got the training of both methods form the educational experts of the Department of Education University of Kotli Azad Kashmir, furthermore he also delivered model lesson in front of them. So, the threats of the teacher's qualification, experience and training were managed successfully.

Subject to be taught: This is another external threat for the validity of the experiment. If same subject is not taught to the control and experimental group, the results may not be reliable and generalizable. To handle this risk the same subject (General Science) taught to both groups.

Environment of the Classrooms: This threat may arise if the groups are treated in two different environments. To manage this hazard, both groups were housed in classrooms within the same building. Furthermore, to minimize any probable classroom preferences, the researcher implemented a classroom rotation strategy, where the groups swapped classrooms every two days.

No Extra Coaching: The threat of extra coaching may also affect the results of the posttest. To handle this risk, the parents of the students (sample) were requested not to give tuition to them at homes and they ensured. So, the threat of extra coaching was coped effectively.

Limited Geographic Scope and Gender-Specific Sample: The sample was drawn from elementary-level students in a single geographic region, which may not reflect the diversity of other regions in Pakistan. Furthermore, as the participants belonged to a gender-specific group, the results may not be equally applicable to mixed-gender or male-only classrooms. To minimize this threat, the sample was randomly selected within the chosen population to enhance representativeness. Moreover, detailed documentation of the research context has been provided, enabling future studies to replicate the design in different regions and with mixed-gender groups.

3.5.8 Fidelity Verification

For the purpose of fidelity verification,the researcher took the services ofan educational expert of the Department of Education, University of Kotli Azad Kashmir. To ensure fidelity of implementation, classroom observations were conducted twice a week during the treatment period.

Fidelity of lesson delivery was ensured through structured classroom observations conducted twice a week by an educational expert from the Department of Education, University of Kotli. The expert monitored adherence to the lesson plans and provided feedback to maintain consistency in teaching practices. The researcher also maintained detailed logs of each session, documenting whether the prescribed steps of Cognitive Activation Method and Lecture Method were followed as planned. This systematic monitoring enhanced the credibility of the intervention. The Monitoring checklists have been added in the Appendices G and H.

3.6 Conduction ofPosttest

The posttest was taken at the end of the treatment of eight weeks. The posttest was same as pretest but the arrangement of the test items was altered to overcome the memory recall of the participants. The purposes of the posttest were; to determine the achievement of the students after the treatment and to assess the differences between the achievements of the students of both groups after the treatment.

3.7 Retention Test

The retention test, comprising the same SAT used in the post-test, was administered to both control and experimental groups four weeks after the completion of the treatment. The test was conducted under standardized conditions to ensure uniformity. The results were analyzed using independent samples t-test to compare the mean scores of both groups, thereby assessing the long-term retention of academic achievement.

3.8 Variables of the study

Following were the variables of the study;

3.8.1 Independent Variables

The strategies of the Cognitive Activation Method and Lecture Method were considered as independent variables.

3.8.2 Dependent Variables

Academic achievements of the students of grade 8 in the General Science were considered as dependent variables. It was measured twice during the study; firstly, before the treatment, and secondly after the treatment.

3.8.3 Extraneous Variables

Time of the experiment, age of the students, subject to be taught, sample size, language of the teaching, and selection of the sample etc. were the extraneous variables of the study.

3.9 Data Collection

The data were collected personally by the researcher. The Subject Achievement Test (SAT) was used for the data collection. The SAT was administered twice in the study, firstly as a pretest and secondly as a posttest. Both tests were administered under the controlled conditions. Extraneous variables such as; background noise, light, seating comfort and invigilation were also considered during the test's conduction.

3.10 Data Analysis

Data were analyzed by using SPSS 25.0 version. Descriptive statistics (Mean and Standard Deviation) were used to calculate the academic achievement of the students before and after the treatment. Inferential statistics (Independent sample t-test, paired sample t-test and Partial Eta Squared test) were used to compare the academic achievement of the students and effect size.Moreover, the effect of retention test was also compared by paired sample t-test and Partial Eta squared Test.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATIONS

This chapter presents the statistical analysis and interpretation of the data collected during the study. Both descriptive statistics (means and standard deviations) and inferential statistics (independent samples t-test, paired samples t-test, and partial eta squared) were employed to analyze and interpret the results. The analysis is structured according to the research objectives and hypotheses.

The chapter begins with a comparison of the pre-test results of the control and experimental groups to ensure equivalence before the intervention. To assess the initial academic achievement of the students, a pre-test was administered to both groups. An independent samples t-test was conducted to compare the mean scores of the control and experimental groups and to determine whether a statistically significant difference existed prior to the treatment.

The results revealed no statistically significant difference between the mean scores of the control and experimental groups ($p > .0033$, Bonferroni's-adjusted alpha value), indicating that the groups were equivalent in terms of academic achievement at the start. Furthermore, the effect size (partial eta squared) was calculated to evaluate the magnitude of the difference, which was found to be negligible, supporting the conclusion of baseline equivalence. These findings provided a sound basis for proceeding with the intervention phase of the study. The data are presented and interpreted as follows:

4.1 Academic Achievements of the Students before Treatment

Table 4.1

Academic achievements of Control and Experimental Group (pre-test)

Group	*N*	*M*	*SD*	*SEM*
Control	30	33.27	10.044	1.834
Experimental	30	32.00	9.660	1.764

N=60

Descriptive statistics (Mean and Standard Deviation) were used to determine the academic achievements of students in General Science before the treatment. Table 4.1 shows that, the pretest marks of the control group were: *N*=30, *M*=33.27, *SD*=10.044, *SEM*= 1.834 and pretest marks of experimental group were; *N*=30, *M*=32.00, *SD*=9.660, *SEM*= 1.664.

4.2 Academic Achievements of the Students after Treatment

Table 4.2

Academic achievements of Control and Experimental Group (post-test)

Group	*N*	*M*	*SD*	*SEM*
Control	30	59.70	10.212	1.864
Experimental	30	78.70	11.818	2.158

N=60

Descriptive statistics (Mean and Standard Deviation) were used to calculate the academic achievements of students in General Science after the treatment. The posttest marks of control group were: *N*=30, *M*=59.70, *SD*=10.212, *SEM*= 1.864 and the posttest marks of experimental group were; *N*=30, *M*=78.70, *SD*=11.818, *SEM*= 2.158. Table 4.5 shows that, there were the posttest marks of experimental group were significantly more than the posttest marks of control group.

4.3 Comparison between the marks of pretest (Baseline Comparison)

Table 4.3

Comparison between marks of pretest of control and experimental group

Pre-test	*N*	*Mean*	*SD*	*Df*	*t*	*p*	*α-adjusted*
Control Group	30	33.27	10.444	58	.498	.933	.0033
Experimental Group	30	32.00	9.660				

N=60

An independent samples t-test was conducted to compare the pretest scores of the control and experimental groups. The control group had a mean score of 33.27 (*SD* = 10.444), while the experimental group had a mean score of 32.00 (*SD* = 9.660). The t-test results showed no statistically significant difference between the two groups at baseline, t (58) =.498, p =.933 > .0033 (Bonferroni's adjusted alpha value). Table 4.3 indicates that both groups had similar academic achievement levels prior to the intervention. The lack of significant difference at the pretest ensures that the groups were comparable before the treatment. This baseline equivalence strengthens the internal validity of the study by confirming that any significant post-test differences in academic achievement can more confidently be attributed to the effect of the Cognitive Activation Method rather than pre-existing differences.

4.4 Analysis Related to Hypothesis ($H_0$1)

Table 4.4

Comparison between marks of pretest and posttest of control group

Control Group	*N*	*Mean*	*SD*	*df*	*t*	*p*	*α*	*ηp2*	*Variance*
Post test	30	59.70	10.212	29	5.360	.001	.0033	.384	38.4%
Pre-test	30	44.83	19.673						

N=60

Table 4.4 presents the comparison between the pretest and posttest scores of the control group, where the Lecture Method was applied. A paired sample t-test shows a statistically significant increase in academic achievement following the treatment, with the posttest (M = 59.70, SD = 10.212) notably higher than the pretest (M = 44.83, SD = 19.673), t (29) = 5.360, p = .001 < .0033 (Bonferroni's-adjusted alpha), indicating that the difference is statistically significant. Moreover, the partial eta squared (ηp^2 = .384) indicates a large effect size according to conventional benchmarks (small = .01, medium = .06, large = .14). This means that approximately 38.4% of the variance in academic achievement can be attributed to the effect of the Lecture Method, demonstrating a strong practical significance of the intervention. This data indicates that students taught through Lecture Method performed significantly better on the General Science test compared to their baseline scores. Therefore, the null hypothesis stating, "There is no significant effect of the Lecture Method on the academic achievement of elementary-level students" is rejected.

4.5 Analysis Related to Hypothesis ($H_0 2$)

Table 4.5

Comparison between pretest and posttest marks of experimental group

Experimental Group	*N*	*Mean*	*SD*	*Df*	*t*	*p*	*α*	*ηp2*	*Variance*

Post test	30	78.70	11.818	29	21.079	.001	.0033	.417	41.7 %
Pre-test	30	32.00	9.660						

N=60

Table 4.5 presents the comparison between the pretest and posttest scores of the experimental group, where the Cognitive Activation Method was applied. A paired sample t-test shows a statistically significant increase in academic achievement after the treatment, with the posttest (*M* = 78.70, *SD* = 11.818) substantially higher than the pretest (*M* = 32.00, *SD* = 9.660), *t* (29) = 21.079, *p* =.001 < .0033 (Bonferroni's adjusted alpha value), indicating that the difference is statistically significant. Moreover, the partial eta squared (ηp^2 =.417) indicates a large effect size according to conventional benchmarks (small = .01, medium = .06, large = .14). This means that approximately 41.7% of the variance in academic achievement can be attributed to the effect of the Cognitive Activation Method, demonstrating a strong practical significance of the intervention. This data indicates that students taught through CAM performed significantly better on the General Science test compared to their baseline scores. Therefore, the null hypothesis stating "There is no significant effect of CAM on the academic achievement of elementary level students in General Science" is rejected.

4.6 Analysis Related to Hypothesis ($H_0$3)

Table 4.6

Comparison between the results of posttest of control and experimental group

Test	*Group*	*N*	*Mean*	*SD*	*df*	*t*	*p*	*ηp2*	*Variance*
Posttest	Experimental	30	78.70	11.818	58	8.594	.001	.347	34.7
	Control	30	59.70	10.212					

N=60

Table 4.6 presents the comparison between the posttest scores of the experimental and control groups, where the Cognitive Activation Method (CAM) and the Lecture Method were applied, respectively. An independent samples *t*-test revealed a statistically significant difference in academic achievement, with the experimental group (M = 78.70, SD = 11.818) scoring higher than the control group (M = 59.70, SD = 10.212), *t* (58) = 8.594, *p* = .001 < .0033 (Bonferroni's-adjusted alpha), indicating a statistically significant difference between the two groups.

Moreover, the partial eta squared ($\eta p^2 = .347$) indicates a large effect size according to conventional benchmarks (small = .01, medium = .06, large = .14). This means that approximately 34.7% of the variance in academic achievement among elementary-level students in General Science can be attributed to the difference in teaching methods. This data illustrates that, there is a significant difference between the effects of the Cognitive Activation Method and the Lecture Method on the academic achievement of elementary-level students in General Science. Therefore, the null hypothesis stating, "There is no significant difference between the effects of the Cognitive Activation Method and the Lecture Method on the academic achievement of elementary-level students in General Science" is rejected.

4.7 Analysis Related to Hypothesis ($H_0$4)

Table 4.7

Comparison between pretest and posttest marks of lower achievers in the control group

Group	Lower Achievers	*N*	*Mean*	*SD*	*df*	*t*	*p*	*ηp2*	*variance*
Control	Post test	8	48.25	3.059	7	33.991	.001	.318	31.8%
	Pre-test	8	20.25	5.148					

N=16

Table 4.7 presents the comparison between the pretest and posttest scores of lower achievers in the control group, where the Lecture Method was applied. A paired sample t-test revealed a statistically significant increase in academic achievement, with posttest scores (M = 48.25, SD = 3.059) notably higher than pretest scores (M = 20.25, SD = 5.148), $t(7) = 33.991$, $p = .001 < .0033$ (Bonferroni's-adjusted alpha), indicating a statistically significant difference. Moreover, the partial eta squared ($\eta p^2 = .318$) indicates a large effect size according to conventional benchmarks (small = .01, medium = .06, large = .14). This means that approximately 31.8% of the variance in academic achievement can be attributed to the Lecture Method, demonstrating strong practical significance of the intervention. This data indicates that There is a significant effect of the Lecture Method on the academic achievement of lower achievers in General Science. Therefore, the null hypothesis stating, "There is no significant effect of the Lecture Method on the academic achievement of lower achievers in General Science" is rejected.

4.8 Analysis Related to Hypothesis ($H_0 5$)

Table 4.8

Comparison between pretest and posttest results for medium achievers in the control group

Group	Medium Achievers	*N*	*Mean*	*SD*	*df*	*t*	*p*	*ηp2*	*Variance*
Control	Post test	14	58.00	4.438	13	56.591	.001	.437	43.7 %
	Pre-test	14	33.93	4.269					

N=28

Table 4.8 presents the comparison between the pretest and posttest scores of medium achievers in the control group, where the Lecture Method was applied. A paired sample *t*-test revealed a statistically significant improvement in academic achievement, with posttest scores (M = 58.00, SD = 4.438) substantially higher than pretest scores (M = 33.93, SD = 4.269), t (13) = 56.591, p = .001 < .0033 (Bonferroni's-adjusted alpha), indicating a statistically significant difference. Moreover, the partial eta squared (ηp^2 = .437) indicates a large effect size according to conventional benchmarks (small = .01, medium = .06, large = .14). This means that approximately 43.7% of the variance in academic achievement can be attributed to the Lecture Method, demonstrating a strong practical significance of the intervention. This data indicates that there is a significant effect of the Lecture Method on the academic achievement of medium achievers in General Science. Therefore, the null hypothesis stating, "There is no significant effect of the Lecture Method on the academic achievement of medium achievers in General Science" is rejected.

4.9 Analysis Related to Hypothesis ($H_0 6$)

Table 4.9

Comparison between pretest and posttest results for higher achievers in the control group

Group	Higher Achievers	N	Mean	SD	*df*	*t*	*p*	*ηp2*	*Variance*
Control	Post test	8	88.12	2.748	7	92.891	.001	.521	52.1 %
	Pre-test	8	45.12	1.553					

N=16

Table 4.9 presents the comparison between the pretest and posttest scores of higher achievers in the control group, where the Lecture Method was applied. A paired sample *t*-test revealed a statistically significant increase in academic achievement, with posttest scores (M = 88.12, SD = 2.748) considerably higher than pretest scores (M = 45.12, SD = 1.553), t (7) = 92.891, p = .001 < .0033 (Bonferroni's-adjusted alpha), indicating a statistically significant difference. Moreover, the partial eta squared (ηp^2 = .521) indicates a large effect size according to conventional benchmarks (small = .01, medium = .06, large = .14). This means that approximately 52.1% of the variance in academic achievement can be attributed to the Lecture Method, demonstrating a strong practical significance of the intervention. This data indicates that, there is a significant effect of the Lecture Method on the academic achievement of higher achievers in General Science. Therefore, the null hypothesis stating, "There is no significant effect of the Lecture Method on the academic achievement of higher achievers in General Science" is rejected.

4.10 Analysis Related to Hypothesis ($H_0$7)

Table 4.10

Comparison between pretest and posttest results of lower achievers in the experimental group

Group	Lower Achievers	N	Mean	*df*	*t*	*p*	*ηp2*	*Variance*
Experimental	Post test	8	62.88	7	38.160	.001	.333	33.3%
	Pre-test	8	18.75					

I=16

Table 4.10 presents the comparison between the pretest and posttest scores of lower achievers in the experimental group, where the Cognitive Activation Method (CAM) was applied. A paired sample *t*-test revealed a statistically significant increase in academic achievement, with posttest scores (M = 62.88, SD = 6.446) considerably higher than pretest scores (M = 18.75, SD = 4.979), t (7) = 38.160, p = .001 < .0033 (Bonferroni's-adjusted alpha), indicating a statistically significant difference. Moreover, the partial eta squared (ηp^2 = .333) indicates a large effect size according to conventional benchmarks (small = .01, medium = .06, large = .14). This means that approximately 33.3% of the variance in academic achievement can be attributed to the Cognitive Activation Method, demonstrating a strong practical significance of the intervention. This data indicates that there is a significant effect of the Cognitive Activation Method on the academic achievement of lower achievers in General

Science. Therefore, the null hypothesis stating, “There is no significant effect of the Cognitive Activation Method on the academic achievement of lower achievers in General Science” is rejected.

4.11 Analysis Related to Hypothesis ($H_0$8)

Table 4.11

Comparison between pretest and posttest results of medium achievers in the experimental group

Group	Med. Achievers	N	Mean	SD	*df*	*t*	*P*	*ηp2*	*Variance*
Experimental	Post test	14	80.86	6.383	13	60.845	.001	.458	45.8%
	Pre-test	14	33.79	4.388					

N=14

Table 4.11 presents the comparison between the pretest and posttest scores of medium achievers in the experimental group, where the Cognitive Activation Method (CAM) was applied. A paired sample *t*-test revealed a statistically significant improvement in academic achievement, with posttest scores (M = 80.86, SD = 6.383) substantially higher than pretest scores (M = 33.79, SD = 4.388), t (13) = 60.845, p = .001 < .0033 (Bonferroni’s-adjusted alpha), indicating a statistically significant difference. Moreover, the partial eta squared (ηp^2 = .458) indicates a large effect size according to conventional benchmarks (small = .01, medium = .06, large = .14). This means that approximately 45.8% of the variance in academic achievement among medium achievers can be attributed to the Cognitive Activation Method, demonstrating a strong practical significance of the intervention. This data describes that there is a significant effect of the Cognitive Activation Method on the academic achievement of medium achievers in General Science. Therefore, the null hypothesis stating, “There is no significant effect of the Cognitive Activation Method on the academic achievement of medium achievers in General Science” is rejected.

4.12 Analysis Related to Hypothesis ($H_0$9)

Table 4.12

Comparison between pretest and posttest marks of higher achievers in the experimental group

Group	Higher Achievers	N	Mean	SD	*df*	*t*	*p*	*ηp2*	*Variance*

Experimental	Post test	8	91.19	1.458	7	149.687	.001	.500	50 %
	Pre-test	8	42.12	1.356					

N=16

Table 4.12 presents the comparison between the pretest and posttest scores of higher achievers in the experimental group, where the Cognitive Activation Method (CAM) was applied. A paired sample t-test revealed a statistically significant increase in academic achievement, with posttest scores (M = 91.19, SD = 1.458) considerably higher than pretest scores (M = 42.12, SD = 1.356), t (7) = 149.687, p = .001 < .0033 (Bonferroni's-adjusted alpha), indicating a statistically significant difference. Moreover, the partial eta squared (ηp^2 = .500) indicates a large effect size according to conventional benchmarks (small = .01, medium = .06, large = .14). This means that approximately 50.0% of the variance in academic achievement can be attributed to the Cognitive Activation Method, demonstrating a very strong practical significance of the intervention. This data shows that, there is a significant effect of the Cognitive Activation Method on the academic achievement of higher achievers in General Science. Therefore, the null hypothesis, "There is no significant effect of the Cognitive Activation Method on the academic achievement of higher achievers in General Science" is rejected.

4.13 Analysis Related to Hypothesis ($H_0$10)

Table 4.13

Comparison between the results of posttest of lower achievers in control and experimental group

Test	Lower achievers	*N*	Mean	*SD*	*df*	*t*	*p*	*ηp2*	*Variance*
Posttest	Experimental Group	8	62.88	8.446	14	11.544	.001	.217	21.7 %
	Control Group	8	48.25	3.059					

N=16

Table 4.13 presents the comparison between the posttest scores of lower achievers in the experimental and control groups, where the Cognitive Activation Method (CAM) and the Lecture Method were applied, respectively. An independent samples *t*-test revealed a statistically significant difference in academic achievement, with the experimental group (M = 62.88, SD = 8.446) scoring higher than the control group (M = 48.25, SD = 3.059), t (14) = 11.544, p = .001 < .0033 (Bonferroni's-adjusted alpha), indicating a statistically significant difference between the two groups. Moreover, the partial eta squared (ηp^2 = .217) indicates a large effect size according to conventional benchmarks (small = .01, medium = .06, large = .14). This means that approximately 21.7% of the variance in academic achievement among lower achievers can be attributed to the difference in teaching methods. These results demonstrate that the effect of the Cognitive Activation Method on lower achievers was greater than that of the Lecture Method. This data states that, there is a significant difference between the effects of the Cognitive Activation Method and the Lecture Method on the academic achievement of lower achievers in General Science. Therefore, the null hypothesis stating, "There is no significant difference between the effects of the Cognitive Activation Method and the Lecture Method on the academic achievement of lower achievers in General Science" is rejected.

4.14 Analysis Related to Hypothesis (H_011)

Table 4.14

Comparison between the marks of posttest of medium achievers in control and experimental group

Test	Medium achievers	*N*	*Mean*	*SD*	*df*	*t*	*p*	*ηp2*	*Variance*
Posttest	Experimental Group	14	80.86	6.383	26	33.702	.000	.287	28.7 %
	Control Group	14	58.00	9.811					

N=28

Table 4.14 presents the comparison between the posttest scores of medium achievers in the experimental and control groups, where the Cognitive Activation Method (CAM) and the Lecture Method were applied, respectively. An independent samples *t*-test revealed a statistically significant difference in academic achievement, with the experimental group (M = 80.86, SD = 6.383) scoring higher than the control group (M = 58.00, SD = 9.811), t (25) = 33.702, p = .000 < .0033 (Bonferroni's-adjusted alpha), indicating a statistically significant difference between the two groups. Moreover, the partial eta squared (ηp^2 = .287) indicates a large effect size according to conventional benchmarks (small = .01, medium = .06, large = .14). This means that approximately 28.7% of the variance in academic achievement among medium achievers can be attributed to the difference in teaching methods. These results demonstrate that the effect of the Cognitive Activation Method on medium achievers was greater than that of the Lecture Method. This data indicates that, there is a significant difference between the effects of the Cognitive Activation Method and the Lecture Method on the academic achievement of medium achievers in General Science. Therefore, the null hypothesis stating, "There is no significant difference between the effects of the Cognitive Activation Method and the Lecture Method on the academic achievement of medium achievers in General Science" is rejected.

4.15 Analysis Related to Hypothesis (H_012)

Table 4.15

Comparison between the results of posttest of higher achievers in control and experimental group

Test	Higher achievers	*Mean*	*N*	*SD*	*df*	*t*	*p*	*ηp2*	*Variance*
Posttest	Experimental Group	8	91.12	1.458	14	4.583	.081	.002	0.2%
	Control Group	8	88.12	2.748					

N=16

Table 4.15 presents the comparison between the posttest scores of higher achievers in the experimental and control groups, where the Cognitive Activation Method (CAM) and the Lecture Method were applied, respectively. An independent samples *t*-test revealed no statistically significant difference in academic achievement between the two groups, with the experimental group (M = 91.12, SD = 1.458) and the control group (M = 88.12, SD = 2.748), t (14) = 4.583, p = .081 > .0033 (Bonferroni's-adjusted alpha), indicating that the observed difference was not statistically significant. Moreover, the partial eta squared (ηp^2 = .002) indicates a negligible effect size according to conventional benchmarks (small = .01, medium = .06, large = .14). This means that only 0.2% of the variance in academic achievement among higher achievers can be attributed to the difference in teaching methods. This data shows that, there is no significant difference between the effects of the Cognitive Activation Method and the Lecture Method on the academic achievement of higher achievers in General Science. Therefore, the null hypothesis stating, "There is no significant difference between the effects of the Cognitive Activation Method and the Lecture Method on the academic achievement of higher achievers in General Science" is accepted.

4.16 Analysis Related to Hypothesis (H_{013})

Table 4.16

Comparison between the results of retention test and posttest of control group

Group	Test	*Mean*	*N*	*SD*	*df*	*t*	*p*
Control	Retention	61.13	30	10.494	29	1.681	.103
	Post	59.77	30	10.180			

N=60

Table 4.16 presents the comparison between the posttest and retention test scores of the control group. A paired samples *t*-test was conducted to examine whether there was a significant change in academic achievement over time. The retention test scores (M = 61.13, SD = 10.494) were slightly higher than the posttest scores (M = 59.77, SD = 10.180), *t* (29) = 1.681, *p* = .103 > .0033 (Bonferroni's-adjusted alpha), indicating no statistically significant difference between the two test scores. This data indicates that there is no significant difference between the posttest and retention test scores of the students taught through Lecture Method. Therefore, the null hypothesis stating, "There is no significant difference between the posttest and retention test scores of the control group" is accepted.

4.17 Analysis Related to Hypothesis ($H_0$17)

Table 4.17

Comparison between the results of retention test and posttest of experimental group

Group	Test	*Mean*	*N*	*SD*	*df*	*t*	*P*
Experimental	Retention	30	79.37	11.118	29	1.247	.222
	Post	30	77.30	11.818			

N=60

Table 4.17 presents the comparison between the posttest and retention test scores of the experimental group, where the Cognitive Activation Method (CAM) was applied. A paired samples *t*-test was conducted to examine whether the academic achievement of students changed over time. The retention test scores (M = 79.37, SD = 11.118) were slightly higher than the posttest scores (M = 77.30, SD = 11.818), *t* (29) = 1.247, *p* = .222 > .0033 (Bonferroni-adjusted alpha), indicating no statistically significant difference between the two test scores. This data clarifies that, there is no significant difference between the posttest and retention test scores of the experimental group. Therefore, the null hypothesis stating, "There is no significant difference between the posttest and retention test scores of the experimental group" is accepted.

4.18 Analysis Related to Hypothesis (H_{015})

Table 4.18

Comparison between the results of retention test of control and experimental group

Test	Group	Mean	*M*	*SD*	*Df*	*t*	*P*

Retention	Experimental	30	79.37	11.118	58	7.958	.001
	Control	30	61.13	11.153			

N=60

Table 4.18 presents the comparison between the retention test scores of the experimental and control groups. An independent samples *t*-test was conducted to determine whether there was a significant difference in retention levels between the two groups. The experimental group (M = 79.37, SD = 11.118) scored higher than the control group (M = 61.13, SD = 11.153), t (58) = 7.958, p = .001 < .0033 (Bonferroni's-adjusted alpha), indicating a statistically significant difference in retention scores. This data indicates that, there is a significant difference between the retention level of the experimental and control groups. These results advocate that students in the experimental group retained their learning more effectively over time compared to those in the control group. Therefore, the null hypothesis stating, "There is no significant difference between the retention level of the experimental and control groups" is rejected.

4.19 Practical Implications of the Cognitive Activation Method

The statistical findings of this research indicate that the Cognitive Activation Method (CAM) has a notable positive impact on students' academic achievement in General Science, especially for low and medium achievers. Beyond numerical significance, these outcomes carry meaningful implications for educational practice. For teachers, CAM offers a structured approach that promotes deeper engagement with content. Starting lessons with thought-provoking questions or real-world phenomena (Step A1) helps capture students' attention and stimulates curiosity. Encouraging students to ask their own questions (A2) and responding with open-ended, thought-provoking prompts (A3) supports higher-order thinking rather than rote learning. This method enables learners to become more active participants in the classroom.

The second phase of CAMfocuses on activating prior knowledge, encouraging in-depth discussion, and introducing cognitive conflict, helps students connect new information with existing understanding. When students are prompted to justify their reasoning (B2) or are presented with unexpected outcomes (B3), it leads to critical reflection and restructuring of knowledge. This route deepens comprehension and makes learning more meaningful.

Instructional dialogue, the final phase of CAM, encourages collaborative learning. When teachers facilitate peer interaction and discussion of errors (C1, C2), students are given opportunities to learn from one another and view mistakes as learning opportunities. This scheme creates a supportive classroom climate where inquiry, dialogue, and exploration are central. In conclusion, the study not only confirms the statistical effectiveness of CAM but also highlights its educational value. By fostering critical thinking, deeper learning, and student engagement, CAM provides a pedagogically sound alternative to traditional teaching approaches.

4.20 Summary

Overall, the results confirmed that CAM had a statistically and practically significant effect on students' academic achievement, especially for low and medium achievers, while its impact on higher achievers was comparable to the Lecture Method. These findings align with the study's research questions by demonstrating the effectiveness of CAM in improving and sustaining learning outcomes at the elementary level.

Table 4.19

Summary of the results

No.	Hypotheses	Results
H_01	There is no significant effect of Cognitive Activation Method on the academic achievement of elementary level students in General Science	Rejected
H_02	There is no significant effect of Lecture Method on the Academic Achievement of elementary level students in General Science	Rejected
H_03	There is no significant effect of Cognitive Activation Method on the academic achievement of lower achievers in General Science.	Rejected
H_04	There is no significant effect of Cognitive Activation Method on the academic achievement of medium achievers in General Science.	Rejected
H_05	There is no significant effect of Cognitive Activation Method on the academic achievement of higher achievers in General Science.	Rejected

$H_0$6	There is no significant effect of Lecture Method on the academic achievement of lower achievers in General Science.	Rejected
$H_0$7	There is no significant effect of Lecture Method the academic achievement of medium achievers in General Science.	Rejected
$H_0$8	There is no significant effect of Lecture Method on the academic achievement of higher achievers in General Science.	Rejected
$H_0$9	There is no significant difference between the effect of Cognitive Activation Method and Lecture Method on the academic achievement of lower achievers in General Science	Rejected
$H_0$10	There is no significant difference between the effect of Cognitive Activation Method and Lecture Method on the academic achievement of medium achievers in General Science	Rejected
$H_0$11	There is no significant difference between the effects of Cognitive Activation Method and Lecture Method on the academic achievement of higher achievers in General Science	Accepted
$H_0$12	There is no significant difference between the effects of Cognitive Activation Method and Lecture Method on the academic achievement of elementary level students in General Science	Rejected
$H_0$13	There is no significant difference between the academic achievements of the students of control group in posttest and retention test.	Accepted
$H_0$14	There is no significant difference between the academic achievements of the students of experimental group in posttest and retention test.	Accepted
$H_0$15	There is no significant difference between the academic achievements of control and experimental group in retention test.	Rejected

CHAPTER 5

SUMMARY, FINDINGS, DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The focus of the current study was to investigate the effect of Cognitive Activation Method (CAM) on the academic achievement of elementary level students in General Science.The objectives of the study were (i) to determine the effect of Lecture Method on the academic achievement of elementary level students in General Science, (ii) to examine the effect of Cognitive Activation on the academic achievement of elementary level students in General Science, (iii) to compare the effect of Lecture Method and Cognitive Activation Method on the academic achievement of elementary level students in General Science, (iv) to determine the effect of Lecture Method on the academic achievement of lower, medium and higher achievers in General Science, (v) to examine the effect of Cognitive Activation Method on the academic achievement of lower, medium and higher achievers in General Science, (vi) to compare the effect of Lecture Method and Cognitive Activation Method on the academic achievement lower, medium and higher achievers in General Science, (vii) to compare the retention level of elementary level students in General Science treated with Cognitive Activation Method and Lecture Method. The study was true experimental and sixty-three (63) students of grade 8, studying in Government Boys Elementary School Palhatar, were the accessible population of the study. Simple Random sampling technique was used to select sixty (60) students as sample of the study. Pretest was conducted, and on the bases of the marks of pretest, the students were divided into two equivalent groups. Thirty (30) students were placed in control group and 30 were placed in experimental group. The students of control group were treated though Lecture Method (LM) whereas the students of experimental group were instructed through Cognitive Activation Method. Posttest was administered after the treatment of eight weeks. The data were analyzed by using SPSS 25 version. Descriptive Statistics (Mean and Standard Deviation) were used to evaluate academic achievements of the students in General Science, whereas inferential statistics (t-test and Partial Eta Squared test) were used to compare the effect of CAM and LM.

5.2 Findings

It was found that;

1. Before the instructional intervention, students in both the control and experimental groups demonstrated comparable academic achievement in General Science. The pretest results reflect the baseline performance of the groups prior to the application of different teaching methods: the Lecture Method (LM) for the

control group and the Cognitive Activation Method (CAM) for the experimental group. This finding indicates that both groups started at an equivalent level of academic performance, providing a fair basis for comparison of the effects of the teaching methods. Descriptive statistics showed that the control group (N = 30) obtained a mean score of 33.27 (*SD* = 10.044, *SEM* = 1.834), while the experimental group (*N* = 30) achieved a mean score of 32.00 (*SD* = 9.660, *SEM* = 1.764 (Table 4.1).

2. After the instructional intervention, students in both the control and experimental groups demonstrated measurable academic achievement in General Science. The post-test results reflect the outcomes following the application of different teaching methods: the Lecture Method (LM) for the control group and the Cognitive Activation Method (CAM) for the experimental group. This finding indicates that both instructional approaches led to observable learning gains among elementary-level students. The post-test performance provides a basis for further analysis of the relative effectiveness of these methods. Descriptive statistics showed that the control group (*N* = 30) obtained a mean score of 59.70 (*SD* = 10.212, *SEM* = 1.864), while the experimental group (*N* = 30) achieved a mean score of 78.70 (*SD* = 11.818, *SEM* = 2.158 (Table 4.2).
3. Control and experimental groups were academically equivalent prior to the application of the instructional methods. The absence of a statistically significant difference at the baseline establishes a sound foundation for the experimental design and enhances the internal validity of the study. This equivalence ensures that any subsequent variation in posttest performance can be reasonably attributed to the instructional intervention, specifically the implementation of the Cognitive Activation Method (CAM) in the experimental group, rather than to pre-existing academic disparities. Statistical analysis confirmed this equivalence: the control group (*N* = 30) obtained a mean score of 33.27 (*SD* = 10.444), while the experimental group (*N* = 30) recorded a mean score of 32.00 (SD = 9.660). The results of the independent samples *t*-test, t (58) = .498, p = .933 > .0033 (Bonferroni's-adjusted alpha), indicated no statistically significant difference between the two groups at the pretest stage (Table 4.3).
4. The academic achievement of students in the control group significantly improved following instruction through the Lecture Method (LM). This increase in scores

demonstrates that the traditional lecture-based instructional approach also had a positive impact on student learning in General Science, though the magnitude of improvement should be evaluated relative to alternative methods. The statistically significant rise between pretest and posttest scores indicates that LM effectively enhanced students' academic performance over the course of the study. This improvement is supported by both statistical and practical significance. Approximately 38.4% of the variance in academic achievement can be attributed to the Lecture Method, reflecting a large effect size. These results validate the effectiveness of LM as an instructional approach, yet they set a benchmark for comparison with the Cognitive Activation Method (CAM) used in the experimental group. Statistical analysis confirmed this effect: the control group's mean score increased from 44.83 (*SD* = 19.673) at pretest to 59.70 (*SD* = 10.212) at posttest. The paired samples t-test indicated a statistically significant difference, t (29) = 5.360, $p < .001 < .0033$ (Bonferroni's-adjusted alpha). The partial eta squared value ($\eta p^2 = .384$) further indicates a large effect size according to conventional benchmarks: small = .01, medium = .06, large = .14 (Table 4.4).

5. The academic achievement of students in the experimental group significantly improved after receiving instruction through the Cognitive Activation Method (CAM). This notable increase in performance provides strong evidence of the effectiveness of CAM in enhancing students' understanding and retention of General Science concepts. The substantial difference between pretest and posttest scores advocates that the intervention had a meaningful and educationally important impact on student learning outcomes. This improvement is not only statistically significant but also practically significant. Approximately 41.7% of the variance in academic achievement can be attributed to the effect of CAM, indicating a large effect size. These results directly support the research hypothesis and demonstrate that CAM is a highly effective instructional approach for improving academic achievement among elementary-level students. Statistical analysis confirmed this outcome: the pretest score of the experimental group (N = 30) were 32.00 (*SD* = 9.660), which increased to a posttest mean of 78.70 (*SD* = 11.818). The results of the paired samples t-test showed a statistically significant difference, t (29) = 21.079, $p < .001 < .0033$ (Bonferroni's-adjusted alpha). The

partial eta squared value (*ηp²* = .417) indicates a large effect size according to benchmarks: small = .01, medium = .06, large = .14 (Table 4.5).

6. The academic achievement of elementary-level students in the experimental group, taught through the Cognitive Activation Method (CAM), significantly improved compared to their counterparts in the control group who received instruction via the Lecture Method (LM). This substantial increase in posttest scores indicates that CAM had a stronger positive impact on students' learning outcomes in General Science. Statistical analysis confirmed this effect: the mean posttest score for the experimental group was 78.70 (*SD* = 11.818), whereas the control group scored 59.70 (*SD* = 10.212). The independent samples t-test revealed a statistically significant difference between the groups, *t* (58) = 8.594, p = .001 < .0033 (Bonferroni's-adjusted alpha). Approximately 34.7% of the variance in academic achievement can be attributed to the difference in teaching methods. These findings highlight the strong practical significance of CAM over LM in enhancing academic performance among elementary students. Additionally, the partial eta squared (*ηp²* = .347) indicates a large effect size according to conventional benchmarks: small = .01, medium = .06, large = .14 (Table 4.6).
7. The academic achievement of lower achievers in the control group significantly improved following instruction through the Lecture Method (LM). This notable increase in scores indicates that even students with initially lower performance benefitted meaningfully from the traditional lecture-based instructional approach in General Science. The statistically significant rise between pretest and posttest scores demonstrates that LM effectively enhanced the academic performance of lower achievers. This improvement is supported by both statistical and practical significance. Approximately 31.8% of the variance in academic achievement among lower achievers can be attributed to LM, reflecting a large effect size and highlighting the practical impact of the intervention. Statistical analysis confirmed this effect: the mean score of lower achievers increased from 20.25 (SD = 5.148) at pretest to 48.25 (*SD* = 3.059) at posttest. The paired samples t-test indicated a statistically significant difference, *t* (7) = 33.991, *p*< .001 < .0033 (Bonferroni-adjusted alpha). The partial eta squared value (*ηp²* = .318) further indicates a large

effect size according to conventional benchmarks: small = .01, medium = .06, large = .14 (Table 4.7).

8. The academic achievement of medium achievers in the control group significantly improved following instruction through the Lecture Method (LM). This significant improvement suggests that the traditional lecture-based instructional approach positively influenced the learning outcomes of medium-achieving students in General Science. The statistically significant increase in pretest to posttest scores indicates the effectiveness of LM in enhancing academic performance. This improvement is supported by both statistical and practical significance. Approximately 43.7% of the variance in academic achievement among medium achievers can be attributed to the Lecture Method, reflecting a large effect size and demonstrating the practical impact of the intervention. Statistical analysis confirmed this effect: the mean score increased from 33.93 (*SD* = 4.269) at pretest to 58.00 (*SD* = 4.438) at posttest. The paired samples t-test indicated a statistically significant difference, t (13) = 56.591, $p < .001 < .0033$ (Bonferroni-adjusted alpha). The partial eta squared value (ηp^2 = .437) further indicates a large effect size according to conventional benchmarks: small = .01, medium = .06, large = .14 (Table 4.8).
9. The academic achievement of higher achievers in the control group significantly improved following instruction through the Lecture Method (LM). This marked increase in scores indicates that the traditional lecture-based instructional approach had a strong positive impact on the learning outcomes of higher-achieving students in General Science. The statistically significant difference between pretest and posttest scores demonstrates that LM effectively enhanced academic performance. This improvement is supported by both statistical and practical significance. Approximately 52.1% of the variance in academic achievement among higher achievers can be attributed to the Lecture Method, indicating a very large effect size and highlighting the practical importance of the intervention. Statistical analysis confirmed this effect: the mean score increased from 45.12 (*SD* = 1.553) at pretest to 88.12 (*SD* = 2.748) at posttest. The paired samples t-test indicated a statistically significant difference, t (7) = 92.891, $p < .001 < .0033$ (Bonferroni's-adjusted alpha). The partial eta squared value (ηp^2 =

.521) further indicates a very large effect size according to conventional benchmarks: small = .01, medium = .06, large = .14 (Table 4.9).

10. The academic achievement of lower achievers in the experimental group significantly improved following instruction through the Cognitive Activation Method (CAM). This substantial increase in scores demonstrates that CAM effectively supports students who initially performed at lower levels, highlighting its potential to enhance learning outcomes for students with diverse academic abilities. The marked improvement indicates that CAM can play a crucial role in bridging achievement gaps in General Science education. The statistically significant rise between pretest and posttest scores shows that CAM had a meaningful and positive impact on the academic performance of lower achievers. This improvement is supported by both statistical and practical significance. Approximately 33.3% of the variance in academic achievement can be attributed to the effect of CAM, reflecting a large effect size. These findings confirm the effectiveness of CAM as an inclusive instructional approach that benefits not only average but also lower-performing students. Statistical analysis confirmed this effect: the mean score of the lower achievers increased from 18.75 (*SD* = 4.979) at pretest to 62.88 (*SD* = 6.446) at posttest. The paired samples t-test indicated a statistically significant difference, t (7) = 38.160, $p < .001 < .0033$ (Bonferroni-adjusted alpha). The partial eta squared value ($\eta p^2 = .333$) further indicates a large effect size according to conventional benchmarks: small = .01, medium = .06, large = .14. (Table 4.10).
11. The academic achievement of medium achievers in the experimental group significantly improved following instruction through the Cognitive Activation Method (CAM). This notable increase in performance indicates that CAM is highly effective in enhancing the learning outcomes of students with average prior achievement, helping them to substantially elevate their understanding and mastery of General Science concepts. The statistically significant difference between pretest and posttest scores demonstrates that CAM had a meaningful and educationally important impact on medium achievers. This improvement is supported by both statistical and practical significance. Approximately 45.8% of the variance in academic achievement among medium achievers can be attributed to the effect of CAM, reflecting a large effect size. These findings underscore the

broad applicability and strong effectiveness of CAM across varying student performance levels. Statistical analysis confirmed this effect: the mean score of medium achievers increased from 33.79 (*SD* = 4.388) at pretest to 80.86 (*SD* = 6.383) at posttest. The paired samples *t*-test indicated a statistically significant difference, $t(13) = 60.845$, $p < .001 < .0033$ (Bonferroni-adjusted alpha). The partial eta squared value ($\eta p^2 = .458$) further indicates a large effect size according to conventional benchmarks: small = .01, medium = .06, large = .14 (Table 4.11).

12. The academic achievement of higher achievers in the experimental group significantly improved following instruction through the Cognitive Activation Method (CAM). This substantial increase in scores highlights the effectiveness of CAM in further advancing the knowledge and performance of already high-performing students in General Science. The statistically significant difference between pretest and posttest scores demonstrates that CAM had a profound and educationally meaningful impact on the learning outcomes of higher achievers. This improvement is supported by both statistical and practical significance. Approximately 50.0% of the variance in academic achievement among higher achievers can be attributed to CAM, indicating a very large effect size. These findings illustrate that CAM is capable of fostering excellence and deeper understanding even among students with higher initial achievement levels. Statistical analysis confirmed this effect: the mean score of higher achievers increased from 42.12 (*SD* = 1.356) at pretest to 91.19 (*SD* = 1.458) at posttest. The paired samples t-test indicated a statistically significant difference, $t(7) = 149.687$, $p < .001 < .0033$ (Bonferroni's-adjusted alpha). The partial eta squared value ($\eta p^2 = .500$) further indicates a very large effect size according to conventional benchmarks: small = .01, medium = .06, large = .14 (Table 4.12).
13. The academic achievement of lower achievers in the experimental group significantly exceeded that of their counterparts in the control group following instruction through the Cognitive Activation Method (CAM). This marked difference in posttest scores indicates that CAM had a stronger positive impact on the learning outcomes of lower-achieving students in General Science compared to the traditional Lecture Method (LM). Statistical analysis confirmed this effect: the mean score of lower achievers in the experimental group was 62.88 (*SD* = 8.446), while in the control group it was 48.25 (*SD* = 3.059). The independent

samples t-test indicated a statistically significant difference, $t(14) = 11.544$, $p = .002 < .0033$ (Bonferroni-adjusted alpha). Approximately 21.7% of the variance in academic achievement among lower achievers can be attributed to the difference in teaching methods. This highlights the practical significance and superiority of CAM over LM for enhancing the academic achievement of lower achievers in General Science. The partial eta squared value ($\eta p^2 = .217$) further indicates a large effect size according to conventional benchmarks: small = .01, medium = .06, large = .14 (Table 4.13).

14. The academic achievement of medium achievers in the experimental group significantly surpassed that of their counterparts in the control group following instruction through the Cognitive Activation Method (CAM). This substantial difference in posttest scores indicates that CAM had a more pronounced positive impact on the learning outcomes of medium-achieving students in General Science compared to the traditional Lecture Method (LM). Statistical analysis confirmed this effect: the mean score of medium achievers in the experimental group was 80.86 ($SD = 6.383$), whereas in the control group it was 58.00 ($SD = 9.811$). The independent samples t-test indicated a statistically significant difference, $t(26) = 33.702$, $p < .001 < .0033$ (Bonferroni's-adjusted alpha). Approximately 28.7% of the variance in academic achievement among medium achievers can be attributed to the difference in teaching methods. This highlights the practical significance and superiority of CAM over LM in enhancing academic achievement for medium achievers in General Science. The partial eta squared value ($\eta p^2 = .287$) further indicates a large effect size according to conventional benchmarks: small = .01, medium = .06, large = .14 (Table 4.14).
15. The academic achievement of higher achievers in the experimental group, taught through the Cognitive Activation Method (CAM), did not significantly differ from that of higher achievers in the control group who received instruction via the Lecture Method (LM). Although the mean posttest score for the experimental group was slightly higher ($M = 91.12$, $SD = 1.458$) compared to the control group ($M = 88.12$, $SD = 2.748$), the difference was not statistically significant. The independent samples t-test showed $t(14) = 4.583$, $p = .081 > .0033$ (Bonferroni's-adjusted alpha). Approximately 0.2% of the variance in academic achievement among higher achievers can be attributed to the difference in teaching methods.

This suggests that both CAM and LM were similarly effective for higher achievers in General Science. Furthermore, the partial eta squared ($\eta p^2 = .002$) indicates a negligible effect size according to conventional benchmarks: small = .01, medium = .06, large = .14 (Table 4.15).

16. The academic achievement of students in the control group did not significantly differ between the posttest and retention test scores following instruction through the Lecture Method (LM). This indicates that students effectively retained their learning over time, with no significant decline in performance. The mean retention test score was 61.13 (*SD* = 10.494), compared to a mean posttest score of 59.77 (*SD* = 10.180). The paired samples t-test showed no statistically significant difference between the two test scores, $t\ (29) = 1.681$, $p = .103 > .0033$ (Bonferroni's-adjusted alpha). These results suggest stable academic performance over the retention period (Table 4.16).
17. The academic achievement of students in the experimental group did not significantly differ between the posttest and retention test scores following instruction through the Cognitive Activation Method (CAM). This indicates that students effectively retained their learning over time, with no significant decline in performance. The mean retention test score was 79.37 (S*D* = 11.118), compared to a mean posttest score of 77.30 (*SD* = 11.818). The paired samples *t*-test showed no statistically significant difference between the two test scores, $t\ (29) = 1.247$, $p = .222 > .0033$ (Bonferroni's-adjusted alpha). These results suggest stable academic performance over the retention period (Table 4.17).
18. The retention test scores of students in the experimental group were significantly higher than those of students in the control group, indicating better retention of learning following instruction through the Cognitive Activation Method (CAM). Statistical analysis confirmed this effect: the mean retention score for the experimental group was 79.37 (*SD* = 11.118), compared to 61.13 (*SD* = 11.153) for the control group. The independent samples t-test revealed a statistically significant difference between the two groups, $t\ (58) = 7.958$, $p < .001 < .0033$ (Bonferroni's-adjusted alpha). These results demonstrate the superior effectiveness of CAM over the Lecture Method in promoting long-term retention of academic content. Approximately 28.4% of the variance in retention scores is attributable to the difference in teaching methods. Furthermore, the partial eta

squared value (ηp^2 = .284) indicates a large effect size according to conventional benchmarks: small = .01, medium = .06, large = .14 (Table 4.18).s

5.3Discussion

This study aims to compare the effect of two teaching methods: Cognitive Activation Method and Lecture Method on the academic performance of elementary school students. The study was conducted under controlled conditions, where the researchers attempted to manage the threat of external variables.

The first objective of the study was to determine the effect of Lecture Method on the academic achievement of elementary level students in General Science. It was evaluated that academic achievement was significantly affected by the strategies of Lecture Method. Numerous studies have been conducted around the world to evaluate the impact of Lecture Method on student academic performance.

Another study was conducted by Lukman (2022), Department of Science Education, Nigeria Agency for Science and Technology, which explored the effectiveness of lecture and discussion methods in teaching physics in secondary schools. A sample of 48 students was selected using random sampling. The post-test results of both groups were better than the pre-test. It can be seen that both methods are effective in physics teaching, but the discussion method is more effective in physics teaching.

The second objective of the study was to examine the effect of Cognitive Activation Method on the academic achievement of elementary level students in General Science. The results indicated that CAM had a statistically significant positive effect on students' academic performance. This finding aligns with the results of a similar study conducted by Laura (2015) in Colombia, which examined the relationship between cognitive activity and academic achievement among 10th-grade students. The study measured cognitive activity through variables such as attention control, cognitive flexibility, inhibitory control, visual memory, and constructive praxis, while academic performance was assessed using school records. The results revealed a significant relationship between cognitive activity and academic success. Furthermore, the improved academic outcomes observed in the present study can be interpreted through the theoretical lens of active learning and cognitive engagement. CAM encourages learners to participate in higher-order thinking by challenging their prior knowledge, prompting inquiry-based discussion, and engaging them in problem-solving processes. These findings are consistent with international research demonstrating CAM's effectiveness in enhancing achievement and retention across diverse contexts.

According to active learning theory, students retain more information when they are intellectually involved in their own learning process. Similarly, cognitive engagement theory emphasizes the importance of deep mental processing and sustained attention for meaningful learning. Therefore, the significant improvement in academic performance seen in students exposed to CAM can be attributed to the method's ability to promote both active participation and cognitive investment in learning tasks

The third objective of the study was to compare the effect of Cognitive Activation Method and Lecture Method on the academic achievement of elementary level students in General Science. The findings revealed that students instructed with CAM retained significantly more General Science content over time compared to those who experienced traditional lectures.

The results revealed a statistically significant improvement in students' academic performance following the use of CAM, suggesting that cognitively activating instructional strategies contribute positively to student learning. These findings are supported by a study conducted by Yue Qi (2022) at the University of Science and Technology Beijing, which explored the influence of various cognitive abilities such as logical reasoning, information processing, and memory on academic performance. Using structural equation modeling, the study found a strong and positive correlation between cognitive abilities and academic achievement, reinforcing the conclusion that cognitively rich learning environments enhance student outcomes. From a theoretical perspective, this can be explained through the lens of active learning and cognitive engagement theories. CAM incorporates elements such as questioning, conceptual conflict, and student reasoning, which align with constructivist principles and promote deeper processing of content. By engaging students in higher-order thinking and encouraging them to connect new knowledge with prior understanding, CAM not only improves immediate performance but also strengthens their ability to apply and retain knowledge over time. Thus, the effectiveness of CAM in this study may be attributed to its alignment with evidence-based principles of how meaningful and sustained learning occurs.

The fourth objective of the study was to examine the effect of Lecture Method on the academic achievement of lower, medium and higher achievers in General Science. The result of the study indicated that there was a significant effect of Lecture Method on the academic achievement of the elementary level students in General Science. Le (2022) also conducted a similar study. The results showed that the prerecorded teaching format adversely affected the academic performance of students with lower academic ability, whereas students with higher academic ability showed no significant adverse effects of this delivery method. In particular, research shows that lower-ability students (defined as those with GPAs in the lowest 50th percentile at the beginning of the semester) were 1.6 percentage points less likely to answer exam questions accurately after receiving pre-test instruction. This finding highlights the quantifiable deterioration in academic outcomes due to the lecture format adopted.

The fifth objective of the study was to determine the effect of Cognitive Activation Method on the academic achievement of lower, medium and higher achievers in General Science. The results indicated that CAM produced a statistically significant improvement for all three groups. This finding echoes Harrathi and Hached's (2024) study in Oman, in which cognitive activation strategies yielded substantial gains in communication skills among low and medium achievers, though high achievers showed smaller improvements. In our science context, however, even high achievers benefited likely because CAM's blend of scaffold prompts and open‑ended questioning can be finely tuned to each learner's readiness level. According to active learning theory, knowledge retention increases when students are mentally engaged in constructing their own understanding, and cognitive engagement theory emphasizes that deep processing and sustained attention are critical for meaningful learning. CAM enacts these principles by challenging students to link new concepts to prior knowledge, engage in inquiry‑based dialogue, and articulate their reasoning throughout the lesson.

The sixth objective of the study was to compare the effect of Cognitive Activation Method and Lecture Method on the academic achievement lower, medium and higher achievers in General Science. The study revealed that, the Cognitive Activation Method is more effective than Lecture Method for the teaching General Science to the students of elementary level.

Bayona & Duran (2024) conducted an identical study to compare the effects of Lecture Method and cognitive learning strategies on students' academic performance. Results showed that the effectiveness of cognitive learning strategies such as problem-based learning was highlighted, with improvements in higher-order cognitive skills compared to traditional lectures.

The present study provides strong empirical support for the superiority of the Cognitive Activation Method (CAM) over the traditional Lecture Method (LM) in enhancing students' academic achievement and retention. This finding can be explained through the lens of major learning theories. Constructivist perspectives emphasize that knowledge is not passively received but actively built by the learner. Piaget's theory highlights the role of cognitive conflict in restructuring prior knowledge, while Vygotsky underscores the importance of social interaction and scaffolding in advancing higher mental processes. The CAM lessons used in this study incorporated questioning, problem solving, and peer discussion, all of which align closely with these theoretical assumptions. By contrast, LM was limited to transmission of information, which encouraged surface-level memorization rather than meaningful learning.

These outcomes are consistent with both national and international research. In Pakistan, several studies have documented the effectiveness of inquiry-based and activity-oriented strategies in science and mathematics classrooms, reporting improved conceptual understanding and higher achievement scores. Comparable findings have been reported internationally: India's Activity-Based Learning programs have shown similar success in sustaining student engagement and improving learning outcomes, while studies from Nigeria and Latin America confirm that active and participatory teaching methods foster deeper comprehension and retention.

While the majority of studies confirm the effectiveness of CAM, some scholars caution that its benefits may vary across subjects, contexts, or learner readiness. For instance, minimally guided approaches have been criticized for potentially increasing cognitive load in novice learners (Kirschner, Sweller, & Clark, 2006). However, in the present study, the structured scaffolding within CAM mitigated this limitation, balancing guidance with inquiry. Nevertheless, some scholars in advanced contexts have argued that minimally guided approaches can overwhelm learners' cognitive load. The structured design of CAM used in this study, however, offered sufficient scaffolding to avoid such pitfalls, thereby balancing guidance with active participation.

The subgroup analysis further enriches the interpretation of findings. Low achievers showed the greatest improvement under CAM, suggesting that cognitively activating strategies provide essential support for learners who often struggle in traditional lecture settings. Middle achievers also benefited substantially, while high achievers recorded smaller relative gains, possibly because they already possessed effective learning strategies. This pattern highlights the equity potential of CAM: it not only raises overall achievement but also reduces performance gaps among students of different ability levels.

Beyond statistical validation, the results carry significant implications for teaching practice, teacher preparation, and curriculum reform. Pedagogically, the study highlights the need for teachers to move away from teacher-centered delivery towards approaches that promote inquiry, reasoning, and collaborative exploration. Teacher education programs, both pre-service and in-service, may provide systematic training in cognitive activation strategies, with emphasis on questioning techniques, scaffolding, and facilitation of student dialogue. At the curriculum level, reforms should encourage activity-based content and assessment practices that reward critical thinking and problem-solving rather than rote reproduction. If embedded at scale, such reforms have the potential to cultivate higher-order thinking and sustainable learning among elementary students in Pakistan and similar educational contexts.

Theoretically, this pattern aligns with depth of processing theory, which holds that memory retention improves when learners engage in meaningful elaboration, and with cognitive engagement theory, emphasizing the role of sustained mental effort in consolidation. CAM's structured prompts for self-explanation and its iterative revisiting of ideas create the kind of retrieval practice and elaborative rehearsal that cognitive psychologists identify as critical for long-term learning.

The findings of this study are consistent with international research reporting the superiority of cognitively activating strategies over lecture-based methods. For instance, studies from Finland and Singapore demonstrated that inquiry-oriented teaching significantly improved science achievement (Freeman *et al*., 2014). Similarly, Harrathi and Hached (2024) reported substantial benefits of cognitive activation in Oman. However, in contrast to some Western contexts where high achievers showed limited additional benefits from CAM (Kirschner, Sweller, & Clark, 2006), the present study found positive gains across all groups, including higher achievers. At the national level, Pakistani research has largely emphasized activity-based or inquiry-oriented methods (Shah *et al.*, 2012; Salmachanna & Karim, 2023), but few studies have empirically tested CAM. By directly comparing CAM and LM under experimental conditions, this study provides rare local evidence that aligns with global trends while extending them to the elementary science context of Pakistan.

The subgroup analysis revealed that lower achievers (LA) benefited the most from CAM, followed by medium achievers (MA), while higher achievers (HA) showed relatively smaller gains. This pattern can be explained by the “compensatory effect” of cognitively activating strategies. For lower achievers, CAM provided scaffolding, structured questioning, and opportunities for peer discussion, which helped address misconceptions and build confidence. Medium achievers also advanced because CAM encouraged them to justify reasoning and connect prior knowledge with new concepts. For higher achievers, the smaller relative gains may be attributed to a “ceiling effect,” as these students’ already possessed effective learning strategies and required more advanced cognitive challenges to show substantial improvement. Nevertheless, the positive effects across all subgroups indicate that CAM not only raises overall performance but also reduces achievement gaps, highlighting its potential as an equitable instructional approach.

5.4 Limitations of the study

Despite these positive outcomes, the study has certain limitations that should be acknowledged. The research was conducted in a single boys’ elementary school with a relatively small sample size of 60 students, which restricts the generalizability of the results to wider populations, particularly mixed-gender or urban schools. Furthermore, the focus on Grade 8 General Science and the limited eight-week intervention period mean that the findings may not fully capture long-term effects or applicability across other subjects and grade levels. These constraints should be kept in mind when interpreting the results, and they provide important directions for future research.

5.5 Conclusions

On the basis of the findings, it is concluded that;

1. Lecture Method has significant effect on the academic achievement of elementary level students in General Science.
2. Cognitive Activation Method has significant effect on the academic achievement of elementary level students in General Science.
3. The effect of Cognitive Activation Method is significantly higher than the effect of Lecture Method on the academic achievement of elementary level students in General Science.
4. The effect of Cognitive Activation Method is significantly higher than the effect of Lecture Method on the academic achievement of lower achievers in General Science.
5. The effect of Cognitive Activation Method is significantly higher than the effect of Lecture Method on the academic achievement of medium achievers in General Science
6. The effect of Cognitive Activation Method is slightly higher than the effect of Lecture Method on the academic achievement of higher achievers in General Science.
7. Both the Lecture Method and the Cognitive Activation Method enabled students to retain their learning; however, the retention level of students taught through the Cognitive Activation Method was significantly higher than that of those taught through the Lecture Method

5.6 Recommendations

The present study concluded that that the Cognitive Activation Method (CAM) produced significantly higher academic achievement and retention level compared to the Lecture Method (LM). In light of these conclusions, the following recommendations are proposed for teachers, students, teachers' training institutes, curriculum developers, policymakers, and future researchers:

5.6.1 Recommendations for Teachers

1. It is concluded that the strategies of the CAM are more effective than the strategies of the lecture Method for the teaching of General Science, so it is recommended that, the teachers may intentionally include challenging and thought-provoking tasks at the beginning of lessons to stimulate curiosity and engage learners cognitively from the beginning. It is also recommended that the teachers may provide students with adequate time and space to pose their

own questions, thereby fostering inquiry and ownership of the learning process. Furthermore, it is recommended that, the teachers may ask cognitively activating questions that go beyond recall, avoid yes/no responses, and require learners to explain, justify, and reflect on their reasoning.

2. It is concluded that the strategies of CAM are more effective than the strategies included in the LM, so it is recommended that the teachers may actively elicit students' prior knowledge and assumptions at the start of the new lesson by encouraging them to share their initial ideas, intuitions, or doubts. This practice not only values learners' voices but also provides teachers with diagnostic insights into students' thinking rather than just the rote memorization assessment of the students. To create in-depth learning opportunities, teachers may consistently ask students to explain how they arrived at particular answers and to justify their reasoning, thereby deepening conceptual understanding. Furthermore, teachers may purposefully introduce cognitive conflicts by presenting facts, experiments, or real-life examples that contradict students' expectations. By confronting misconceptions in this constructive way, teachers may guide learners toward conceptual change and higher-order reasoning.
3. It is concluded that the third strategies of the Cognitive Activation Method are more effective than the strategies of LM, so it is recommended that the teachers may deliberately create opportunities for instructional dialogue by encouraging learners to share, compare, and build on each other's ideas during classroom discussions. Furthermore, it us recommended that, the teachers may sight student errors as valuable learning resources rather than faults. The teachers may use the faults to spark the discussion, clarify misconceptions, and promote deeper understanding of the lesson.

5.6.2 Recommendations for the students

1. As the strategies of the CAM significantly affected academic achievement and retention level of the elementary level students and the participation of the students in the lesson is the key component of the CAM. So it is recommended that the students may take initiative in asking their own questions and exploring different perspectives, rather than relying solely on the teacher's explanations. By doing so, they develop curiosity, ownership of learning, and

readiness for deeper inquiry, which ultimately results into the achievement of the desired learning outcomes.

2. Being most important phase of CAM “Prior Knowledge, In-depth Learning, and Cognitive Conflicts” plays a vital role in the execution of the CAM. Therefore it is recommended that, the students may openly share their assumptions, prior knowledge, and alternative ideas during discussions. It is recommended that the students may justify their answers, explain the reasoning behind their choices, and remain open to reconsidering their views when confronted with new evidence or contradictions.
3. The instructional dialogue is the main phase of the CAM in which teacher and students share their views, teacher picks misconceptions and takes them for the further course of the lesson. Therefore, it is recommended that, the students should participate in peer discussions and collaborative exchanges, carefully listening to and reflecting on the viewpoints of others. It is recommended that the students may treat the mistakes of the others and their own not as a failure but as the opportunities for better learning. It is recommended that the students may engage themselves constructively in dialogue and reflecting on errors to strengthen their ability to think critically, refine ideas, and retain knowledge more effectively.

5.6.3 Recommendations for Teachers’ Training Institutes

1. The present study concluded that the Cognitive Activation Method (CAM) was more effective than the Lecture Method (LM) in enhancing students’ achievement and retention; therefore, it is recommended that teacher training institutions formulate structured training modules that emphasize the practical use of CAM in classroom teaching. These modules should go beyond theoretical orientation and provide teachers with opportunities to practice and reflect on instructional strategies consistent with the phases of CAM. The content of such training may include:
    a. The designing of the challenging questions to spark curiosity
    b. Scaffolding reasoning and exploring prior knowledge
    c. Facilitating peer dialogue, and addressing misconceptions through cognitive conflict.

2. It is recommended that such modules may be the part of both pre-service teacher education programs (B.Ed) and in-service professional development initiatives, including CPD and workshops organized by the Provincial Institutes of Teacher Education (PITE).

5.6.4 Recommendations for the curriculum developers

1. The adoption of CAM requires parallel adjustments in curriculum design, therefore it is recommended that the curriculum developers may embed "cognitively challenging tasks, inquiry-based activities, and open-ended questions" into science textbooks and learning materials.
2. It is also recommended that the assessment models within the curriculum may also be revised to reward higher-order thinking and reasoning rather than rote memorization in order to align the implementation of CAM in a more practical essence
3. It is recommended that the curriculum developers of the teachers training programs may design curricula that contain structured phases of cognitive activation, such as activating prior knowledge, challenging students with conceptual conflicts, and promoting instructional dialogue into pre-service and in-service training.
4. It is recommended that the curriculum developers may integrate existing curriculum with cognitive engagement, reasoning ability, and critical thinking.
5. It is recommended that the curriculum developers of teachers training programs may include guiding prompts, sample cognitively activating questions, and classroom activities designed to promote the stages of Cognitive Activation Method.
6. It is recommended that the curriculum developers of teachers training programs may integrate formative assessments that measure cognitive engagement, critical thinking, and problem-solving skills instead of rote learning.
7. It is recommended that curriculum developers may embed cognitively challenging tasks and inquiry-based activities into science textbooks, and provide teacher guides with sample CAM lesson plans, questioning techniques, and assessment rubrics.

5.6.5 Recommendations for Policymakers

1. It is recommended that the policymakers may provide "systemic support" for innovative methods like CAM by including them in teacher performance standards, allocating resources for teacher training workshops, and integrating them into national education reforms.
2. It is recommended that the Incentive structures for schools that successfully adopt student-centered pedagogies could further encourage the shift. At a broader level, the Ministry of Education and provincial education boards may recognize CAM as a viable pedagogical approach in official policy frameworks.
3. It is recommended that the policymakers may prioritize professional development initiatives that equip teachers with skills to implement cognitively activating instructional strategies in line with modern learning theories.
4. It is recommended that the policymakers may ensure the resource allocation such as such as problem-based learning kits, digital simulations, and peer collaboration platforms.
5. It is recommended that national assessments scheme may be modify to measure deep understanding and application of knowledge, not just rote memorization, thereby aligning evaluation systems with cognitively activating teaching.

5.6.6 Recommendations for the future researchers

1. The current study was conducted to find out the effect of Cognitive Activation Method on the academic achievement of elementary level students in General Science, the future researchers may conduct the research in order to find out the impact of CAM on students' scientific attitudes, critical thinking abilities, or collaborative problem-solving skills at secondary and higher-secondary levels.
2. It is recommended that the future researchers may conduct longitudinal studies to assess the long-term impact of CAM on knowledge retention, motivation, and transfer of learning in diverse classroom contexts.
3. It is recommended that the future researchers may test the effectiveness of CAM in mixed-gender and urban school contexts to examine its applicability across diverse settings.

5.6.7 Practical Plan for Implementation

1. To implement the recommendations effectively, teachers may begin by integrating CAM strategies gradually into their daily lessons, starting with simple cognitive-activating questions and structured peer discussions.
2. Training sessions and workshops may provide hands-on practice with scaffolding techniques, real-life examples, and formative assessments.
3. Curriculum developers can support this by embedding inquiry-based tasks, open-ended questions, and sample lesson plans aligned with CAM principles
4. Policymakers should ensure the availability of teaching resources, digital tools, and continuous professional development programs to sustain the adoption of CAM.
5. Regular monitoring, feedback, and reflective teaching practices will help in fine-tuning the implementation for consistent improvement in student learning outcomes.