EFFECT OF 4MAT TEACHING CYCLE ON THE ACADEMIC ACHIEVEMENT OF THE STUDENTS AT SECONDARY SCHOOL LEVEL IN BALUCHISTAN

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Dedicated

To

My Parents and my Respected Teachers

SUPERVISOR'S CERTIFICATE

The thesis titled "Effect of 4MAT Teaching cycle on the Academic Achievement of the Students at Secondary School Level in Baluchistan" submitted by Mr. Riaz Ahmed Panezai, Reg. No. 119-FSS/PHDEDU/S15 is partial fulfilment 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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APPROVAL SHEET

EFFECT OF 4MAT CYCLE ON THE ACADEMIC ACHIEVEMENTS OF THE STUDENTS IN THE SUBJECT OF BIOLOGY AT SECONDARY LEVEL IN BALUCHISTAN

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AUTHOR'S DECLARATION

I, Riaz Ahmed Panezai, Reg. No. 119-FSS/PHDEDU/S15 as a student of PhD in Education at International Islamic University, Islamabad do hereby declare that the thesis entitled "Effect of 4MAT Teaching cycle on the Academic Achievement of the Students at Secondary School Level in Baluchistan", submitted for the partial fulfilment of PhD in 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 researchers for obtaining and degree from this or any other university or institutions.

Riaz Ahmed Panezai

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Abstract

Instruction plays vital role in the process of teaching and learning. In the modern era evidence of paradigm shift moves the focus of the entire education process to the learning of the students. It does not matter how the teacher is teaching; how the students are learning is important. Student engagement in the classroom and enhancement of their learning is still huge challenge before the teachers. Teaching strategy and learning styles are the most crucial topics of education. How student learn is still an immense challenge before the educationalist. The purpose of this research study is to investigate the effect of 4 MAT Cycle on the academic achievements of the biology students at secondary level in Baluchistan. The study consists of 5 Research Questions and 3 Research Hypotheses. True Experimental Design was selected for the study specifically Pre-test Post-test control group design. The study take place in Tehsil Karazat District Pishin. The population size of the study is all the students of the 9th class study the subject Biology. The sample was drawn using random sampling technique. Two groups were used in the study control and experimental group. 4 MAT Cycle was used in experimental group while traditional lecture method was used in control group. The study consists of 72 students. The experiment was lasted for eight weeks. A Subject Achievement Test was used as instrument for both the groups in the study. The same test was used as pre-test for both the groups. Research questions were answered using mean and standard deviation. T Test was used and Hypotheses were tested. The same Subject Achievement Test (SAT) with reshuffled version was used after three months to investigate the retention level of the students in both the groups in the subject concern. The major conclusion of the study was aboutthe effect of 4 MAT cycle on students' academic achievement in biology at secondary level. From the findings it was revealed that the experimental group achieved significantly better in the post-test as compared to the pre-test. It was concluded that the students at secondary level can be developed in learning by applying 4 MAT cycle model in the class room and the effect of traditional teaching method on students' academic achievement in biology at the secondary level. It was concluded that the achievement scores through traditional teaching methods in control group indicated the significant difference of scores before and after the different classroom strategies. The significant difference in the scores of the pre-test and the post-test confirms that students achieved significantly in the post-test. The major recommendations of the study were that teachers at the secondary level should be equipped with 4 MAT cycle teaching method to apply these skills in the classroom. Moreover, it is recommended that the content of this teaching method may be included in the pre-service as well as in-service teachers' training. Teachers should links the concept of the lesson and capture students attention, teacher may ask learners to think about the experience and share it with others, immediate reflection from teacher, may give information and say students to practice and teacher guide, analyse and encourage the practice and creativity of students. The Provincial Institute for Teacher Education (PITE) Baluchistan is recommended to develop module of 4 MAT cycle for teacher training. The subject content should be developed based on 4 MAT cycle of teaching method so that the students can follow it automatically. The assessment exercises in the textbooks should reflect all the steps of 4MAT cycle of

teaching method of the learners that may affect the educational achievement of the students. Such type of recommendations can be achieved by professional development of curriculum developers and text book writers. The Text Book Board Baluchistan would need to be responsible for implementation

LIST OF ABBREVIATIONS

4MAT	Four Mode Application Technique
ANOVA	Analysis of Variance
BCSEA	Bhutan Council of School Examination and Assessment
MANOVA	Multivariate Analysis of Variance
LTM	Learning Type Measure
SAT	Subject Achievements Tests
SPSS	Statistical Package for Social Sciences
STEM	Science, Technology, Engineering and Mathematics
TSI	Teaching Style Inventory
UK	United Kingdom
USA	United State of America

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

Biology is the essential subject of science education at secondary level because it occupies unique position in curriculum of secondary education at school level and it is also called science of life. It is significant to achieve national curriculum objectives regarding biology. Teaching learning process is essential regarding the achievements of such goals. This will help the students to construct their own views and knowledge and will be in position to apply the knowledge in daily life. Cainc (2002) stated that it is essential for teacher to organize classroom in such a way where activity plays major role in that classroom. Such activity based teaching will help students to construct their own knowledge and understanding through interaction with environment around them. Studies have shown that effective instructional strategies have not been used in the subject of biology and resultantly students cannot develop their own knowledge in real life (Nwagbo, 2011).

Agame (2010) further stated that in most of secondary schools teacher use inappropriate instructional method and students are confined to text book taking notes and memorization of the fact. Conventional lecture method does not allow the learner to play active role in class and construct their own knowledge. In most traditional classrooms, teacher does not focus individual and attention of students is not drawn to the subject. In traditional classroom students easily learn more concrete and less abstract subjects (Baki, 2002). All students in classroom are not equal, they are form different perspective and different cultural backgrounds. They have different intelligent quotients, hence cannot be treated equally. Since 1940 different models of

learning styles have been presented across world. Each model emphasizes on several domains e.g. cognitive, effective, and psychological domains. The cognitive domain emphasizes perception and operation of knowledge (Cornet, 1983). How individual learn, what are differences between individuals and what kind of instruction will be appropriate for what kind of individual, if this is determined that students will learn easily. In such situation it will be easy for the teacher to manage everything. Different studies have proven that when teacher strategy match learning style that optimizes learning of students (Scales, 2000). 4MAT is four Mode Application Technique used to facilitate every learner in classrooms. 4MAT Cycle will be effective in this regard specially to facilitate the individuals in classrooms.

4MAT cycle was developed by Brince McCarthy (1981). The model is based upon experiential learning theory and learning theory of David Kolb (1984). Kolb's theory was based on experiential learning and work of Dewey, Lewin, Piaged and Vygotsky. Kolb has divided his theory in four styles. At the same time, McCarthy was influenced by these studies and developed his own Model. The Model is called 4 MAT Cycle and the model consists of eight stages. All the stages are interconnected and moving in loop. McCarthy classified the learning styles as Innovative Learners, Analytic Learners, Common Sense Learners, Dynamic Learners (Ojure, 1997).

1.2 McCarthy Classification the Learner

Type 1: Innovative Learners are primarily interested in personal meaning. They need to have reasons for learning--ideally, reasons that connect new information with personal experience and establish that usefulness information in daily life. Few of the instructional modes which are effective with this learner type are cooperative learning, brainstorming, and integration of content areas.

Type 2: Analytic Learners are primarily interested in acquiring facts in order to deepen their understanding of concepts and processes. They are capable of learning effectively from lectures, and enjoy independent research, analysis of data, and hearing what "the experts" have to say.

Type 3: Common Sense Learners are primarily interested in how things work; they want to "get in and try it." Concrete, experiential learning activities work best for them as they manipulate, hands-on tasks, kinaesthetic experience, etc.

Type 4: Dynamic Learners are primarily interested in self-directed discovery. They rely heavily on their own intuition, and seek to teach both themselves and others. Any type of independent study is effective for these learners. They also enjoy simulations, role play, and games.

McCarthy further defined the learning theory of David Kolb that consists of four styles while 4MAT Cycle consists of 8 stages well defined and interconnected. McCarthy stated that every individual perceives and processes information in different ways. McCarthy has remarked that individuals perceive and operate the information in different ways. The forms of individuals' perception of the information are their abilities of concrete experiences and abstract conceptualization. In new learning situations, directly concentrating on their concrete experiences, some individuals perceive the information by sensing and feeling. In operation of information, the skills of active experience and reflective observation are significant. Some individuals operate (clusters) information by watching and some of them by doing and applying (Peker, 2003).

In 4MAT Cycle, students move around the loop in specific order. Learning takes place in natural learning process. According to McCarthy, knowledge should be taught to individual in concerned four learning styles. This model facilitates all four

types of learners. Students perceive and process knowledge in different ways. Traditional method could not address all the learners and role of teacher is different in the loop. Teacher play different role at different places.

Brnice McCarthy's 4MAT Cycle provides systematic approach to organize and deliver instruction that addresses the learning style. This instructional design consists of four quadrants each of the quadrants represent one of four major learning styles. The 4MAT Cycle is constructivist model of pedagogy which is interconnected in four essential phases of learning (McCarthy, 1981). McCarthy called his model as "Natural learning cycle" This model moves students through activities appropriate for four types of learners. They progress from experience to abstraction and from experimentation to assimilation. When teacher moves in a circle he uses different instructional strategies. In these instructional strategies teacher provide an opportunity to every individual to perceive and process information. This model encourages the teacher to adopt different roles as motivator, facilitator, information giver and evaluators (McCarthy, 1981).

4 MAT Cycle suggest the teacher that he should design his learning activities in such a way where student take active part and construct his own knowledge. This design will also be helpful for the teacher to design activities. In this design student becomes active learner and construct his own knowledge. This model places the learners in comfortable mode.

1.3 Eight stages of 4 MAT model

Step 1: Connect or create an Experience. This step links the concept of the lesson to the individual in a personal and meaningful way. The teachers will capture students' attention by starting with a situation that is familiar to students and builds on what they already know. Activities for a situation may include sharing personal

reflections and autobiographical information, brainstorming, listening, speaking, mind mapping, drawing, interacting, idea generating, and role-play, etc.

Step 2: Attend or Reflect on an Experience. Teacher can ask learners to think about the experience and share it with others. This step is critical in applying constructivist learning theory in classrooms. Before beginning any new learning, teacher can surface the prior knowledge that students bring with them. To organize effective learning step, it is important to find out what current perception, construction or misconception students bring with them. Teacher must understand what students actually know or think before introducing new learning. Role of teacher in this phase is to guide students to reflection and analysis of the experience in step one. After that, the students share their perceptions and beliefs to create and reinforce the meaning that brings real understanding and the reason to learn.

Step 3: Image or Integrate the Observation into Concepts. Here, teacher synthesizes the reflections from previous personal experience into a visual or poetic image or feeling that links the personal experience to concept under study. Teachers will deepen the connection between concept and its relationship to students' lives and keep relating what students already know about the experts have found. They use another medium to connect the students' personal knowledge to the concept to be taught into an image or experience, a "sneak preview" for the students. Activities may include seeing relationships and connections; patterning; creating analogy, metaphors, and non-verbal or spatial representations; discussing.

Step 4: Inform or Developing Theories and Concepts. Give learners conceptual and factual information from experts. Teachers will provide information related to the concept through lecture, text films, and visual computer-assisted instruction or through charts. They emphasize on the most significant aspects of the concept in an

organized, organic manner and present information sequentially so that the students see continuity.

Step 5: Practice or Using Information Practically. Learners practice using information to see "how it works" in the real world. Teachers will provide hand-on activities for practice and mastery to check understanding of concepts and skills. Activities may include exploring, manipulating, applying the facts and concepts, field and lab work, adapting knowledge to personal use, demonstrations, worksheets, puzzles, diagrams, computer experiments, conversations with peers and instructors.

Step 6: Extend or Integrate Material with Self. The learners add something themselves by extending what is learnt through their own project choices and individualizing their own experimentation. Teachers will provide the opportunity for students to design their own open-ended explorations of the concept. Learners begin integrating the information with themselves to evolve a personal synthesis. The learner can choose to work cooperatively in a team or alone and share ideas later.

Step 7: Refine or Analyse the Usefulness or Application. The learner moves beyond simple practice and reinforcement and uses the information in creative way. Teachers will give guidance and feedback to encourage, refine, and help student to analyse their use of the learning for meaning, relevance, and originality. Students edit (revise, refine), assess quality of evidence, synthesize original performances, analyse what they have planned as their "proof" of learning based on relevance to content, originality, and excellence, prepare and present exhibitions and publications.

Step 8: Perform or Integrating Application and Experience. The learners present or perform the original example of their learning, sharing it with others in a meaningful way. This is also the time to celebrate the learner's accomplishments. As this step moves from individual, private acts to more open and public exhibits, power

of social interaction shapes learning profoundly. Moreover, students will gain the basic social skills of critical thinking, communicating, relating from an effective public presentation.

1.4 Learning Style

Learning style is an individual's unique way to perceive and process information. Reynold (1993) stated that learning styles are basically individuals own natural or habitual pattern of acquiring and processing information in learning situation. Learning styles deal with individual characteristics. Byrne (2002) further stated that learning styles enhance the academic performance as well as improve construction of their own knowledge regarding any topic. Students perceive and process the information in different way e.g. seeing, hearing, reflecting acting, analysing, and visualize. Ingham (2003) argues that student in classroom are not equal and every student has particular learning style.

There is major relationship between instructional approach and learning style. Brown (2003) stated that when instructional design meets the learning style positive impact has been observed on the academic performance of the learner. Teacher must design instructional approach in such a way to facilitate learning style of the student. Such approach will be the only way to facilitate difference of individual in a group.Merill (2003) further stated that students come with different learning styles in the classroom and all the styles need to be address during the learning process.

1.5Statement of the Problem

Retention of the acquired knowledge is a big challenge for modern day students and rote memorization cannot help students to retain the knowledge when needed. Various methods were propounded through researches to enhance student's retention and achievement in science subjects. Biology is an important science subject

being taught in schools since long. This subject is completely based upon activities and requires the teaching strategy that can enhance learning outcome of students. This study was embarked upon to check the effect of 4MAT model for enhancement of students' learning at secondary level as it provides an opportunity for students to re-construct their own knowledge.

1.6 Objectives of Study

Following were the objectives of study:-

1. To investigate the effect of 4MAT model on academic achievement of students in subject of Biology at secondary level in Baluchistan.
2. To evaluate effect of conventional method on academic achievement of student in subject of Biology at secondary level in Baluchistan.
3. To compare effectiveness of using 4MAT Cycle and traditional conventional method on academic achievements of the students.
4. To find out retention level of students using 4MAT cycle on academic achievements of student in the subject of Biology.
5. To explore the retention level of students using traditional conventional method on academic performance of the student in the subject of Biology.

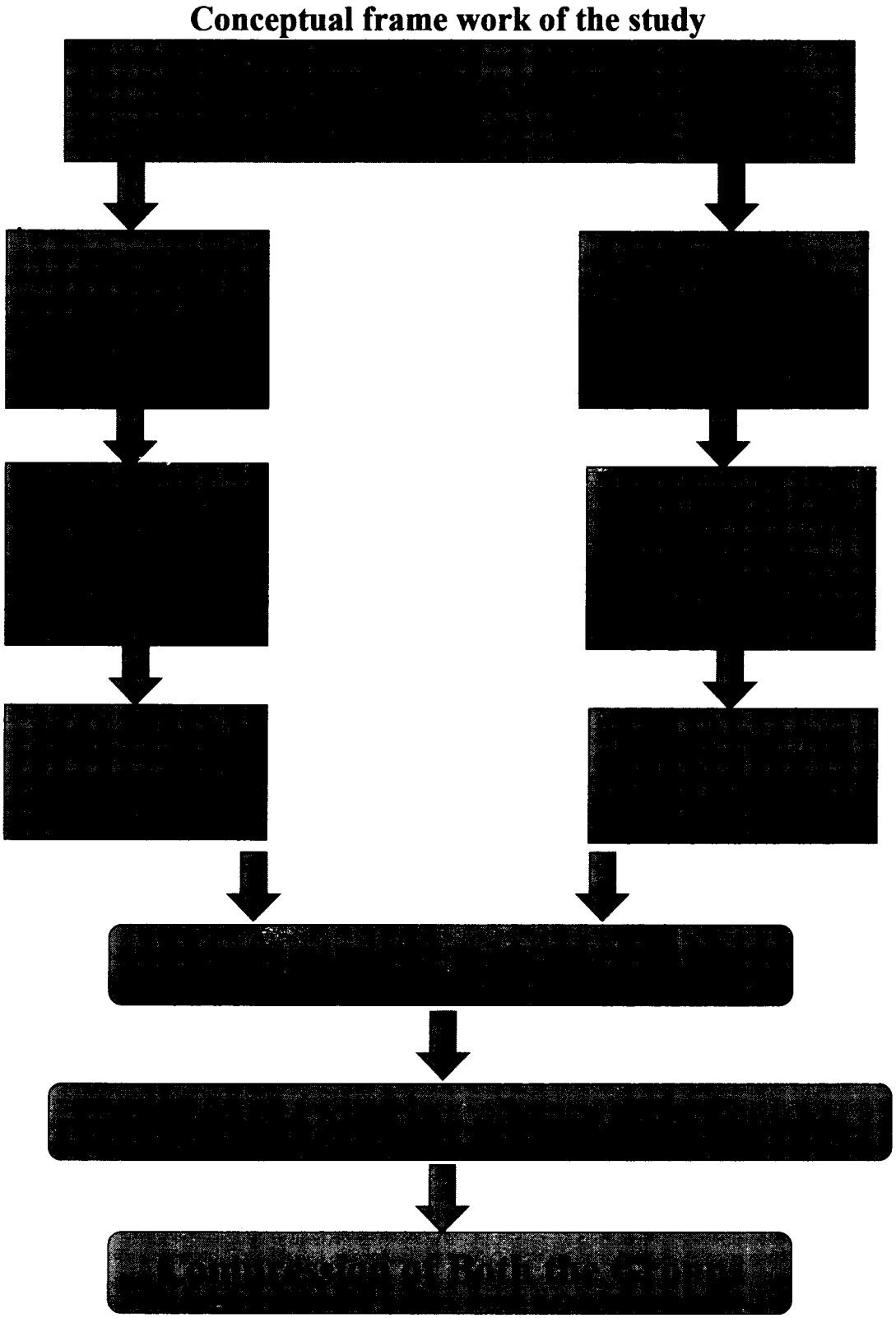
1.7 Hypotheses of the Study

H_{01}: There is no significant difference between mean achievement score of control and experimental group in pre-test.

H_{02}: There no significant difference between the mean achievements scores of control and experimental group in post-test.

H_{03}: There is no significant difference between mean achievements scores of control group and experimental group with regard to retention level over a period of three months.

1.8 Conceptual frame work of the study



1.8 Significance of the Study

This study was significant in following ways.

1. The findings of the study would enhance awareness among secondary school teachers regarding the importance of 4 MAT Cycle and learning style of the student. The findings would further enlighten perception and conception of teachers regarding 4MAT Cycle.
2. Study has not found application of 4 MAT Cycle at secondary school level in Baluchistan. Limited literature exists regarding experimental studies at school level in Baluchistan. The study may help the teachers in general and secondary school teacher in particular. This study may be important addition in instructional literature in Baluchistan.
3. The finding of the study would be helpful for curriculum developers and all those related to the field of education. The findings of study would be helpful for educators to understand the role of 4MAT Cycle and its impact on student learning and achievements.
4. Findings of the study would be helpful for all those related to field of education including Teachers, Parents, Management and Policy Makers. The findings of study may be helpful for the researcher as well. The Researcher has been serving as Secondary school Teacher for the last20 years.

1.9 Delimitation of the Study

It was not possible for trained teacher or researcher to teach whole book to the students according to 4.MAT teaching style in limited time. Therefore, this research study was delimited to

1. 9^{th}-grade biology students for two chapters such chapter No.8 and chapter No.9

2. One Government High school in Khanozai City was delimited out of 964 high schools in Baluchistan (Baluchistan Education statistics 2016-17).
3. Experiment prolonged for eight weeks.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

4MAT has recently been used in a variety of educational settings and disciplines, including medicine education (Spatz, 1991; Erwin et al., 1992), law studies (Kelly, 1990), and scientific education (Bowers, 1987; Ursin, 1995; Jackson, 2001). Many instructional strategies, for example, were used to fit the learning styles of engineering economy students. To swiftly calculate the present value of an alternative, an experiential learning cycle and a creative business game were used (Yanti, 2021). Nowacki (2011) applied the 4MAT model to the learning process in order to turn a biostatistics course into a problem-based learning experience. Students felt more passionately, encouraged sharing, and integrated concepts across subjects, according to the findings.

In addition, suggestions for problem-based learning strategies were given.At various levels of education, studies of the 4MAT model were also conducted. The findings revealed that using the 4MAT approach resulted in more positive attitudes, increased academic accomplishment, and more long-term learning (Dikkartin, 2006; Ergin and Sari, 2012; Tatar and Dikici, 2009; Uyangor, 2012). Kemal and Huseyin (2014) evaluated the impact of learning activities on high school students' academic achievement and attitude toward mathematics, using a method that was compatible with the 4MAT system. Academic achievement and problem-solving skills improved as a result of the study. Uyangor and Sevinc (2012) studied the effects of the 4MAT model on seventh-grade students' academic achievement and attitudes toward mathematics in public schools. The authors used an experimental paradigm with a pre-test and post-test on a control group.

The findings demonstrate that the 4MAT method was more efficient than the old method (Uyangor and Sevinc, 2012). The impacts of the 4MAT learning model on seventh-grade students' academic achievement and motivation on the "Particulate Nature of Matter" were studied by Aktas and Bilgin (2015). The results showed that the 4MAT approach was more effective than the traditional way in terms of higher achievement and motivation (Aktasa & Bilgin, 2015).

The teacher plays a vital role in the traditional lecture method. In the lecture method, the teacher is at the centre of all activities; the focus is not on the pupil but on the teacher. Control of learning is in the hands of the instructor under the teacher-centered method (McDonald, 2002). The teacher-centered approach is limited to facts and information delivery, and it is currently regarded a poor way of instruction (Mandor, 2002). The lecture approach is the most widely used of the traditional methods. The lecture approach involves presenting ideas, concepts, and facts verbally. The teacher takes an active role in the lecture technique, while the student takes a passive position. According to Ibe (2004), the lecture approach leads to rote memorization since students do not participate in the presentation and instead learn facts and knowledge in the order in which the teacher presents them. In science subjects, especially biology, such an approach is useless. Science courses necessitate direct student participation in the lecture, and the lecture approach is insufficient to clear the student's notion. He goes on to say that traditional methods are insufficient for effective learning. The chalk and speak method has shown to be ineffective. Despite this, the majority of scientific teachers continue to follow the old method, resulting in worse academic standards in the long-term (Inanyang & Ekpeyoung, 2000).

2.2 Method of Teaching Science

There seems to be a variety of ways used as a medium of instruction in the classroom around the world, but there is no single method for teaching science subjects. The approach is determined by a variety of elements, including the learner's nature, age, environment, and talents (Agbai, 2004). Different tactics are employed in the classroom; however, it is critical for teachers to use a variety of approaches when teaching science. Traditional methods (chalk and talk) and inquiry methods, interdisciplinary nature, laboratory methods, demonstrations, and problem-based learning are all common science teaching methods (Obiekwe, 2008). As far as learning goes, there are two approaches. A student-centered and teacher-centered approach. According to Guisti (2008), the teacher-centered technique is a traditional method, as are all traditional approaches based on behaviourism.

2.3 Learning Style of Students

Students at all levels (primary, secondary, and high school) have regarded science as a challenging subject (Ayas, zmen, & alk 2010). Based on some literature research, zmen (2011) identified three causes for this problem. The first is that science issues are highly abstract. The second point is that words in everyday life have varied meanings. The third issue is pupils' lack of prior knowledge as well as their lack of image abilities.

Furthermore, they must comprehend theoretical knowledge, which combines information and abilities in order to absorb the entire or specific process of a scientific theory. The typical classroom setting is another source of learning inadequacy. It is acknowledged in a traditional teaching style that all pupils may study in the same setting, using the same equipment and methods. Students who succeed at the end of such a learning process are labelled as "more skilled and intelligent," while those who

fail are labelled as "less skilled and intelligent" (Dikkartn 2006). However, believing that students from various backgrounds cannot have distinct intellect structures and learning styles is tantamount to treating a student's intelligence like machinery.

The student's learning style is a natural way of obtaining and processing information in a learning context. According to, a learning style directs teaching and learning (Kolb & Kolb, 2005). Learning styles are a collection of circumstances, attitudes, and behaviours that make it easier to learn in a certain scenario. Learning styles have an impact on how teachers teach, how students learn, and how teachers and students interact in the classroom. Every person is distinct in terms of their characteristics and is born with various proclivities towards certain types. Personal experience, culture, development, and maturity level all impact these innate features (Kolb & Kolb, 2005). Each learner has a unique manner of understanding, organising, and remembering what they have learned. There are three types of learning styles: cognitive, emotive, and psychosocial.

Personalised learning was first proposed in 1970. From teacher-centered to student-centered learning, there was a paradigm change. It makes no difference how you teach; what matters is how the pupil learns. According to Swasin (2012), the most essential feature about learning styles is that cognitive, emotional, and psychological components acted as reliable indicators in the learning process. The most significant aspect of a learning style is how the learner interacts, perceives, processes, and responds in the learning environment, as well as how the student receives and processes information. Learner styles, according to Magner (2009), are biological and developmental sets of personal qualities that make specific educational environments, resources, and approaches beneficial for some but ineffective for others. David Kolb

has presented learning styles in this regard. In a distinct context, each individual perceives and processes information in a different way (Kolb, 1984).

Although all pupils can learn, they cannot all learn in the same way (Commission, 2003). Individuals have distinct learning styles, just as they have varied fingerprints (Dunn, 1990). Furthermore, when processing information in the brain, each individual uses separate cerebral hemispheres (Ersen, 2018). As a result, such disparities should be taken into account in the educational setting in order to assist each student in learning. Many scholars study learning styles and how they evolve throughout the learning and teaching processes to ensure that all students have an equal opportunity to learn (Nicoll-Senft & Seider 2010).

The 4MAT model is one of the learning models that takes individual differences in learning into consideration. 4MAT has the advantage of taking into account individual characteristics such as learning styles and brain processing capabilities. Moreover, it provides students with possibilities to comprehend the particulate nature of matter, such as modelling, visualisation, theoretical knowledge, application, demonstrating individual creativity, integrating these opportunities, and knowledge transfer through interaction with tasks.

2.4 Definition of 4MAT Strategy

4MAT defines four connected learning styles based on a continuum of how learners perceive and process new information, according to Nicoll- Senft and Seedier (2010) and Kutay (2006). The learner's individual learning style is determined by where he or she stands on the continuum. Imaginative learners, analytic learners, common sense learners, and dynamic learners are the four learning styles identified by McCarthy. Personal experience is the best way for imaginative learners to learn. They like discussing their thoughts, feelings, and opinions with others, and they

benefit from possibilities to discover meaning in what they are learning. They are naturally reflective and learn through discourse. Individual student development is their top goal in the classroom (AlSaleem, 2019).

For these students, cooperative learning, brainstorming, and the integration of many curriculum areas, such as science and writing models, are successful. Analytic learners examine details and intricacies in order to learn in a logical, ordered manner. They frequently perform well in traditional educational settings, and they love reflecting on new ideas and linking what they've learned to other facts they already know. They are also logical by nature and enjoy putting theories and models together. They value clarity and seek professors who share this trait. Traditional lectures, individual study, and listening to subject matter experts are preferred by these students. Teachers should focus introducing the subject through well-organized and logical lectures, note taking, and readings to better satisfy student needs. Learners with rational thinking learn by doing.

They concentrate on the practical applications of new knowledge. They are dynamic students that prefer to work in a classroom setting. They despise assignments that lack a clear purpose or application. Hands-on, experiential learning activities are the best way for them to learn. Concrete style, experimental activities, hands-on work, and kinaesthetic experience are preferred by these learners. Teachers should give students the chance to practise new abilities. Finally, dynamic learners like taking risks and want to learn mostly through self-discovery. They enjoy making connections between what they're learning and what matters in their life. They enjoy putting information together and implementing what they've learned in new settings. These students believe in their feelings and like teaching others. They prefer participation in

independent study, role-playing, and games. Such kids are challenged by teachers who create real-life learning situations in the classroom.

The 4 MAT method, according to BulBul and Ozsoy (2015), sequence the four learning styles in a framework that replicates the natural learning cycle of the learners. This cycle begins with the student's prior experiences and knowledge, and then adds new information or insight to be learnt. The learner then has the opportunity to alter the new information before applying what he or she has learned to the world around him or her and to his or her own life. The learners create a fresh base from which to interact and restart the cycle at this stage in the cycle.

The 4MAT method is based on Kolb's (1984) brain hemisphere research findings and experimental teaching philosophy (Uyangor, 2012). When it comes to processing new information, a person favours the right or left hemispheres of the brain. The learner with a right hemisphere operational inclination understands images, seeks patterns, produces analogies, and is simultaneous in nature. The student who prefers the left hemisphere of the brain works with analysis, languages, abstracts experiences, and has a good sense of numbers. A student, on the other hand, does not employ one hemisphere exclusively. He/she shifts from one hemisphere to the other depending on the situation (BulBul & Ossoy, 2015).

2.5 4MAT Teaching Method: General Overview

McCarthy characterised the 4MAT teaching technique as a teaching strategy, which was first designed in accordance with constructivism's underpinnings (1987). This model depicts an educational system that aids teachers in the creation of study modules that address different learning styles. The model is adaptable to any curriculum area and can be used at any grade level. The 4MAT system consists of four different learning styles focusing on acknowledging and processing acquired

information, according to McCarthy's (1987) paradigm.A first instructional approach is primarily concerned with personal meaning (experience phase), but the second type is concerned with the specifics since they lead to conceptual knowledge (commonly referred to as the conceptualization phase). The third type of learner is interested in figuring out how things function and concentrating on the more practical aspects of concepts (recognized as the applying phase). The fourth type of learner is interested in self-improvement and self-discovery, which is referred to as the initial stages of a project.

The 4MAT system's cycle consists of eight separate tasks that span the four types of learning and make use of both left- and right-brain processing methods in all quadrants (Tatar & Dekici, 2009). 4MAT's teaching model can be regarded as a combined teaching method that facilitates a variety of constructivist-based teaching approaches and methodologies. The methodology encourages students to come to their own conclusions about their views and understandings. Learning becomes more supportive and fascinating as a result of the integration of diverse teaching approaches, which promotes permanence (Pruekpramool, 2011).

The large number of students prefer to learn using all four ways, which limits the development of other learning tools. The 4MAT teaching approach, on the other hand, has the advantage of allowing all learners to adopt their preferred learning styles; as a result, educational settings must be designed to accommodate learners' preferred learning styles (Ergin & Atasoy, 2013). Some students, for example, are better at learning science through more concrete tasks like experiment completion, whilst others may prefer more abstract mental exercises. On the other hand, some students learn better when they give solo presentations on a project, whereas others may favour group learning ways.

Morris and McCarthy (1990) believe that every student can participate in various stages of the learning cycle. Analytic, common sense, dynamic, and innovative learning styles are the four types of key learning styles. Students can use a variety of learning strategies throughout their studies. An analytic learner, for example, may have a preference for what experts think, so that the learner learns by thinking through ideas; a common sense learner may seek to determine how things work, so that the learner learns through a hands-on approach; a dynamic learner may be more inclined to complete a variety of activities, so that the learner learns by focusing on self-discovery; and finally, an innovative learner may require personal involvement, so that the learner learn (McCarthy, 1980, as cited in Wilkerson & White, 1988).

2.6 Four Mode Application Techniques (4MAT)

The way people learn differs from person to person. Individual learning styles are recognised and defined as a result of these variances. Several educators have attempted to research learning styles. For example, concrete experience, introspective observation, abstract conceptualization, and active experimentation are all required for learners to be effective. Bernice McCarthy developed the four Mode Application Techniques (4MAT) based on the preceding line of reasoning from Kolb's learning circle. Kolb's learning approach was enriched by the 4MAT Cycle. As a result, the 4MAT System is a teaching model related to human brain function research in order to provide a practical teaching approach for maximising human learning and development (Kolb, 1983).

4MAT is an instructional approach based on the concept that learners' perceptions and processing of those perceptions are intertwined. Some students perceive information in two ways: first, through experience, and then, through

conceptualization. They sense concepts, are present in the moment, are emotionally captured by the moment, and feel the learning through experience. Furthermore, learners use conceptualization to transfer their experiences into conceptual forms using language, concepts, systems, and an abstract approach to figure out what is going on and name it (Aliuslaoglui, 2022).

The learning process depends on the interaction between the feeling of experience and conceptualization. It connects learners' personal worth and perceptions to those of experts. Learner's process information in addition to experiencing it, and this information is processed in two ways: by reflecting on it and by acting on it. By reflecting on information, learners apply their knowledge to the outside world, try out things by doing and testing; by action, learners apply their knowledge to the outside world, pondering, questioning, feeling how one feels, observing others, feeling the same way or differently, and figuring out where one is with what is experienced; by action, learners apply their knowledge to the outside world, try out things by doing and testing (Pratoomtong, 2011). The interaction between "viewing" reflections and "performing actions" is critical since it offers the motivation to act on internal ideas. It challenges students to put their theories to the test in the real world and to apply what they've learned to a variety of ambiguous circumstances. Perception and understanding are two terms that describe the entire range of learning experiences (learning style). While learners engage in a variety of learning activities, the majority appear to favour one type of learner over another. Imaginative learners, analytic learners, common sense learners, and dynamic learners are the four categories of students (McCarthy, 2005).

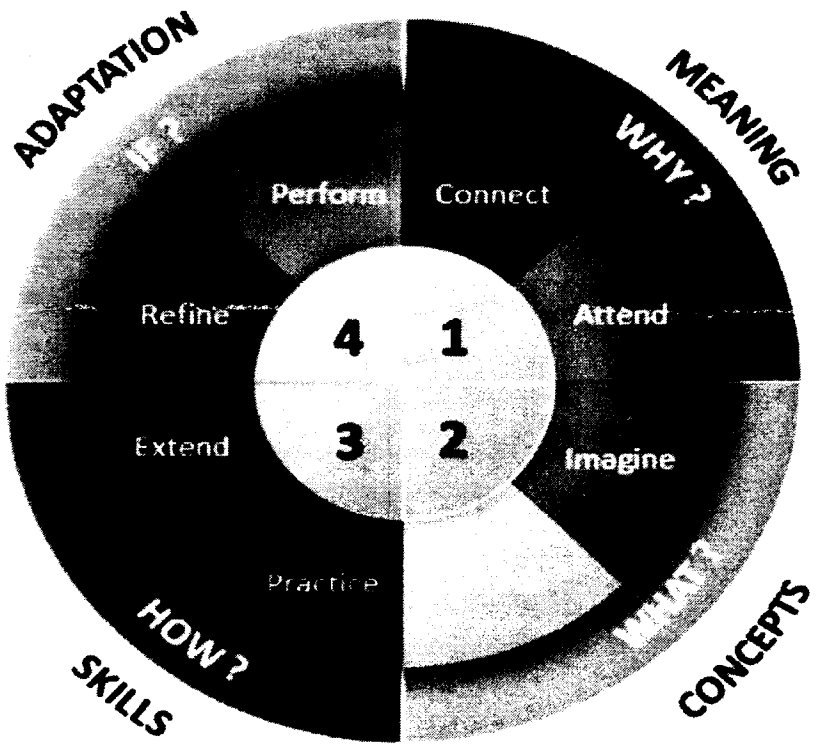
Type one students are inventive, looking for personal connections, meaning, and involvement. WHY is their main question when it comes to building connections?

Analytic learners are type two learners. They like listening to and thinking about information; they look for facts, consider alternatives, and listen to experts. The key question they ask when formulating ideas is what? The common sense learners are type three learners. Experimenting, developing ideas, creating usability, and fiddling with concepts are how they learn. HOW is their main concern? Type four students are active learners. They prefer to do and feel things, look for hidden opportunities, experiment with learning via trial and error, and associated with self. The primary question they ask themselves when crafting creative adaptations is, "What if?" That is, what can I do with this IF it is true? These four types of learners must learn all parts of the cycle at the same time in order to be successful learners, i.e., a type one learner must learn how to be a type two, three, and four learner in order to learn anything well. To fully engage in the activities of the four different learners, the learner must ride this cycle with a spin.

Learning, according to McCarthy, comprises the interplay between the left and right hemispheres of the brain, in addition to the four modalities of learning. Structure, sequence, and language are the best ways for the left brain to function. It also looks at elements, acts on a numerical basis, and analyses or breaks down information into words. The right brain comprehends images, searches parts, forms metaphors, and tries to synthesise and integrate information at the same time (McCarthy, 1983). We have a complete 4MAT if the teacher integrates the activities of the left and right hemispheres into the four learning modes during the class. Learning and thinking require the interaction of the left and right brains. It allows for a wider spectrum of creative expression, in-depth comprehension, and problem solving. Within the four separate phases of the learning cycle, the 4MAT teaching paradigm incorporates the utilisation of left and right brain instructional tactics.

2.7 The 4MAT Process

4MAT differs from other learning styles theories in that it incorporates many learning styles into a single learning cycle that includes all learners' differences. McCarthy (McCarthy, 1987).



Using the 4MAT System to Bring Learning Styles to Schools (McCarthy, 990).

The four-quadrant model of 4MAT is depicted in the diagram above, with each quadrant reflecting one of the four major learning styles. An eight-step cycle is constructed by superimposing right and left hemispheric preferences on each of the four quadrants, and right mode or left mode is selected. Each of the eight steps has its own set of educational tactics. It is founded on constructivist theory's assumptions and processes, and it provides a new way of thinking about learning. The following are the quadrants, together with their steps and teacher and student activities:

Quadrant 1: Meaning

Step 1: Connect or Create an Experience. This stage personalises and meaningfully connects the lesson's concept to the students. Teachers will pique students' interest by starting with a situation that they are familiar with and building on what they already know. Sharing personal insights and autobiographical information, brainstorming, listening, speaking, mind mapping, drawing, conversing, idea generation, and role-playing are some of the activities that can be used in a setting.

Step 2: Examine or Reflect on the Experience. The teacher can then ask students to reflect on the experience and share it with others. This is a crucial step in putting constructivist learning theory into practise in the classroom. Before commencing any new learning, the teacher can bring up the students' prior knowledge. It is critical to determine what present perceptions, constructions, or misconceptions pupils bring with them in order to create an efficient learning phase. Before imparting new information, the teacher must first determine what the students already know or believe. The teacher's role in this step is to lead pupils through reflection and analysis of the previous step's experience.

1. The students then share their thoughts and beliefs in order to establish and reinforce the meaning that leads to true comprehension and motivation to study.

Quadrant 2: Concepts

Step 3: Image or Integrate the Observation into Concepts

The teacher combines the teacher's reflections from the preceding personal experience into a visual or poetic image or sensation that connects the personal experience to the idea being studied. Teachers will continue to relate what students already know to what specialists have discovered, deepening the connection between

the topic and its application to their lives. They use a different media to relate the students' personal knowledge to the subject to be taught, transforming it into an image or experience, giving the students a "sneak preview." Seeing relationships and connections; patterning; producing analogies, metaphors, and non-verbal or spatial representations; and discussing are some examples of activities.

Step 4: Inform or Developing Theories and Concepts.

Experts should provide learners with conceptual and factual information. Teachers will present information about the idea in the form of a lecture, text videos, visual computer-assisted education, or charts. They provide material progressively so that pupils notice continuity and emphasise the most important components of the subject in an ordered, organic manner.

Quadrant 3: Skills

Step 5: Practicing or putting information to use in a practical way. Learners experience using information in the actual world to see "how it works." Teachers will give hands-on activities for students to practise and master ideas and skills. Exploring, manipulating, and applying facts and concepts, field and lab work, adapting information to personal use, demonstrations, worksheets, puzzles, diagrams, computer experiments, and interactions with peers and instructors are some of the activities that may be included.

Step 6: Extend or Integrating Material with Self. By extending what they've learned through their own project selections and personalising their own experimentation, the students bring something unique to the table. Students will be able to construct their own open-ended explorations of the idea with the help of their teachers. Learners begin to integrate the information with their own experiences in

order to create a personal synthesis. The student has the option of working in a group or working alone and sharing ideas subsequently.

Quadrant 4: Adaptation

Step 7: Refine or Analysing for Usefulness or Application. The learner goes beyond basic repetition and reinforcement to make creative use of the information. Teachers will provide assistance and comments to students in order to motivate, enhance, and assist them in analysing their learning for meaning, relevance, and uniqueness. Students edit (revise, refine), evaluate evidence quality, synthesise original performances, review what they have planned as their "proof" of learning based on subject relevancy, creativity, and excellence, and develop and present exhibits and publication.

Step 8: Perform or Integrating Application and Experience. The students present or execute an original example of their learning, allowing them to meaningfully share it with others. This is also the opportunity to congratulate the learner on his or her achievements. The force of social connection influences learning significantly as this stage evolves from individual, private acts to more open and public exhibits. Furthermore, a great public presentation will provide students with the fundamental social skills of critical thinking, speaking, and relating.

2.8 Advantages of 4 MAT Strategy

Seker and Ovez (2018), as well as Irfang; Almufadiz and Brisha (2016). The 4MAT method has a number of benefits. For starters, it encourages pupils to expand their own knowledge and perceptions. Second, by supporting an integrated teaching approach, it allows the teaching environment to be arranged around certain topics and facilitates the employment of various methodologies. Learning becomes more engaging when diverse teaching styles are combined in an integrated manner. Finally,

it is a student-centered approach. It organises learning around students' needs and gives teachers a framework for planning eight-stage learning activities in a regular cycle. Fourth, it honours individual differences among students, ensures the passage from subjectivity to objective for integrated learning, and enhances holistic thinking. Fifth, it leads to more positive mindsets, improved academic accomplishment, and lifelong learning

2.9 Role of Teachers and Students in 4MAT System

When the 4MAT is used to plan a system approach, each quadrant of the 4MAT cycle can be separated into teacher and student activities, according to McCarthy (1990). The following are the details:

The first section is focused to the question "why?" During the learning process, the teacher's responsibility entails attaching meaning to content and respecting student variety. What does Quadrant Two become? The instructor takes on the leadership position in the classroom. They must manage and produce knowledge units based on conceptualised themes that are patterned into meaningful relationships and which connect the parts to the whole. The topic of the lesson is understood by the students. How does this function in Quadrant Three? The teacher takes on the role of coach. He leads students in the understanding and interpretation of the material they have learned, as well as the usage and incorporation of the material they have learned. Students take on the role of content and skill users.

If you're in section four, you'll have to ask yourself, "What if Teachers take on the role as facilitators of creative possibilities. They will supervise student self-discovery, facilitate student sharing, promote a variety of learning styles, and elaborate, critique, and reward student creativity. Students take on the role of innovators. 4MAT is a framework that can assist students with a variety of learning

styles at the same time. This concept is likewise based on hemisphere preferences in the brain (Musa & Wood, 2003). As a result, the 4MAT is an instructional model that helps teachers create units of study that address students' learning styles and hemispheric preferences. Teachers can use 4MAT to foster critical discussion so that students can build interpersonal and intrapersonal cognitive skills for themselves, by themselves, and with one another. 4MAT requires teachers to offer instruction in each of the four learning styles in order to create other learning styles, effectively employ their own learning styles, and achieve success.

Because student-centered teaching methods focus on how to teach rather than what to teach, studies on learner characteristics have accelerated, and the notion of learning styles has been created as a result. Since the 1940s, several psychologists and pedagogues have been researching learning styles, which are defined as all of the learner's choices during the learning process (Erden&Altun, 2006). Though learning styles are recognised as one of the most important indications of students' needs, motivation, attitude, and expectation in the classroom, they are also recognised as one of the most important components of the teaching learning process (Ekici, 2003; O'Banion, 1997). Carl Jung's "personality type theory" underpins the concepts of studies involving learning styles (Ekici, 2003; Keefe & Ferrell, 1990).Furthermore, Kolb's "experimental learning theory," which is based on Dewey, Lewin, and Piaget's learning theories (AçkgözÜn, 2005), has given the concept a lot of traction. Learning is a four-step process, according to experimental learning theory. This process repeats again, causing the learner to obtain new experiences, which then lead to the learner's participation in subsequent learning cycles (Kolb, 1984).

Despite being influenced by a variety of learning styles, the 4MAT (4 Mode Applications Techniques) is theoretically based on Kolb's experimental learning

theory but is mostly based on McCarty's teaching approaches. Different learning styles are produced by variances that occur during the perception and processing of information, according to McCarty (2000), based on Kolb. The research of Dax, Gall, Spinger, and Deutsch revealed that the right and left hemispheres of the brain function differently (Duman, 2007). San, 2004; Anadolu Journal of Educational Sciences International, Art Education Special Issue, November 2015, zsoy, 2003; Caine & Caine, 2002) found that the left hemisphere of the brain organises logical and analytical thoughts, whereas the right hemisphere functions about intuitional and integrated ones. These findings have aided in the acceptance of the idea that learning styles differ from one another (Denison & Kirk, 1990).

2.10 4MAT Model in the Development of Meta-Cognitive Thinking in Science

There are just a few researches (Zohar &Barzilai, 2013; Hartman, 2001; Fisher, 1998) in the field of science on the integration of the 4MAT teaching model in the development of meta-cognitive thinking in diverse disciplines. Studies on teaching and learning science disciplines have emphasised the importance of evaluating not just the learner's cognitive structure, but also the elements that influence the construction of that structure (Chin, Tuan, and the Shieh 2005). Attitude, interest, belief, value, self-efficacy, and motivation are all examples of affective elements (Dede and Yaman 2008). Motivation, coupled with consistency of success, is a very significant component for student achievement, according to various studies and practitioners (Guay et al. 2010; Pintrich 2003).

According to Krşolu (2005), extensive expertise and knowledge may not be sufficient in every topic, particularly when teaching science subjects. Traditional teaching strategies and methodologies are insufficient in this regard. It was also

stressed that semi-controlled teaching models self-regulate and build inner dynamics in accordance with requirements. According to Buyurgan (2000), science education should not be centred on forcing pupils to think, try, and research. Rather, the 4MAT model, which is suitable for both brain hemisphere dominance and is based on learning styles, is expected to be the most appropriate teaching technique in high school science classes.

The majority of studies in the review of literature focus on permanency, attitude, and achievement. There is a scarcity of research that examines the impact of 4MAT on motivation in depth. Similarly, there are few studies that examine student perceptions of the 4MAT paradigm (Uysal 2009, Nicoll-Senft and Seider 2010). In truth, there has never been a comprehensive examination of the 4MAT model's positive and negative effects. The current research seeks to make a substantial contribution to the field of 9th grade science education.

2.11 Effect of the 4MAT Learning Model on the Achievement of Science Students

Students at all levels (primary, secondary, and high school) have a negative perception of science (Adadan, Irving, & Trundle 2009). Based on some literature research, zmen (2011) identified three causes for this problem. The first is that science issues are highly abstract. The second point is that words in everyday life have varied meanings. The third issue is pupils' lack of prior knowledge as well as their lack of image abilities. Another reason for this difficulty, according to several academics, is the complexity of chemistry's nature (Chang, Quntana, and Krajck 2010; Devetak et al. 2004; Kozma 2003).The three stages of chemistry are macroscopic, microscopic, and symbolic. Students are expected to comprehend atomic and molecular explanations and theories that are transformed and given in symbols and formulas

(Devetak et al. 2004). This causes students to struggle with comprehending since they are unable to translate knowledge offered at a symbolic level into explanations and theories.

Chang et al. (2010), zmen (2011), and Treaguest (2010) all concur that matter, chemical characteristics, and chemical reactions are the foundation of 5th–8th grade chemistry difficulties. Furthermore, the particle nature of matter is at the heart of these topics. As a result, these concepts cannot be fully comprehended without first comprehending the particle nature of matter, which can lead to learning problems (Chang et al. 2010).Furthermore, due to the abstract character of the atoms and molecules that make up matter, learning challenges may arise. Traditional curriculum materials are one of the reasons why pupils struggle to understand the particle nature of matter. Traditional materials just offer theoretical knowledge in a brief paragraph without assisting students in grasping the concepts (Harrison and Treaguest 2002). We do know, however, that the information offered cannot be assimilated without application (Abbott and Ryan 1999). In traditional classes, models have been utilised to improve comprehension. Students, on the other hand, have a hard time making the connection between molecular explanations and graphical models (Stavridou & Solomonidou, 1998).

Students must handle related scientific knowledge, such as molecular formation of a given substance (Nakhleh, Samarapungavan, & Salam, 2005), and they must specialise in certain abilities and skills that combine multiple presentations, as well as visualisation of chemical reactions at the molecular level, in order to gain a deeper understanding of the particulate nature of matter (Kozma 2003). Furthermore, they must comprehend theoretical knowledge, which combines information and abilities in order to absorb the entire or specific process of a scientific concept.

The typical classroom setting is another source of learning inadequacy. It is acknowledged in a traditional teaching style that all pupils may study in the same setting, using the same equipment and methods. Students who succeed at the end of such a learning process are labelled as "more skilled and intelligent," while those who fail are labelled as "less skilled and intelligent" (Dikkartn 2006). However, believing that students from various backgrounds cannot have distinct intellect structures and learning styles is tantamount to treating a student's intelligence like a machine.

Although all pupils can learn, they cannot all learn in the same way (Commission, 2003). Individuals have distinct learning styles, just as they have varied fingerprints (Dunn, 1990). Furthermore, when processing information in the brain, each individual uses separate cerebral hemispheres (Davs, 2004). As a result, such disparities should be taken into account in the educational setting in order to assist each student in learning. Many scholars study learning styles and how they evolve throughout the learning and teaching processes to ensure that all students have an equal opportunity to learn (Nicoll-Senft & Seider, 2010). The 4MAT model is one of the learning models that takes individual differences in learning into consideration.

4MAT has the advantage of taking into account individual characteristics such as learning styles and brain processing capabilities. Furthermore, it provides students with possibilities to comprehend the particulate nature of matter, such as modelling, visualisation, theoretical knowledge, application, demonstrating individual creativity, integrating these opportunities, and knowledge transfer through interaction with tasks.

2.12 Traditional Conventional Method on the Academic Achievements of the Student in the Subject of Biology at Secondary Level

Concerns regarding the quality of education in Bhutan have grown in recent years, both within the Ministry of Education and among international agencies. Bhutanese pupils, according to a World Bank survey from 2009, have low learning levels and a lack of critical thinking, communication, and problem-solving skills. Furthermore, according to a research conducted by the Royal Education Council (2010), children perform below grade level expectations in both basic and advanced academic skills, and they lack basic communication and analytical skills. Teachers' inadequate teaching approaches are one of the key reasons contributing to pupils' low levels of learning (REC, 2009). The most common teaching approach is the traditional lecture-based strategy. Classroom instruction is facilitated in traditional methods, with teachers taking centre stage, playing dominant roles, and acting as knowledge transmitters (REC, 2009).They rarely use creative teaching methods, and their instructional practises are not constructivist in nature. Students rarely get opportunities to chat, express ideas, or ask questions in class because most interactions are started by the teacher (Rabgay, 2014). Poor conceptual understanding and academic accomplishment have resulted from such learning environments (REC, 2011).

Furthermore, rather than encouraging pupils to innovate, inquire, and think scientifically, it has encouraged them to memorise knowledge that are readily forgotten (REC, 2011). Students have become passive learners who are unable to actively participate in the learning process. It has been discovered that students rely

on teachers to decide what, when, and how they should learn (Dorji, 2005).If the current tendency of teacher-centered instruction continues, Bhutan's teaching and learning standards are doomed to remain stagnant (REC, 2008; Sherab, 2009). With the current need to improve the country's educational quality, efforts must be directed toward moving the pedagogical trend away from teacher-centered teaching and toward learner-centered teaching. To change the teaching pattern, teachers must employ creative and participatory teaching strategies. CL technique has evolved as a dominant teaching strategy to classroom education over the previous decade. It is based on constructivist learning theories and reflects a paradigm change in education from teacher-centered to learner-centered teaching (Muraya & Kimamo, 2011).

CL, according to Johnson and Johnson (1994), is an alternative to typical classroom teaching approaches. Students studying cooperative group assignments had higher academic test scores, more self-esteem, more positive social skills, and improved comprehension of the information they study, according to their research in a variety of school settings and across a wide range of content areas. CL delivers advances across all curriculum areas, all grade levels, and among all types of kids, including special needs, high achievers, genius, urban, rural, and all ethnic and racial groupings, according to over 500 research studies (Ho & Boo, 2007). CL is widely utilised in many nations, including the United States, the United Kingdom, Singapore, Africa, and others, due to its numerous advantages. Despite its widespread use in other regions of the world, CL is rarely employed by Bhutanese teachers. Teachers are introduced to CL during their pre-service training, but they rarely use it once they are fully qualified teachers.

Many researchers (Humphreys, Johnson & Johnson, 1982; Slavin, 1995) argue that CL's advantages are not culturally specific. As a result, it is critical for Bhutanese

teachers to adopt the CL technique as a supplement to the lecture approach. However, more research is needed to establish the impact of the CL technique. In Bhutan, no prior research has been conducted to establish the impact of the CL technique. As a result, the study's goal was to look into the impact of CL in a Bhutanese school setting.

Grade ten and biology were chosen as the subject and grade to evaluate the effect of CL because it is one of the courses in which most Bhutanese students scored poorly (Tenzin, Johnson & Ramachandran, 2006). According to the Bhutan Council of School Examination and Assessment's (BCSEA) Pupils Performance Report for the last three years (2016, 2015, 2014), pupils' average scores in grade ten biology have not exceeded sixty, suggesting underperformance in the subject. One of the reasons students perform poorly in biology is their unfavourable attitude toward the subject, which they view to be difficult and boring, as well as a lack of learning satisfaction and conceptual grasp (Tenzin, Johnson & Ramachandran, 2009).

Furthermore, the researcher's motivation for choosing biology stems from a prior study (Rabgay, 2014) that shown the necessity to improve teacher-student interaction patterns in order to increase grade ten students' biology learning achievement. Other motivations for studying biology include the country's emphasis on STEM (Science, Technology, Engineering, and Mathematics) topics. The country aspires to improve student proficiency in STEM disciplines in order to generate a human capital with the necessary scientific attitudes and abilities to aid in its development. Teachers must be introduced to suitable teaching and learning methodologies that are learner-centered rather than teacher-centered in order to solve the issue of teacher-centered education and the low achievement and negative attitude toward biology. Student-centered teaching and learning methodologies actively

engage the learner in the learning process, resulting in effective mastery of subject information and a positive attitude toward the subject. To increase academic accomplishment, a teacher's teaching methods should make learning more learner-centered, promoting imaginative, critical, and creative skills in students, which will lead to improved achievement of instructional goals. As a result, the study focused on determining the impact of applying the CL method on grade ten students' biology learning achievement as well as their attitude toward the topic in terms of their degree of interest, understanding, satisfaction, and difficulty in studying it.

2.13 Related Studies

Ergin and Atasoy (2013) conducted research to investigate student misunderstandings about electricity and the impact of the 4MAT teaching style on such beliefs. A non-equivalent pre-test–post-test control group design was used in conjunction with a three-level test to identify pupils who had misconceptions about electricity. A sample of 100 ninth-grade students was used. Students have misconceptions about attenuation, current flow as water flow, current potential difference confusion, empirical rule model, local reasoning, power supply as a continuous current source model, sequential reasoning, and short circuits, according to the study. It was also found that after implementing innovation, the frequency of the bulk of the misconceptions decreased.

In a study by Aktas and Bilgin (2015), the effects of the 4MAT learning framework on academic achievement of seventh-grade students were investigated, with a focus on establishing motivation for learners toward the 'Particulate Nature of Matter' unit and identifying students' perspectives on the 4MAT approach. A total of 235 Turkish students were included in the study. Following the implementation, open-ended questions were used to gauge students' perspectives on the 4MAT framework

in the experimental groups. The study's findings revealed that implementing the 4MAT approach increased students' overall engagement and motivation in class. Furthermore, pupils perceived lectures to be more entertaining and gained self-confidence as a result. However, several students stated that the technique was time-consuming, that they were not motivated, and that the material was not made more understandable by the usage of the system. Nonetheless, the 4MAT model was found to be more helpful in enhancing motivation and academic accomplishment than the old technique.

Alhadaybeh and Ambusaedy (2016) investigated the impact of the 4MAT model on the development of reflective thinking and science accomplishment in a group of 55 sixth-grade female students from two separate schools in the Dakhiliyah Governorate. The study's findings revealed that when the experimental and control groups' means were compared, there were statistically significant differences in all reflective thinking skills and science accomplishment test scores, showing that the experimental group performed better.

With a sample of 59 eighth-grade students, Azam (2016) studied the effectiveness of the 4MAT teaching approach in terms of acquiring and understanding scientific concepts, as well as learning and applying thinking methods. The total efficacy of using the 4MAT in gaining scientific concepts in fossils and the protection of species from extinction unit underwent restructuring through the 4MAT system, according to the researcher. The researcher, on the other hand, was unable to determine learning and application thinking types.

Ghazal (2016) looked on the benefits of using the 4MAT teaching method in enhancing the scientific thinking skills and concepts of seventh-grade female students. The total number of people in the sample was 61. The results revealed a statistical

significance in terms of the differences between the experimental and control groups' mean scores, with the experimental group outperforming the control group. Importantly, the 4MAT system has been found to be beneficial in the development of scientific thinking abilities and ideas in the teaching of other disciplines.

In a study by Jassim, Mahdi, and Kareem, the benefits of using the 4MAT model on improving understanding of biological ideas and retention for female students in secondary biology classes were investigated (2016). There were 83 students who took part in the study. The researchers utilised a two-group experimental design with experimental and control groups. Importantly, both groups were statistically equal in terms of age, IQ, prior knowledge, prior information, and parental education. The study's findings revealed that the experimental group outperformed the control group. As a result, the findings recommend that biology teachers notice and explore incorporating more traditional techniques in their college teaching. Tezcan and Güvenç (2017) investigated the impacts of the 4MAT system and the Whole Brain Model on academic achievement in science, comparing the effects of the 4MAT system and the Whole Brain Model to the effects of inquiry-based education.

The study was designed as a static group pre-test–post-test. When comparing the 4MAT Teaching Model to the Whole Brain Model, researchers discovered that inquiry-based instruction was more beneficial in terms of improving students' academic attainment. Nonetheless, it was discovered that the 4MAT Teaching Model and Whole Brain Model had an impact on academic achievement in some fields of science, but that these impacts were not different from those of inquiry-based learning. Moreover, the impact of the 4MAT Teaching Model and the Whole Brain Model on academic accomplishment in science was found to have no differences in

students' learning styles. When the 4MAT Teaching and Whole Brain Models used a more divergent learning approach, however, it was discovered that inquiry-based education did not help students attain academic success.

In Saudi Arabia, there has been little research on the 4MAT model, hence there is little evidence that it helps female students understand physics topics like electricity. The subject looks to be unpopular, with girls demonstrating a clear preference for biology (Britner, 2008; Osborne & Collins, 2001) and a larger interest in more aesthetic subjects like animals and nourishment. Female learners engage themselves in scientific learning in ways that may differ greatly from educational establishments' dominant and traditional views of gender, according to Brickhouse, Lowery, and Schultz (2000). This is an important topic since school policies on gender in mathematics and science might influence students' preferences for possible science-related jobs. In addition, social synergy and practical experience in an educational setting have been discovered to alter girls' attitudes toward scientific disciplines (Aldahmash, Mansour, Alshamrani, & Almohi, 2016; Dawson, 2000).

According to Zmen (2011), there are three causes for this difference. To begin with, scientific topics can be thought of as abstract. Second, common terms are frequently loaded with several meanings.Furthermore, there is a scarcity of image skills, and students frequently lack prior subject understanding. One of the 4MAT teaching method's greatest qualities is its sensitivity to students' needs, with a learning environment that is strengthened by the use of worksheets, experiments, and sample cases. In dealing with misinterpretations, the 4MAT approach integrates well-organized training approaches and offers an upgrade over standard curricula. The diversity of pupils' life experiences, learning styles, and brain hemispheres is taken into account, according to Ergin (2011), through the deployment of programmes that

reflect these variances. Furthermore, learners are placed in a position to confront their beliefs thanks to the availability of continual scientific discovery, as well as conceptual dialogues and evaluations.

Khaoanurak (2015) studied the implementation of the 4MAT method in EFL classes to improve students' critical thinking. A total of 50 students from Matthayomsueksa at The Prince Royal's College in Chiang Mai Province took part in the study. Data was collected using a critical thinking exam, a questionnaire, an interview schedule, and an observation form. The 4MAT technique increased students' critical thinking and motivated them to study English, according to the findings. Eker and Vez (2018) investigated the efficiency of a model based on the 4MAT teaching model and trans-disciplinary concept models in developing students' learning acquisitions and accomplishment levels. A total of 65 elementary school pupils took part in the study. Data was gathered using a learning style questionnaire and an accomplishment exam.Students' attainment levels and mean scores favoured the experimental group significantly, according to the findings. In addition, as compared to the control group, the proposed technique aided the experimental group pupils in developing critical thinking skills.

Pratoomtong (2011) conducted research on the development of science learning activities based on the 4MAT model to help sixth-grade students build multiple intelligences. The goal of the study was to create science learning activities based on the 4MAT System to promote multiple intelligences in sixth grade students, as well as to investigate their performance on students' achievement, science process skills, attitudes toward science, academic levels, and creative thinking, as well as to investigate students' and teachers' perceptions of the 4MAT System science learning activities model. The study was quasi-experimental in nature, with a pre-test, post-

test, control-group design. The samples consisted of two sixth-grade classrooms that were chosen via cluster sampling. One classroom served as the control group (30 students), which received traditional instruction, and the other served as the experimental group (33 students), who received science learning activities based on the 4MAT System. The topic was Substance in Everyday Life. During the first semester of the school year 2010, this study lasted 27 periods. Achievement test, science process assessment, attitudes toward science measures, multiple intelligences assessment, evaluation form of creative thinking, and teachers' and students' opinions about science learning activities based on 4MAT System interview form were the instruments used in the study for data collection. Mean values and standard deviation were used to analyse the data. At the 0.05 level of significance, hypotheses were tested using Multivariate Analysis of Variance (MANOVA).

The following were discovered as a result of the findings: Students who learned through science learning activities based on the 4MAT System had higher achievement and attitudes toward science than students who learned through the traditional method of teaching; there was no difference in science process skills or multiple intelligences between the two groups. Students demonstrated progress in creative thinking, and students with different learning styles had no difference in achievement, science process skills, attitudes toward science, multiple intelligences, and creative thinking, according to a review of science learning activities based on the 4MAT System. On achievement, science process abilities, creative thinking, and multiple intelligences, there was a strong interaction effect of technique and gender.

Both the teacher and the students were enthusiastic about the 4MAT System-based science learning activities. This study is similar to the current study in terms of the independent variable (4MAT) and some of the dependent variables used, such as

multiple intelligences and student achievement, but it differs in that the current study looked at the effect of 4MAT on achievement, retention, and multiple intelligences of students with various learning styles. The study differs from the current one in terms of the place where it was conducted and the degree of students involved.

Kelimeler and Ogrenme (2009) evaluated the impact of the 4MATmodel on student success and retention in a similar study. The research looked at how teachers taught the subject of 'Orbit and Circle' in 'Geometry and Measure.' The 4MAT instruction approach was used to teach the unit. The study used a quasi-experimental approach, namely a pre-test post-test experimental research model with a single-control group. The study included 106 7th grade pupils from central primary schools in Balikesir, who were selected using a stratified sample technique. The Achievement test and the Kolb learning type questionnaire were used to collect data. The study's findings revealed that teaching geometry to students based on their learning styles had a positive impact on their achievement; the findings also revealed that learning style instructional strategy aids student retention, and that students' gain scores differed depending on the school and their learning styles. Male students scored higher on achievement and retention than female students, according to the survey. In terms of methodology, this study is comparable to the current one, but it differs in terms of location, subject, class level, and other independent variables like retention and multiple intelligences. In particular, the impact of gender on student achievement when using 4MAT will be investigated in this research.

Taylor and Francis (2009) looked into the impact of the 4MAT Method (Learning Styles and Brain Hemispheres) of instruction on mathematics achievement. The goal of this study was to see how effective the 4MAT method of instruction is in teaching the binary operation and its properties in mathematics, which takes into

account learning styles and cerebral hemispheres. The participants in this study were 58 ninth-grade students from two different high school classes. One class was chosen at random to be the experimental group, in which the 4MAT method of instruction was employed, while the other class was chosen to be the control group, in which traditional training was delivered.

"Mathematical knowledge test," "mathematical attitude scale," and "knowledge test on binary operation and its properties" are the tools used to collect data. In the teaching of the binary operation subject in mathematics, it was discovered that the 4MATmethod of instruction was more efficient than the standard technique. This study varies from the current one in that it aims to examine the impact of 4MAT on students' achievement, retention, and multiple intelligences across a range of learning styles.

In the elementary music classroom, Phatchariya-Phetdong (2005) evaluated the impact of the 4MAT system of instruction on academic success and attitude. A quasi-experimental design was used in this work, specifically a pre-test post-test design. The study had a sample size of 23 fourth-grade students. The study used four research questions and four hypotheses. The pre- and post-test findings, as well as the results of the attitudes survey, were analysed using a t-test, with significance set at the 0.05 level for one-tailed comparisons. The mean difference in achievement scores between the two groups revealed that students in the 4MATgroup outperformed those in the textbook group substantially. This study is similar to the current one in terms of methodology, but it differs in that it examines the impact of the 4MAT model on accomplishment, retention, and multidimensional intelligence in students with various learning styles. Furthermore, the current study investigates the impact of gender on achievement of students who are taught biology using the 4MAT model, which was

not investigated in the previous study. In addition, the two research' locations and subjects differ.

A study evaluating the impact of the 4MAT system of instruction on academic achievement and learning retention was also conducted (Piyalux-Potiwan, 2004). The goal of this study was to see how the 4MAT System, a strategy for addressing learning styles and hemispheric preferences, affected (a) academic accomplishment and (b) learning retention. Students' interest in the substance of teaching, science, and attitudes toward the unit of study, as well as teacher perceptions of instructional approaches and student behaviour, were all investigated. The participants were 50 pupils from a public school in the Piedmont region of North Carolina who were chosen at random. Eight one-hour lessons on simple machines were given to the students. The 4MAT System was used to teach the experimental group, whereas a textbook approach was used to teach the control group. Following the end of the unit, the two groups were given a two-part achievement test. Part A assessed knowledge, comprehension, application, and analysis, while Part B assessed synthesis and evaluation. A one-factor analysis of variance was used to compare group means on Part A, and significant differences were identified in favour of the 4MAT group (F 1, 44 = 4.06 p.05). Part B of the exam was graded, and the group means were compared using a one-factor analysis of variance. On Part B, there were no significant variations in the means (p >.05). The same form of the test was administered to both groups 35 days after the unit's finish. A one-factor analysis of variance was used to compare group means on Part A, and significant differences were identified in favour of the 4MAT group (F 1, 46 = 10.10, p.05).A one-factor analysis of variance was used to compare student performance on Part B; no significant relationship was found (p >.05). Journals and a questionnaire were used to examine students' interest in science

and attitudes toward the instructional activities. Students in the 4MAT group were more interested in the unit, had a more favourable attitude toward the teachings, and displayed better on-task conduct than students in the textbook group, according to data analysis. This study is related to the current study because both used 4MAT to determine student achievement, but they differ in terms of students' class level, location, subject, and, most importantly, the current study seeks to determine the effect of 4MAT on achievement, retention, and multiple intelligences of students with various learning styles in biology.

Nitita-Kusolpoon (2002) conducted research on teaching to a variety of learning styles in a block schedule school using the 4MAT model. The study's main goal was to see how the 4MAT system of instruction affected student performance in a block-scheduled school. Three ninth-grade students were divided into three groups and taught in three distinct disciplines: English, Math, and Learning Support Science. Seven pupils were chosen at random from each class to be evaluated on their academic performance. Bernice McCarthy's eight-step educational technique was used to create the 4MAT lessons. The teachings were delivered over a nine-week period. Data was gathered via observational schedules, teacher interviews, and writing assessments. Pre- and post-test performance assessments for the three groups were used to evaluate the accomplishment hypothesis. The pre- and post-test scores were analysed using a rubric created by the Pennsylvania State Writing Assessment. To determine teachers' and students' learning styles, the Learning Type Measure (LTM) was used as an evaluation tool. To measure individual teaching styles, teachers were given the Teaching Style Inventory (TSI). Each class had different levels of student performance. The total performance scores in the Math class improved significantly. The performance scores in English class were small or insignificant. Students in the

Learning Support Science Class made no progress. This study is only relevant to the current study in terms of approach and design. The two studies are also linked since they both looked at how students with different learning styles performed.

Doughathai (2001) also looked at the impact of adopting the 4MAT lesson plan on learning success, responsibility, and attitude in both the education and professions populations. The study used a pre-test post-test randomised control group design. The study's sample size was 19 respondents, who were chosen using a basic random sampling procedure. The study was directed by four research questions. The achievement test and a learning attitude scale were used to collect data for the study. The study's findings revealed that the learning achievement of students taught using the 4MAT lesson plan and students taught using the department of curriculum's lesson plan differed.

Students that were taught using the 4MAT lesson plan outperformed their peers in the control group. In terms of method, this study is similar to the current one, but it is different in terms of subject and place. Huitt (2000) also investigated the impact of the 4MAT system of education on student achievement and attitudes in science. The study included 72 students from a Connecticut public high school in a rural setting. For one semester, the pupils were taught an Earth Science curriculum. A quasi-experimental group design was used in this investigation. The 4MAT System was used to teach the experimental group, whereas the textbook approach was used to teach the control group. Analysis of Covariance was used to test the hypothesis about students' attitudes toward science. There were no major differences discovered. On the other hand, the experimental group showed positive changes in attitude after the post-test. For six individual categories, total performance, and categories 1-8 combined, the Analysis of Variance on the product scores revealed substantial

differences favouring the control group. There were no significant variations in overall evaluation. A t-test found no significant differences in achievement across the groups. The experimental group outperformed the control group on the post-test, according to the mean achievement scores. An examination of covariance, on the other hand, revealed no significant differences. The study is, however, related to the current study in a number of respects, including a similar title, goal, and design. Nonetheless, the two studies differ in that the current study looked at the impact of the 4MAT of multiple intelligences on student retention and retention of students with diverse learning styles, which the prior study did not. The two studies also differ in terms of geography, or the location in which they are conducted.

Naveen (2021) investigated the impact of the 4MAT system of education on ninth-grade students' achievement, products, and attitudes toward science. The study's goal was to see how the 4MAT System of Instruction affected students' science achievement, products, and attitudes. The 4MAT model is an organised way of training that identifies students' learning styles, according to the study. The study included 48 students from a Connecticut public high school in a rural setting. For one semester, the pupils were taught an Earth Science curriculum. The 4MAT System was used to teach the experimental group, whereas the textbook approach was used to teach the control group. The study employed quantitative technique. To assess students' attitudes toward science and achievement, data was collected and evaluated using Analysis of Covariance and Analysis of Variance, respectively. The product scores were also subjected to an analysis of variance. Analysis of Covariance was used to test the hypothesis about students' attitudes toward science. The null hypothesis was not rejected since no significant differences were discovered. The experimental group, on the other hand, showed favourable changes in attitude after

the post-test. On total attitude ratings, a two-way Analysis of Variance by sex and class revealed no significant differences between the sexes in both groups. As a result, the idea was not disproved. For six individual categories, total performance, and categories 1-8 combined, the Analysis of Variance on the product scores revealed substantial differences favouring the control group. There were no significant variations in overall rating.

As a result, the null hypothesis was not disproved. Students in both groups had descriptive data tables created to reflect their preferred learning styles. A t-test found no significant differences in achievement across the groups. The experimental group's post-achievement mean scores suggested that they performed better on the post-test. An examination of covariance, on the other hand, revealed no significant differences. As a result, the null hypothesis was not disproved. The mean gain score for experimental group ladies was 9.94 points, while the mean gain score for experimental group males was 6.41 points. The results were shown to be significant using a t-test. In terms of method, gender, and experimental design, this study is similar to the current one, but it differs in other dependent variables such as multiple intelligence and retention.

Wilkerson and White (1998) looked at the impact of the 4MAT system on students' achievement, retention, and attitudes toward science. For one month, the study employed the 4MAT method to teach a scientific subject. A quasi-experimental approach was used in this investigation, namely a post-test only design. The study's sample size was 54 third-grade kids who were chosen using purposive sampling techniques. For the study, two entire classes were used. The experimental group was in one class, while the control group was in the other. The study used three instruments to collect data: a science achievement test, an attitude scale, and a

retention test, which was given unannounced 35 days after the post test. In this study, students who were taught using the4MAT method understood more content on simple machines, had better long-term recall as judged by an unannounced test 35 days later, and had a more favourable attitude toward the unit than students who were taught using the textbook approach. The 4MAT system of education was determined to be a successful instructional model for elementary pupils in this study. Male students who were taught utilising the 4MAT system did higher than their female counterparts, according to the study. This study is connected to the current study since it used the 4MAT method to assess student achievement and retention, which is something that the current study is investigating. The current study, on the other hand, attempts to investigate the impact of 4MAT on students' multiple intelligences, which appears to be a deviation from the previous study. Finally, the two research vary in terms of the locations where they were conducted.

Ukozor (2011) looked at the impact of constructivist teaching strategies on physics achievement and self-efficacy in senior secondary school students. A quasi-experimental design was used in this investigation. The study's sample size was 184 pupils recruited from the study's population from four secondary schools (two boys and two girls). The study was led by five research topics and three null hypotheses. The research questions were answered using mean and standard deviation, and the hypotheses were tested using ANCOVA. Male students were found to have a substantial effect of gender on their physics academic achievement. This study is related to the current study because gender is a moderating variable in the study, but the two studies are not identical in terms of the research methodologies.

Baser (2006) conducted a meta-analysis of gender inequalities in physics student performance and conceptual change. A total of 23 studies were selected from

a population of 5032. The goal of the study was to find out how big and how far gender inequalities in physics are among Nigerian students. For this study synthesis, 23 research studies from all around Nigeria were gathered. The data was analysed using the mean and standard deviation. The findings revealed that there is no substantial difference in physics between men and women. In terms of gender, this study is similar to the current one, but it differs in terms of research method, subject area, and location.

Madu (2004) investigated the impact of the constructivist instructional model (PEDDA) on student conceptual change. A quasi-experimental design was used in this investigation. The study was led by five research topics and four null hypotheses. A total of 134 SSII students were used in the investigation. The study questions were answered using mean and standard deviation, while the hypotheses were tested using ANCOVA at the 0.05 level of significance. The findings of the conceptual change trace analysis revealed that conceptual change is gender-dependent, with male students in science experiencing more conceptual shift than female students. Gender influences students' comprehension from preconception or alternative conception to scientific conception, according to the study. This study is related to the current study because gender is a moderating variable in the study, but the two studies are not identical in terms of the research methodologies.

The impacts of recorded instruction on secondary school students' progress in Biology were explored by Agommuoh and Nzewi (2003). Three hundred and ninety-eight SS1 children from two co-educational schools were chosen. We employed stratified and purposeful sampling approaches. The data was analysed using mean and standard deviation, and the hypotheses were tested using Analysis of Covariance (ANOVA) at 0.05 significance. Students' physics achievement improved significantly

when filmed instruction was used, according to the findings. When video-taped lessons were employed, student gender had no effect on their physics achievement. This study is similar to the current one in terms of gender, but it differs in terms of research method and place.

However, some of the works examined are biassed in favour of male students, while others are biassed in favour of female students. None of them, however, explained why there are significant gender variances. As a result, the current research will look into the relative effects of 4MAT on student achievement, retention, and multiple intelligences in Biology. This study aims to determine if 4MAT teachings favour male or female students the most. There is a gap in the body of knowledge on gender and achievement in science as a result of these inconsistent findings on gender and student achievement. The current study aims to fill that gap by contributing to the body of knowledge on gender and achievement in science.

2.14 Summary of Literature Review

According to the studies reviewed, science subjects in secondary schools are taught using a variety of teaching methods. These approaches include lecture, inquiry, discussion, and other problem-solving strategies, and they span from teacher-centered to student-centered instructional methods. Students' learning styles were also examined in the study. Individuals' learning styles are their distinct ways of perceiving and processing information. According to the review, different people learn in different ways. Individual learning styles are recognised and defined as a result of these variances. Many educators have attempted to do research on learning styles. Kolb, for example, claimed that learners require four different types of talents in order to be effective: concrete experience, reflective observation, abstract conceptualization, and active experimentation. This is called Kolb's learning circle.

Bernice McCarthy conducted study in 1972 on the best approach to teach learners in a class based on the above line of thought on learning styles and brain hemispheres. As a result, the four Mode Application Techniques were created (4MAT). The model brought two fresh perspectives on how the brain operates (right/left hemisphere) to Kolb's model (McCarthy, 1990). As a result, the 4MAT is a teaching model based on human brain function research in order to provide a practical teaching approach for maximising human learning and potential. Piaget's, Vygotsky's, and Jerome Bruner's constructivist theories are examined in this study. Learners are actively involved in the building and generation of knowledge, according to constructivist theory. More authentic learning may arise as a result of this. The usage of the 4MAT instructional model is recommended in this theory. The 4MAT concept encourages students to develop their own ideas and encourages them to use their many intelligences. Teachers can use the approach to incorporate a number of steps into their lessons. Connect, explain, image, inform, practise, expand, refine, and execute are the eight steps of 4MAT. Instructions that can stimulate the function of the two hemispheres of the brain are included into the session as it progresses. When adopting the 4MAT model, learning activities are organised in such a way that they address the model's eight steps. Because of the nature of the activities included in the model, the current study aimed to see if it may help students acquire multiple intelligences.

According to the evaluation, no research on the impact of the 4MAT on student success, retention, or multiple intelligences in the Abakaliki Local Government Area of Ebonyi State has been undertaken. However, many research on the impact of 4MAT on student accomplishment have been conducted without considering how students with different learning styles perform when exposed to

4MAT instructions, which formed the foundation for Bernice McCarthy's invention of the model in 1972. The goals of this study are to determine the impact of 4MAT on students' academic achievement, retention, and Multiple Intelligences in Biology, as well as to add to the body of evidence on gender and academic achievement, retention, and Multiple Intelligences.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This research study was conducted to find out the effect of 4MAT cycle on academic achievement of the students at secondary level in subject of Biology. The academic achievement of science students after eight weeks intervention in experimental and control groups was compared to evaluate the effect of 4MAT cycle. Two chapters (8, 9) from the 9thclass text book of Biology 2021 were selected for the study. Introduction to Nutrition and Transport are the names of these chapters respectively. Lesson plans were developed based on 4MAT teaching method and conventional teaching method for experimental and control group. Lesson plans were validated with the help of biology teachers and opinions of the experts. Researcher developed the Subject Achievement Test (SAT) as a research instrument to collect data pertaining to academic achievement of students that was constructed by the researcher.

3.2 Research Design

True experimental design was used in this study. In this design, pre-test post-test of control and experimental groups was conducted. Pre-test post-test control group design was used in the researches to control all the threats to internal and external validity. In this design participants are randomly selected and assigned. This is the only design which controls all threats related the experimental research (Gay, 2009).

The study is designed to investigate effect of4MAT Cycle on academic performance of students. The students of 9thclass were divided into two groups control

group and experimental group. Group one acted as a control group and taught with traditional method. While the other group was experimental group taught with 4MAT Cycle. Pre-test post-test control group true experimental design was selected for the study. The systematic description of the design is as follows:-

R = O1 T1 O2

R = O3 T2 04 (Creswell, 2009; Gay, 2009)

At this point

R means "random assignment of the subject to group",

O1 and O3 stand for "Pre- tests"

O2and O4 stand for "Post- tests"

T1 stands for "treatment with the 4 MAT Cycle".

T2 stand for "treatment with traditional lecture method".

Experimental group received instruction based on 4MAT Cycle while the control group received instruction using traditional lecture method. A male science teacher having qualification of M.Sc and B.Ed with ten years' experience was selected as instructor. The concerned teacher received training regarding the research study and implementation of 4MAT Cycle in classroom. Span of study was eight weeks and each session consisted of forty minutes each day for both groups. Subject Achievements Tests (SAT) was administered as Pre-test for both groups. Prior to conduct of experiment approval was taken from the administration.

3.3 Target Population

According to Gay, Mills and Airasian (2012) the population is the target group which is the group of interest for researcher and results of research study can be generalized. Population by its characteristics needs to be accessible or available in

term of time and cost. Thus the population is a realistic choice not an idealistic one (Gay, Mills & Airasian, 2012). In this study, target population consisted of all the science students at secondary level in Balochistan. As it was not possible to reach the target population. Therefore, researcher defined the accessible population of this study. There are 15 high schools in Tehsil Karazat District Pishin. In this connection the 9thclass Biology students in Government High School (Boys) randomly selected for the study.

3.4 Sample and Sampling of the study

Sample is a small group of individuals, things or events representing characteristics of larger group from which it is drawn (Gay, Mills & Airasian, 2012). In this study, the target population was consisted of all science students at secondary level in Balochistan. It was not possible to reach target population; hence, researcher. Due to financial, security and other constrains the study was limited to only district and one tehsil. The study was conducted in district Pishin and tehsil Karazat and only one school was randomly selected for the study.

Govt boys High School Khanozai was randomly selected for this study. All students of 9thgrade studying the subject of Biology of that school were selected as sample of study. The class was divided into equal groups experimental and control and each group consisted of 36 students. The students were divided randomly in equal groups on the basis of pre-test.

3.5 Instrument of the Study

In order to measure academic achievements of students in subject of Biology researcher developed the Subject Achievement Test (SAT), consisting of multiple-choice items. Researcher developed the research instrument named Subject Achievement Test (SAT) with the help of supervisor. SAT was consisted of 40

multiple choice questions (MCQs). This research instrument was used for both pre-test and post-test in the experimental and control groups.

3.6 Validity of the Instrument

All items of test instrument were improved by the expert opinions, because a good instrument must not only be reliable but also be valid.

3.7 Reliability of Instrument

Split-half method was applied to test the reliability of the test items. For the purpose of split-half method Subject Achievement Test was applied for pilot testing. In this connection twenty students of class 9^{th} were selected randomly from other school. This method is used to test the correlation among the even and odd numbers of test items of the instrument for its reliability through coefficient alpha. So the reliability coefficient alpha reflected that the research instrument was reliable as the coefficient alpha of test items remained 0.80.

3.8 Development and Validation of Lesson Plans

Researcher developed 40 lesson plans for the conventional lecture method and 4MAT cycle lesson planning comprised of 8 lessons. Each lesson plan consisted of one week. Lesson planning was according to sub-topics of two chapters. Lesson plans of experimental groups were planned implying 4MAT cycle consist of 8 stages method but the lesson plans of control group were reflected through conventional teaching method. Researcher himself trained the school teachers regarding 4MAT learning cycle. While the same school teacher of biology taught the control group according to developed lesson plans.

3.9 Treatment in the Study

The study spanned over eight weeks and each session for both groups consisted of forty minutes. Govt High School Khanozai was randomly selected for

thispurpose. Total students of class 9th were 72 and all were divided in two groups - control and experiment. Students were divided on the basis of pre-test. Control group was taught through traditional method and 4MAT Cycle method was applied on experimental group. SAT was used for both the groups andone teacher was trained regarding 4MAT cycle. Teacher had undergone one week training.The teacher was fully trained regarding the research. 4MAT cycle lectures consisted of 8 steps and the teacher was provided detailed lesson plan based upon 4MAT Cycle.

Researcher designed conventional teaching method for control groups. This type of teaching method was already in practice in government high schools of Baluchistan. Therefore, it was decided to continue lecture method for the control group. School teachers of Biology applied following different strategies of conventional teaching method for the students of control group;

(i) encourage rote memorization

(ii) transfer the subject material through lecture and by using white board

(iii) There was a poor interactive activity between teacher and students

(iv) only text book was used for teaching, formative assessment and to assign homework

(v) No collaborative work was assigned only engaged the students in individual

(vi) Students were forced to maintain and to complete their note books

(vii) students remained physically passive and cognitively active

(viii) teacher centred environment in class room was maintained

(ix) Biological concepts were explained by teachers through reading text book and dictating the diagrams and main points of the concept.

(x) individual differences of students and learning motivations were neglected

(xi) Teachers show anger to the students due to the poor interest, questioning during lecture and asking permit to drink water and washroom during lecture.

After eight weeks, post test was conducted for both the groups and the data was collected. To assess the retention of the content in both the groups SAT was applied after three months and data was collected.

3.10 Analysis of the Data

The entire research question was answered using mean and standard deviation. T-test was applied and the hypotheses were tested. The data was analyzed using latest version of Statistical Package for Social Sciences (SPSS). Mean, Standard deviation and difference of mean were computed. T-test was applied to measure the significance difference between mean of two groups.

3.11 Selection of Text

Prior to selection of text to conduct experiment, researcher considered specific text on following basis (i)meeting to discuss the syllabus covered by the working teachers of concerned 9^{th}classes (ii)course out-line for9^{th}class biology proposed by Baluchistan Text Board Quetta(iii) School examination limitations two units of class 9^{th} biology were planned for intervention. Biology text book, published by Baluchistan Text Book Board Quetta, 2018 was present for the purpose.

Detail of these two units is as follows: Chapter 8 "Introduction of Nutrition" which contains the following sub topics. Components of Human Foods, Mineral, Calcium, Iron, Vitamins, Dietary Fiber and Balance Deit (ii) Problem related to nutrition, Malnutrition, Kwashiorkor, Mineral Deficiency, Diseases, Overtake of

Nutrients, (iii) Effects of nutrients, (iv) Factor that contribute to famine, Digestive system, Alimentary Canal, Pharynx and Esophagus, (v) Stomach, Small intestine, Large intestine (vi)Structure and Function of Villus Role of pancreas in Digestion, (vii) Role of liver in metabolism and digestive disorder. Chapter 9 "Transport" was consisted of following sub topics: i. Introduction ii Transportation and Transpiration in Plants iii. Factor Affecting Transpiration, iv. Significance of Transpiration, v. Transport of water in stem, iv. Translocation of Food in Plants

3.12 Construction of Test Items

The researcher from the selected text developed 16 MCQs and 1 Label the diagram Question from chapter No8, 16 MCQs from chapter No.9 and 1 Question regarding label the diagram. Adopting this procedure test items of the instrument were developed. Researcher applied nature of questions present in text book of Biology for class 9th printed by Baluchistan Text Book Board Quetta

3.13 Marking of test items.

Marking scheme for MCQs was developed by researcher in such a way that one mark was assigned to each correct answer which is international standard. Research instrument contained 32 MCQs and two diagrams to be labelled from chapter 8 and 9 text book of biology for class 9th printed by Baluchistan Text Book Board Quetta that was marked with the help of Rubric(Appendix 8).

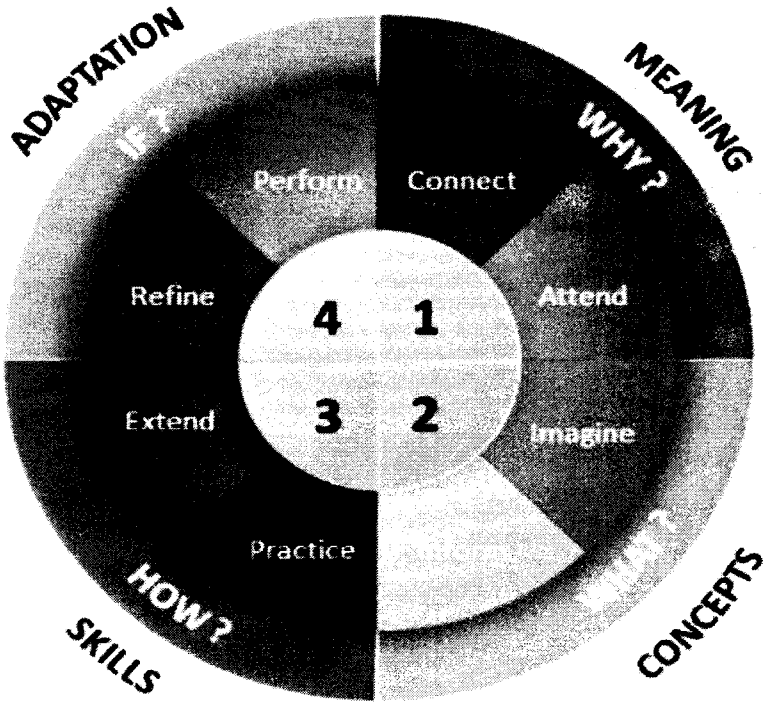
3.14 Explanation of the experiment

Govt Boys High School Khanozai was randomly selected for this research study. There were two sections in class 9$^{th.}$ Pre-test was administered for both the section. They were divided in two groups on the basis of pre-test. Both the groups were taught for eights week. Group A was treated as traditional conventional method while group B was treated as 4 MAT method. The time period of experiment was

eight weeks. Chapter 8 and 9 Biology Book printed by Baluchistan Text Board of Quetta, was selected for the study. Introduction to nutrition and Transportation are the names of these chapter. There were 40 period in the entire study each period consists of 40 minutes from Monday to Friday. Two chapter were covered in the study. 40 lessoning plans was made by the researcher for the traditional conventional classrooms. There were 5 periods in each week. While 4MAT lesson plans was consists of the entire week. That was further divided on 8 steps of the model. After eight weeks post-test was administered for both the groups. After the time period of three months retention test was administered for both the groups

3.15 Development and Validation of Lesson Plans

Researcher developed fourty (40) lesson plan for traditional conventional group from chapter 8 and 9 from the text book of Biology for class 9th Prepared by Baluchistan Text Book Board Quetta. While 8 lesson plans were prepared for experimental group based 4MAT model that is further divided in 8 stages.



The figure above 4MAT cycle consists of eighty stages, it is based on the assumption and processes of constructivist's theory and it offers different ways of thinking about learning. The quadrants with their steps and teachers and students activities are discussed below:

3.16 Duration of Experiment

Researcher performed the experiment from May, 24 to July 17, 2021. According to time table of the selected schools, 40 minutes per day were specified for intervention in experimental and control groups. In this way experiments prolonged for eight weeks (5 days per week).

3.17 Instructional Strategies of Experimental and Control Groups

Experimental group was treated through 4MAT cycle that was developed by Brince McCatthy and researcher designed conventional teaching method for control group. This type of teaching method was already in practice in government high schools of Baluchistan. Therefore, it was decided to continue lecture method for the control group. School teachers of biology applied following different strategies of conventional teaching method for the students of control group. i. encourage rote memorization ii. Transfer the subject material through lecture and by using white board iii. There was a poor interactive activity with teachers and among the students. iv. Only text book was used for teaching, formative assessment and to assign homework v. No collaborative work was assigned only engaged the students in individual vi. Students were forced to maintain and to complete their note books vii. Make the student's physically passive and cognitively active viii. Maintain teacher centered environment in the class room ix. Biological concepts were explained by the teachers through reading the text book and dictating the diagrams and main points of the concept. x. neglect the individual differences of students and learning motivations.

xi. Teachers show anger to students due to poor interest, questioning during lecture and asking permit to drink water and washroom during lecture.

3.18 Equal educational Opportunities

Researcher was bound to provide equal educational opportunities to the experimental and control groups. Following steps were taken for the purpose:-

(i) Time duration of teaching /day,(ii) Subject matter or chapters of text book to teach,(iii) Total number of lesson plans (iv) administration time of students' achievement test

3. 19 Execution of Experiment

Following steps were taken to precede the experiment:-

3.19.1Ethical Consideration

Before execution of experiment, the consent forms and children assent forms were signed with the schools' headmaster and the biology subject teachers (as a guardian) of class 9th respectively. Permission letter for intervention was already taken from District Education Officer Pishin. Students were informed about experimental research and were asked to take part in this experiment. The aim of study was to enhance deep concepts of Biology and critical thinking skills. The researcher assured them that the secrecy and confidentiality of the institution (including the participants) will be maintained. The information obtained will be kept securely and data will only be used by the research team for academic purposes (Fraenkel, wallen & Hyun, 2012).

3.19.2Administration of pre-test

Prior to start intervention, Subject Achievement Test SAT was administered as pre-test on May 24, 2021. The scores collected from pre-test were used to assess the academic ability of students in biology (see analysis in chapter No.4).

3.19.3Variables' control in study

Intervention was held in government boys high schools Khanozai Tehsil Karazat District Pishin. The researcher has taken following steps to decrease the effect of internal and external threats.

3.19.4. Control of internal threat

Researcher took following steps to control the internal threats of the experiment.

1) History: Experiments of the study continued for eight weeks. There was no any incident happened during this period that might influence the academic achievement of the students.

2) Testing: One threat of testing can be the text book based test which may be familiar to the student and can affect the validity of the results. Therefore, researcher developed the instrument based on 4MAT model was content based and quite new for the students. Second threat of testing was the time duration of experiment. For the purpose two months duration is enough to forget the unseen items of pre-test. More over the students were not aware the conduction of post-test at the end.

3) Developing of Instrument: Subject achievement test (SAT) was validated and reliability was taken before administering it on the students to avoid the threat of instrumentation.

4) Mortality: This experiment was limited to eight weeks which is not a long period. In addition, the cooperation of school management and the interest of the students also made sure that no student remained absent during the study.

3.19.5 External validity of the experiment

External threats were controlled by the researcher by taking following steps:

1) Interference of multiple treatments: There is no chance to take coaching class as extra treatment by the subjects instead of the researcher or the subjects were already involved in any related research study which can interfere the true results of experiment. School teachers of Govt High School Khanozai were unaware of the 4MAT model, so it was not a risk of interference of treatment. Moreover, researcher applied a single treatment in the both experimental and control groups.

2. Selection of students: simple random sampling and pair random sampling were used for the selection of the subjects to avoid the subjectivity.

3) Specificity of variables: All the procedural steps were taken carefully to avoid the external threats. Lesson plans were validated, SAT was pilot tested and randomly administered. Due to such specificities, it was tried to avoid this threat. There was no gap between the end of experimentation and post-test. All the criteria of the experiment were well defined like pre-test, post-test, rubric, applying of 4 MAT model duration of intervention.

3.20 Conduction of Post-Test

Post-test was administered to the next day of last session of intervention on July17, 2021. Achievement scores of all the students were calculated by subtracting the pre-test scores from post test scores.

3.20.1 Retention test

After the passage of three months retention rest was conducted on October 24, 2021. To assess how much the students, retain concepts. The test was administered for both groups controlled and experimental group.

3.21 Teacher Training

One-week teacher training was organized by the researcher for the concern teacher regarding 4 MAT learning cycle for Biology Teacher in Govt Boy High

School Khanozai. He was trained how to teach biology through 4MAT learning cycle Eight Stages. He was trained in the entire circle of eight stages.

Day One

Two steps were covered in each day in first day step one and step two were covered.

Step One Connect

The first step was designed in such a way. To engage the learner and assess prior knowledge of the learner along with prior experience. The concern teacher was trained how to capture the attention of the students and to link the concept with the prior knowledge of the students. The teacher was trained to start from a point which is familiar to the students and build on the prior knowledge of the students. Activities may be included in this stage such as listening, speaking, autobiographical information, personal reflection, mind mapping, role play and drawing. For example, if a teacher wants to teach respiratory system the teacher will call the student to run around the classroom and observe breathing what happened. Prior knowledge is important in this stage. Teacher will encourage the student and teacher will connect the student in personal way.

Step Two Attend

In the second step of the 4 MAT learning cycle teacher will apply constructivist learning theory in the classroom. In this stage the teacher can ask learner think about experience and share this with rest of the class. The concern was trained on how to use entry behaviour to initiate prior knowledge into the new concept under study. In this stage it is important to find out what is the current, perception, construction and misconception student bring with them or exist regarding the topic. The teacher must know what students actually know about the current topic and what

is their perception regarding the topic. Without knowing their perception and understanding regarding topic understudy it will be impossible to connect and lead the students toward the topic under study. In this stage the teacher will guide and encouraged the students to reflect and analyze their experience regarding step one. After analyzation the students will be guided to share to the class. Sharing of experience and information will realize a teacher regarding their current state of understanding about the topic. Teacher will teach and lead the class in the light of their current state of knowledge regarding the topic under study. This is the judgement and dialogued generated stage. Teacher will engage the student's reflection upon their existing level of knowledge and experience.

Day two

Step three and step four will be covered in the second day.

Step three Image

This is the third step of 4 MAT learning cycle this connecting stage. In this stage teacher is expected to synthesize the reflection from previous individual and personal experience in to visual image or feeling. In this stage teacher will connect personal experience of the students with the current topic and concept under study, teacher will relate the concept with the understanding level of the students. Teacher will deepen the connection between the current concept and what the students already know about the topic. The teacher will also assess what are their misconception regarding the topic. Teacher may use different strategies to connect the concept and current state of knowledge of the students. He will be taught in to an image or experience a "Sneak Preview" for the students. Different activities may be included such as creating analogies, parenting metaphors and discussion. Model or drawing will play significant role in the stage. Teacher must prepare a diagram or model

begore the class. Image will play vital role in connection image making is the central activity of the stage.

Step four

In this stage the teacher gives factual and conceptual information to the students regarding the topic understudy. Teacher will cover all aspects of the topic, and teacher will provide information regarding the current topic. Students will listen attentively ask the question where necessary and follow the instruction of the teacher. Different medial can be used in this stage such as lecture. Visual computer assisted instruction, test film, charts, play cards and diagrams. Information will be provided in organized manner and sequence will be followed while delivering the lecture or any other teaching method. Students will be fully engaged and will be answered regarding the topic. Complete information will be provided while covering the different aspects of the topic. In this stage the role of teacher will be information provider and information will be provided in systematic way. The student will be provided acknowledge body of information.

Day three

Step 5 and 6 will be covered on third day of the training.

Step four Practice

In the fifth stage of the 4 MAT learning cycle learner will practice and use the information. How it works is the most important aspects of this stage. Learner will use information in real world, apply and assess how it works. Teacher will play the role of guide in the stage and learner will practice the lecture information. Student will apply the information in real world specially related to their lives. Hands on activities will be provided by teacher to the students in the regard. Teacher will check, assess the concept, mastery and skill of students related to topic understudy. Activities may be

included field work, lab work, exploring, manipulating, and applying fact and concepts, work sheets, puzzles, labelling diagrams and computer experiment. In this stage emphasize shift from acquisition and assimilation to adaption and testing. Teacher will guide and support the students to apply what he was taught

Step Six Extend

In sixth stage of 4MAT learning cycle students will test the limits and contradiction of what he learned. Student will use information in more sophisticated way. Teacher will be encouraged and motivated the learner to apply what he learned but with new idea in personal way. In this stage students will be encouraged to developed their own application which will realize the level of understanding of the learner regarding the concept. Project work is the essence of the stage. Teacher will assign different sub topics to the different group inside the classroom. Or student can select topic or project of their choice regarding the concept understudy. Student can design their own project or topic to be explored. In this stage students work cooperatively. In this stage students do more than just practice exploring the topic or project will lead them toward more understanding regarding the topic. This activity will tighten the grip of the students over the topic under study

Day four

Step seven and eight were covered in the session:-

Step seven

In this stage teacher guided and got answer of questions of the students and refine knowledge regarding the concepts. The learner moves from simple to complex practices and use the information. Feedback will be provided by the teacher in this stage to remove the quarries of the students. His information will be refined and the learning will be encouraged to analyze their use of learning. Students edits, revise, his

proclaim regarding the concept under study. Feedback and assessment will be provided by the teacher to strengthen the grip over the topic and remove the quarries of the learner regarding the topic understudy. Students will perform to show proof of their learning based on relevance to content. Students will realize what why he was performing in a wrong way.

Step eight

This is the last stage of 4MAT learning cycle. In this stage students will present the original example of their learning. Students will show their presentation to other students of the class in meaning full way. In this step they move from individual, private act to more open and public exhibits. This stage can be name as learner accomplishment stage. This stage is integration, celebration and closing stage of the learning cycle. This is also a presentation stage, teacher will assess the understanding of the students regarding the concepts under study. This is a stage where final draft is submitted, letters are mailed and poems are recited by the learner. The role of teacher is facilitator, supporter and to join the celebration and preparation for nest unit.

Day five and sixth

On the fifth and sixth day of the training a biology teacher was observed during the teaching based on 4 MAT learning cycle. He was further trained while teaching and observed at in the different stages of the cycle. A small topic was selected to practice based on 4 MAT learning cycle before carrying out the experimental group. Researcher monitored the teacher to ensure the understanding of teacher regarding 4MAT learning cycle. The researcher supported and corrected where necessary.

3.22 Role of Teacher in Different Stages of 4MAT

3.22.1 Role of teacher in step one

The first step of the 4MAT System is designed to engage the learner to search of prior knowledge and prior experience. This search is designed to create an interactive group dialogue which connects what the learner already knows and believes to what the teacher intends to teach. In this dialogue there are no correct answers. Learners experience and compare their perceptions of their existing state of knowledge and work cooperatively to create an overall learning set from which to proceed. In this step the teacher encourages diversification of ideas, dialogue and participation. The teacher will connect students directly to the concept in a personal way and he will capture students' attention by initiating a group problem-solving activity before delivery of instruction. Teacher will deliberate any situation that is familiar to students and builds on what they already know. Teacher will construct a learning experience that allows diverse and personal student responses. He will facilitate the work of cooperative teams of students.

3.22.2 Role of teacher in step two

The second step of McCarthy's 4MAT System is designed to add process judgment to the perceptions and dialogue generated in step one. In this teaching set, the teacher engages student reflection upon their existing level of their knowledge and experience to determine if their opinions and beliefs are supportable. The emphasis here is not to qualify or bring closure to student thinking. The teacher will guide students to reflection and analysis of the experience. The teacher will encourage students to share their perceptions and beliefs with teacher and students. Teacher will summarize and review similarities and differences, establish a positive attitude toward the diversity of different people's experience. Teacher will clarify the reason for the

learning. This is the prime question of the stage why students are learning. What is the basic reason of learning the current topic or concept?

3.22.3 Role of teacher in step three

Step three of the 4MAT System is designed to create a context for the learner to represent the subjective nature of his/her existing knowledge as a preparation for the validation and analysis of ideas. In this step learners are encouraged to symbolize, in as many modalities as feasible, their present state of understanding of the subject matter. Image making, central to this step, the emphasis here is the expansion of representations of meaning. However, this step requires the learner to begin to shift from reflective experience to reflective thinking. The teacher's role here is to draw attention to aspects of structure and objectivity implicit in the student's representations of what they know. Teacher will lift students into a wider view of the concept and he will use another medium (not reading or writing) to connect students' personal knowing to the concept (i.e. visual arts, music, movement, etc.). Teacher will involve learners in reflective production that blends the emotional and the cognitive. Transform the concept yet to be taught into an image or experience, a "sneak preview" for the students. Teacher will try to deepen the connection between the concept and its relationship to the students' lives. Teacher will relate what the students already know to what the experts have found.

3.22.4 Role of teacher in Step Four

Step four of the 4MAT System engages students in objective thinking. The emphasis here is analysis of verifiable concepts, facts, generalizations and theories. The role of the teacher is to present information and experience in complete and systematic ways. Define theories and concepts. Teacher will provide "acknowledged body of knowledge" related to the concept or topic. Teacher will emphasize the most

significant aspects of the concept in an organized, organic manner. He will present information sequentially so students see continuity. Teacher will try to draw attention to important, discrete details; don't swamp students with myriad facts. Teacher will use a variety of delivery systems: interactive lecture, text, guest speakers, films, visuals, demonstrations, etc. when available. Teacher will use variety of instructions to make them understand.

3.22.5 Role of teacher in step five

In step five of the 4MAT System the teacher's role here is coaching and assisting as students refine their ability to find applications of their ideas the emphasis shifts from acquisition and assimilation to testing and adaptation. Students now take the lead to apply what has been taught.

Students demonstrate their ability to apply the concepts is important here. This is the stage of practice in this stage students was apply the idea taught to them in the class and teacher was provide hands-on activities for practice and mastery. Teacher was check for understanding of concepts and skills by using relevant standard materials, i.e. worksheets, text problems, workbooks, teacher prepared exercises, etc. he will provide opportunities for students to practice new learning, perhaps in multi-modal ways (learning centers, games fostering skills development, etc.). Teacher was concept of mastery learning to determine if re-teaching is necessary and how it was carried out. Teacher was also observe how students create additional multi-modal practice for each other.

3.22.6 Role of teacher in step six

Step six of the 4MAT System, in this learning set the student tests the limits and contradictions of his/her understanding. The teacher's role is to encourage students to take the application of learned ideas to more sophisticated, personal levels.

Students are encouraged to develop their own applications which demonstrate that they understand and can apply what has been learned. Project work is the essence of this phase of the 4MAT Model. Teacher was encourage tinkering with ideas/relationships/connections, and he was set up situations where students have to find information not readily available in school texts or book. They was provided opportunity to design their own open-ended explorations of the concept. Teacher was provide multiple options so students can plan a unique "proof" of learning. Teacher was help students to organize and synthesize their learning in some personal, meaningful way. This stage is also called project stage in this stage teacher was assess students' performance regarding the concept.

3.22.7 Role of teacher in step seven

Step seven of the 4MAT System requires the learner to critically examine the place of the newly acquired knowledge and experience in his/her existing world view the teacher's role here is to guide the refinement of the old schema and encourage the formation of a more complete perspective. Note the requisite of this step to objectify intuition. The central issue here is what new questions do I have and what must be done to integrate this learning into a meaningful conceptual subset. Working alone or preferably in pairs and triads, learners in this learning set edit and refine their work. They also face and resolve contradictions implicit in the tension between new and earlier schema. In this step teacher was provide guidance and feedback to students and help students to analyze their use of the learning for meaning, relevance, and originality, maintain high expectations for completion of chosen options. Teacher was use mistakes as learning opportunities. Teacher summarize by reviewing the whole, bringing students "full circle" to the experience with which the learning began.

3.22.8 Role of teacher in step eight

The essence of step eight in the 4MAT System is integration, celebration and closure. In this learning set, the learner returns to the place where he/she began, the self, and integrates the learning experience into a slightly different, personally held world view. This is the step where presentations are given, where poems are recited, where letters are mailed and research reports submitted. The teacher's role is to join in the celebration and facilitate entry into the next unit of study. The role of teacher in this stage is to conduct summative assessment in the class and he was also support students in learning, teaching, and sharing with others. Teacher was establish a classroom atmosphere that celebrates the sharing of learning. There was an opportunity for students to practice new leaning. Teacher was make students learning available to the larger community, i.e. books students write are shared with other classes; students report in school paper; student work is displayed throughout the school; etc. teacher was leave students wondering (creatively) about further possible applications of the concept, extending the "what ifs" into the future.

CHAPTER NO4

DATA ANALYSES AND INTERPRETATION

Present research study was conducted to find out effectiveness of 4MAT Teaching model in Biology at Secondary level. This chapter deals with analysis of data and its interpretation. This experimental study was conducted in government high school in Baluchistan. Data were collected through self-made students achievement test (SAT). Descriptive analysis was used to calculate the central tendency and variation. In addition inferential analysis was applied on the data to compare the academic achievement of students within and across groups. The significance level (0.05) was applied in the comparison of the groups for the acceptance or rejection of the hypotheses. Interpretation and analysis of data are as follows:-

4.1 Comparison of Pre- test Scores of Experimental and Control Group

Table 4.1

*Experimental and Control groupPre-test mean (*Group statistics)

	Male	N	Mean	Std. Deviation	Std. Error Mean
pre test score male	Experimental	36	4.7778	2.13957	.35660
	Control	36	4.7500	2.08909	.34818

In the Table 4.1 there was same number of candidates in the control group and experimental group who were tested before the instruction. Mean scores of experimental group was 4.77 and mean scores of control group was 4.75. Standard deviation mean of experimental group and control group was 2.13 and 2.08 respectively.

Means result of two groups indicate that there was no difference in the scores of the experimental group and control group.

Table 4.2

Comparison of pre test mean of Experimental group and Control group

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
pre test score	Equal variances assumed	.064	.801	.056	70	.956	.027	.498	-.966	1.021
	Equal variances not assumed			.056	69.960	.956	.027	.498	-.966	1.021

It is evident from table 4.2 that mean difference in pre- test of experimental group and control group before the treatment was 0.027 and the standard error difference was 0.49. The t value was 0.056 and the significance level was 0.95 which is more than 0.05. It was interpreted that there was no significant difference in the scores of control group and experimental group before the treatment.

4.2 Academic Achievement of experimental group

Table 4.3

Experimental grouppre-test post-test mean (Paired Samples Statistics)

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre test	4.77	36	2.139	.356
	Post test	31.86	36	3.562	.593

Table 4.3 indicates that there were 36 candidates in the experimental group who were tested before and after the treatment. The mean of marks of pre-test of experimental group was 4.77 and the mean of marks of post test of the same group after treatment was 31.86. Standard deviation means before and after treatment to the experimental group was 2.13 and 3.56 respectively.

Means results indicate that there was improvement in students before and after treatment. The experimental group was treated with the 4MAT teaching model.

Table 4.4

*Experimental grouppre-test post-test correlation (*Paired Samples Correlations)

		N	Correlation	Sig.
Pair 1	Post test & Pre test	36	-.030	.860

Table 4.4 shows the correlation between pre-test and post-test in the experimental group. The correlation of 36 candidates score was -.030 which shows increasing the achievements of the students from pre-test to post test.

Table 4.5

*Experimental group pre-test post-test comparison t test (*Paired Samples Test)

		Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Post test – Pre test	-27.08	4.21	.701	-28.50	-25.65	-38.5	35	.000

Table 4.5 shows that mean score difference between pre-test score and post-test score is 27.08 and standard deviation is 4.21, t value is 38.58 and the significance value is less than 0.05. There was a clear difference between the two values of pre-test and post-test which was a 27.08.The significant difference was interpreted by the value of significance of pre-test score and post-test score which is less than 0.05.

4.3Academic achievement of control group

Table 4.6

Control grouppre-test post-test mean (Paired Samples Statistics)

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	4.75	36	2.089	.348
	Posttest	19.86	36	6.169	1.028

Table 4.6 indicates that there were 36 candidates in the control group who were tested before and after the treatment. The mean of marks of pre-test of control group was 4.75 and the mean of marks of post test of the same group after treatment was 19.86.

Standard deviation "mean" before and after treatment to the control group was 2.08 and 6.16 respectively.

The means of results indicate that there was improvement in the students before and after the treatment. The control group was treated with the traditional lecture method.

Table 4.7

*Control group pre-test post-test correlation (*Paired Samples Correlations)

		N	Correlation	Sig.
Pair 1	pre-test&post-test	36	.731	.000

Table 4.7 shows the correlation between pre-test and post-test in the control group. The correlation of the marks of 36 candidates was 0.73 and the significance level was 0.00. This positive correlation shows the improvement of the students.

Table 4.8

*Control group pre-test post-test comparison t test (*Paired Samples Test)

		Paired Differences					T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	pre-test - post-test	-15.11	4.85	.80	-16.75	-13.46	-18.66	35	.000

Table 4.8 shows that mean score difference between pre-test score and post-test score is 15.11 and standard deviation is 4.85, t value is 18.66. There was a clear difference between the two values of pre-test and post-test which was 15.11.The significant difference was interpreted by the value of significance of pre-test score and post-test score which was less than 0.05.

4.4Academic Achievement comparison of Experimental and control group

Table 4.9

Experimental and Control group achievement mean(group statistics)

	Group	N	Mean	Std. Deviation	Std. Error Mean
post test	Experimental group	36	31.86	3.562	.593
	Control group	36	19.86	6.169	1.028

In Table 4.9 there was same number of candidates in control group and experimental group who were tested after instruction. Mean scores of experimental group was 31.86 and the mean of scores of control group was 19.86. Standard deviation mean of experimental group and control group was 3.56 and 6.16 respectively.

Means results of two groups indicate that there was significant difference in the scores of the experimental group and control group.

Table 4.10

Experimental and Control group post test mean(independent samples test)

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
post test	Equal variances assumed	8.49	.005	10.10	70	.000	12.00	1.18	9.63	14.36
	Equal variances not assumed			10.10	56.00	.000	12.00	1.18	9.62	14.37

It is clear from table 4.10 that the mean difference in post test of experimental group and control group after the treatment was 12.00 and the standard error difference was 1.18. The t value was 10.10 and the significance level was 0.00 which is less than 0.05. It was interpreted that there was a significant difference in the achievements of control group and experimental group after the treatment. It was observed that there was a significant difference between effectiveness of 4MAT teaching model and conventional teaching method on students' achievements.

4.5 Retention test of Experimental group

Table 4.11

Experimental group post-test retention-test mean (Paired Samples Statistics)

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Post-test	31.86	36	3.562	.593
	Retentiontest	31.52	36	3.798	.633

Table 4.11 indicates that there were 36 candidates in the experimental group who were tested for retention after three months of the post test. The mean of marks of post-test of experimental group was 31.86 and the mean of marks of retention test of the same group was 31.52. Standard deviation "mean" of post test and retention test scores was 3.56 and 3.79 respectively.

The means of results indicate that there was no big difference in the scores of students in post test and retention test.

Table 4.12

*Experimental group post-test Retention-test correlation (*Paired Samples Correlations)

		N	Correlation	Sig.
Pair 1	Post-test & Retentiontest	36	.960	.000

Table 4.12 shows the correlation between post-test and retention test in the experimental group. The correlation of the marks of 36 candidates was 0.96 and the significance level was 0.00.

Table 4.13

*Experimental group post-test Retention-test comparison t test (*Paired Samples Test)

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Post-test & Retention test	.33	1.06	.17	-.02	.69	1.87	35	.070

Table 4.13 shows that mean score difference between post-test and retention test score is 0.33 and standard deviation is 1.06, t value is 1.87. There was a very less difference between the two values of post-test and retention test which was 0.33.There was no significant difference was interpreted by the value of significance of post test score and retention-test score(0.07) which is more than 0.05.

4.6 Retention test of Control group

Table 4.14

Control group post-test retention-test mean (Paired Samples Statistics)

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Posttest	19.86	36	6.169	1.028
	Retentiontest	18.61	36	5.607	.934

Table 4.14 indicates that there were 36 candidates in the control group who were tested for retention test after three months of post test. The mean marks of post test of control group was 19.86 and the mean of marks of retention test of the same group was 18.61. Standard deviation "mean" of post test scores and retention test scores to the control group was 6.16 and 5.60 respectively.

The means of results indicate that there was difference in the scores of students in post test and retention test. The control group was treated with the traditional lecture method.

Table 4.15

*Control grouppost-test retention test correlation (*Paired Samples Correlations)

		N	Correlation	Sig.
Pair 1	Posttest & Retentiontest	36	.935	.000

Table 4.15 shows the correlation between post-test and retention test in the control group. The correlation of the marks of 36 candidates was 0.935 and the significance level was 0.000

Table 4.16

*Control grouppost-test retention test comparison t test (*Paired Samples Test)

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Posttest – Retentiontest	1.250	2.195	.365	.507	1.99	3.41	35	.002

Table 4.16 shows that mean score difference between post-test and retention score is 1.25 and standard deviation is 2.19, t value is 3.41. There was a clear difference between the two values of post-test and retention test which was 1.25.The significant difference was interpreted by the value of significance of post-test and retention score which was less than 0.05.

4.7 Comparison of Experimental and control group Retention test

Table 4.17

Experimental and Control group achievement mean(group statistics)

Group		N	Mean	Std. Deviation	Std. Error Mean
Retentionte st	experimental group	36	31.52	3.798	.633
	control group	36	18.61	5.607	.934

In the Table 4.17, there was same number of candidates in the control group and experimental group who were tested after three months of post test for retention. The mean of scores of experimental group was 31.52 and the mean of scores of control group was 18.61. Standard deviation mean of experimental group and control group was 3.79 and 5.60 respectively.

The means of results of two groups indicate that there was a difference in the scores of the experimental group and control group in retention test.

Table 4.18

Experimental and Control group post test mean(independent samples test)

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Retentionte st	Equal variances assumed	4.45	.038	11.44	70	.000	12.916	1.128	10.665	15.168

Equal variances not assumed	11.44	61.53	.000	12.916	1.128	10.659	15.173

It is clear from table 4.18 that mean difference in retention test of experimental group and control group after three months of post test was 12.91 and the standard error difference was 1.12. The t value was 11.44 and the significance level was 0.00 which is less than 0.05. It was interpreted that there was a significant difference in the achievements of control group and experimental group in the retention test. It was observed that there was a significant improvement and consistency in the learning of students based on 4 MAT model of teaching method as compared to conventional teaching method.

4.8 ANOVA of Retention –Test Experimental and Control groups

Table 4.19

ANOVA of Achievement

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	3474.569	5	694.914	40.442	.000
Within Groups	1134.083	66	17.183		
Total	4608.653	71			

Table 4.19 indicates that the value of F is 40.44, which reaches significance with a *p*-value of .000 (which is less than the .05 alpha level). This means there is a statistically significant difference between the means of the different levels of the ability.

There was a statistical significant difference between groups as demonstrated by one way ANOVA (F(5,66)= 45.55, P= 0.000).

Table 4.20

Multiple comparison of achievement in method of instruction and ability level

(I) Male	(J) Male	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
	AAE	1.083	1.692	.987	-3.88	6.05
	LAE	-1.417	1.692	.959	-6.38	3.55
HAE	HAC	8.500*	1.692	.000	3.53	13.47
	AAC	12.917*	1.692	.000	7.95	17.88
	LAC	17.000*	1.692	.000	12.03	21.97
	HAE	-1.083	1.692	.987	-6.05	3.88
	LAE	-2.500	1.692	.680	-7.47	2.47
AAE	HAC	7.417*	1.692	.001	2.45	12.38
	AAC	11.833*	1.692	.000	6.87	16.80
	LAC	15.917*	1.692	.000	10.95	20.88
	HAE	1.417	1.692	.959	-3.55	6.38
	AAE	2.500	1.692	.680	-2.47	7.47
LAE	HAC	9.917*	1.692	.000	4.95	14.88
	AAC	14.333*	1.692	.000	9.37	19.30
	LAC	18.417*	1.692	.000	13.45	23.38
	HAE	-8.500*	1.692	.000	-13.47	-3.53
	AAE	-7.417*	1.692	.001	-12.38	-2.45
HAC	LAE	-9.917*	1.692	.000	-14.88	-4.95
	AAC	4.417	1.692	.109	-.55	9.38
	LAC	8.500*	1.692	.000	3.53	13.47
	HAE	-12.917*	1.692	.000	-17.88	-7.95
	AAE	-11.833*	1.692	.000	-16.80	-6.87
AAC	LAE	-14.333*	1.692	.000	-19.30	-9.37
	HAC	-4.417	1.692	.109	-9.38	.55

	LAC	4.083	1.692	.167	-.88	9.05
	HAE	-17.000*	1.692	.000	-21.97	-12.03
	AAE	-15.917*	1.692	.000	-20.88	-10.95
LAC	LAE	-18.417*	1.692	.000	-23.38	-13.45
	HAC	-8.500*	1.692	.000	-13.47	-3.53
	AAC	-4.083	1.692	.167	-9.05	.88

*. The mean difference is significant at the 0.05 level.

Multiple Comparisons table 4.20 shows the significance values for the mean differences of achievement between pairs of the various levels of ability (High Achievers, Average Achievers and Low Achievers in experimental and control groups).

Tukey HSD (Honest Significant Difference) shows that it is the mean difference between the pairs of ability level as follow

1. High Achievers Experimental group (HAE) indicates the significance difference between the HAC (0.00) AAC (0.00), LAC (0.00) whose p values are less than the standard .05 alpha level. But there is no significant difference between the higher achievers and Average achievers and lower achievers in experimental group because the p value of AAE (0.98) and LAE (0.95) is more than the alpha value(0.05)
2. Average Achievers Experimental group (AAE) indicates the significance difference between the HAC (0.01), AAC (0.00) and LAC (0.00) whose p values are less than the standard .05 alpha level. But there is insignificant difference of AAE between the HAE and LAE in experimental group because the p value(0.98) and (0.68) respectively is more than the alpha value(0.05)

3. Low Achievers Experimental group (LAE) shows the significance difference between the HAE (0.03), HAC (0.00), AAC (0.00) and LAC(0.00) whose p values are less than the standard .05 alpha level. But there is insignificant difference of LAE and HAE (0.95) and AAE(0.68) in experimental group because the p valuesare more than the alpha value(0.05)
4. High Achievers Control Group (HAC) indicates the significance difference between the HAE (0.00) AAE (0.01), LAE (0.00) and LAC (0.00) whose p values are less than the standard .05 alpha level. But there is insignificant difference of HAC between the AAC (0.10) in control group because the p is more than the alpha value (0.05).
5. Average Achievers Control Group (AAC) indicates the significance difference between the HAE (0.00) AAE (0.00) and LAE (0.00) whose p values are less than the standard .05 alpha level. But there is insignificant difference of HAC between the AAC and LAC in control group because the p value (0.10) and (0.16) respectively is more than the alpha value (0.05).
6. Low Achievers Control Group (LAC) shows the significance difference between the HAE (0.00) AAE (0.00), LAE (0.00) and HAC(0.00) whose p values are less than the standard .05 alpha level. But there is insignificant difference of LAC between the AAC in control group because the p value (0.16) is more than the alpha value (0.05).

CHAPTER NO5

SUMMARY, FINDINGS, CONCLUSIONS DISCUSSION AND RECOMMENDATIONS

5.1 Summary

This study was conducted to determine the effectiveness of 4MAT cycle model comparing with conventional teaching methods in biology at the secondary level. Two units (8&9) were included from biology textbook of class 9th for this experimental study. Textbook was published by Baluchistan Text Book Board in (2017). Researcher developed lesson plans from these two units to treat experimental and control groups. Expert opinions were also taken to develop lesson plans. Subject Achievement Test (SAT) as research instrument was developed that was based on 4MAT cycle model through table of specification. It was applied before and after intervention as pre-test and post-test respectively. Moreover, pilot testing was conducted for reliability of research instrument. Split-half method was applied for reliability of research instrument:-

All secondary level science students in Balochistan were considered as the target population of study. The Researcher selected one government boys high schools khanozai district Pishin as an accessible population to conduct experiment of study. Sample size consisted of 72 students in this school and was selected through simple random sampling. The researcher divided sample into two equal experimental and control groups through pairing technique with the help of pre-test. Each group was further divided equally at ability levels. The abilities were categorised into higher achievers, average achievers and lower achievers to determine the abilities of the students. Base line of students in Biology was checked by Pre-test. The experimental

groupwas treated by teacher trained by researcher for 4MAT model teaching method. Control group was taught by their school teacher through conventional teaching method.

After collecting data of the post-test, the data were analyzed through SPSS (V.20). The researcher applied dependent t-test to compare the achievement of students of the same group in pre-test and post-test. Another inferential statistical test was used as independent sample t-test, which is a statistical test to compare achievements of experimental and control groups and to determine significant difference in both groups. Similarly, significant difference in academic achievement in three ability levels was calculated by application of analysis of variance (ANOVA) to find out effectiveness of 4MAT cycle model in different ability level of students.

5.2 Findings of Study

The findings of the study were drawn from the analysis of data:-

1. Basic abilities and concepts of the Biology of experimental and control groups were determined before the treatment. From the result, it was found that there is a minor difference in mean scores (0.027) of experimental and control groups because the mean scores of pre-test in the experimental and control groups were 4.77 and 4.75respectively, in addition, inferential analysis in same table confirms comparison of both groups and declared that there was no significant difference between the experimental and control groups before the treatment. (H_{01}). It was proved that null hypotheses (H01) was accepted.
2. To determine the effect of 4MAT cycle on students' academic achievement in Biology at secondary level. It was found that the experimental group achieved significantly better in the post-test as compared to the pre-test. Moreover, the correlation of 36 students appears positive (0.03) which proves the

achievement in the post-test. In this continuation, there was found a significant difference in scores of pre-test and post-test.(OBJECTIVE 1)

3. Achievement scores through traditional teaching methods in control group indicated the difference of scores before and after the treatments. The findings of table 4.6 indicated the difference in scores before and after the treatments in the control group. The difference in mean scores (15.11) indicated that the control group also improved after the treatment. Additionally, the correlation of 36 candidates score was 0.731 which is a positive correlation increasing the achievements of the sample before and after the treatment. The significant difference in the scores of the pre-test and the post-test confirms that students achieved significantly in the post-test.(OBJECTIVE2)
4. To compare the achievement of students in biology based on 4 MAT teaching cycle and traditional teaching method on academic achievement of students at the secondary level (objective 3), it was found that the significant academic achievement difference in the experimental and control group was found after intervention through 4 MAT teaching cycle and traditional teaching methods respectively. The descriptive and inferential statistical analysis of post-test scores in experimental and control group found the mean score difference which is 12.00and p-value (0.00) is less than 0.5 which indicates that there is a significant difference in the academic achievement of experimental and control group. (Table 4.10). (H02) It was proved that null hypotheses (H02) was rejected.
5. After the results of post test and comparison of achievements, Retention test was conducted in experimental and control group after three months of post test. The purpose of the retention test was to check the stability and deep

learning of the students. It was found that there was no significant difference in experimental group. The mean difference of post test and retention test in experimental groupwas found 0.33 with a positive correlation (0.96). p value was 0.07 which is more than alpha value 0.05, which indicates that there was no significant difference after three months.(Objective 4)

6. It was found that there was a significant difference in control group between post test and retention test. The mean difference of post test and retention test in control group was found 1.25 with a positive correlation (0.93). p value was 0.002 which is less than alpha value 0.05, which indicates that there was a significant difference after three months. (Objective 5)
7. It was found that mean difference in retention test of experimental group and control group after three months of post test was 12.91 and the significance level was 0.00 which is less than 0.05. There was a significant difference in the achievements of control group and experimental group in the retention test. It was observed that there was a significant improvement and consistency in the learning of students based on 4 MAT model of teaching method as compared to conventional teaching method. (H03) it was proved that null hypotheses was rejected.
8. It was found from the analysis of variance (ANOVA) that there is a significant difference in the academic achievement of the experimental and control groups based on ability level. It also inferred the multiple comparisons at ability levels (HAE, AAE, LAE, HAC, AAC, and LAC) after the treatment as follows(4.19-4.20). HAE in the experimental group has a significant improvement among all the ability levels of both groups. AAE and LAE also achieved significantly better than all ability levels of the control group.

Similarly, HAC, AAC, and LAC in the control group have a significant difference among all the ability levels of experimental groups but there is no significant difference of ability levels in the same control group after the treatment. It was found that the three groups of ability level students (HAE, AAE, LAE) taught through 4MAT teaching cycle performed significantly better as compared to the students (HAC, AAC, LAC) taught through the traditional teaching method.

5.3 Discussion

Biology is one of the essential science subject at secondary level because it occupies unique position in the curriculum of secondary education at school level and it is also called science of life. It is important to achieve national curriculum objectives regarding biology. Teaching learning process is essential regarding the achievements of such goals. This will help the student to construct their own views and knowledge and will be in the position to apply the knowledge in daily life. Cainc (2002) stated that it is essential for the teacher to organize classroom in such a way where activity play major role in that classroom. Such activity base teaching will help student to construct their own knowledge and understanding through interacting with environment around them. Studies have shown that effective instructional strategies have not been used in the subject of biology due to that student cannot develop their own knowledge in real life (Nwagbo 2011).

4MAT has recently been used in a variety of educational settings and disciplines, including medicine education (Spatz, 1991; Erwin et al., 1992), law studies (Kelly, 1990), and scientific education (Bowers, 1987; Ursin, 1995; Jackson, 2001). Many instructional strategies, for example, were used to fit the learning styles of engineering economy students. To swiftly calculate the present value of an alternative, an

experiential learning cycle and a creative business game were used (Mare, 1993). Nowacki (2011) applied the 4MAT model to the learning process in order to turn a biostatistics course into a problem-based learning experience. Students felt more passionately, encouraged sharing, and integrated concepts across subjects, according to the findings. The 4MAT model is one of the learning models that takes individual differences in learning into consideration. 4MAT has the advantage of taking into account individual characteristics such as learning styles and brain processing capabilities. Moreover, it provides students with possibilities to comprehend the particulate nature of matter, such as modelling, visualisation, theoretical knowledge, application, demonstrating individual creativity, integrating these opportunities, and knowledge transfer through interaction with tasks.

4MAT defines four connected learning styles based on a continuum of how learners perceive and process new information, according to Nicoll- Senft & Seedier (2010) and Kutay (2006). The learner's individual learning style is determined by where he or she stands on the continuum. Imaginative learners, analytic learners, common sense learners, and dynamic learners are the four learning styles identified by McCarthy. Personal experience is the best way for imaginative learners to learn. They like discussing their thoughts, feelings, and opinions with others, and they benefit from possibilities to discover meaning in what they are learning. They are naturally reflective and learn through discourse. Individual student development is their top goal in the classroom. The 4 MAT method, according to BulBul and Ozsoy (2015), sequence the four learning styles in a framework that replicates the natural learning cycle of the learners. This cycle begins with the student's prior experiences and knowledge, and then adds new information or insight to be learnt. The learner then has the opportunity to alter the new information before applying what he or she

has learned to the world around him or her and to his or her own life. The learners create a fresh base from which to interact and restart the cycle at this stage in the cycle.

The 4MAT system's cycle consists of eight separate tasks that span the four types of learning and make use of both left- and right-brain processing methods in all quadrants (Tatar & Dekici, 2009). 4MAT's teaching model can be regarded as a combined teaching method that facilitates a variety of constructivist-based teaching approaches and methodologies. The methodology encourages students to come to their own conclusions about their views and understandings. Learning becomes more supportive and fascinating as a result of the integration of diverse teaching approaches, which promotes permanence (Pruekpramool, 2011). 4MAT is an instructional approach based on the concept that learners' perceptions and processing of those perceptions are intertwined. Some students perceive information in two ways: first, through experience, and then, through conceptualization. They sense concepts, are present in the moment, are emotionally captured by the moment, and feel the learning through experience. Furthermore, learners use conceptualization to transfer their experiences into conceptual forms using language, concepts, systems, and an abstract approach to figure out what is going on and name it (McCarthy, 1990).

According to Krşolu (2005), extensive expertise and knowledge may not be sufficient in every topic, particularly when teaching science subjects. Traditional teaching strategies and methodologies are insufficient in this regard. It was also stressed that semi-controlled teaching models self-regulate and build inner dynamics in accordance with requirements. According to Buyurgan (2000), science education should not be centred on forcing pupils to think, try, and research. Rather, the 4MAT model, which is suitable for both brain hemisphere dominance and is based on

learning styles, is expected to be the most appropriate teaching technique in high school science classes. The majority of studies in the review of literature focus on permanency, attitude, and achievement. There is a scarcity of research that examines the impact of 4MAT on motivation in depth. Similarly, there are few studies that examine student perceptions of the 4MAT paradigm (Uysal 2009, Nicoll-Senft and Seider 2010). In truth, there has never been a comprehensive examination of the 4MAT model's positive and negative effects. The current research seeks to make a substantial contribution to the field of 9th grade science education.

In a study by Aktas and Bilgin (2015), the effects of the 4MAT learning framework on academic achievement of seventh-grade students were investigated, with a focus on establishing motivation for learners toward the 'Particulate Nature of Matter' unit and identifying students' perspectives on the 4MAT approach. A total of 235 Turkish students were included in the study. Following the implementation, open-ended questions were used to gauge students' perspectives on the 4MAT framework in the experimental groups. The study's findings revealed that implementing the 4MAT approach increased students' overall engagement and motivation in class. Furthermore, pupils perceived lectures to be more entertaining and gained self-confidence as a result. However, several students stated that the technique was time-consuming, that they were not motivated, and that the material was not made more understandable by the usage of the system. Nonetheless, the 4MAT model was found to be more helpful in enhancing motivation and academic accomplishment than the old technique.

Ghazal (2016) looked on the benefits of using the 4MAT teaching method in enhancing the scientific thinking skills and concepts of seventh-grade female students. The total number of people in the sample was 61. The results revealed a statistical

significance in terms of the differences between the experimental and control groups' mean scores, with the experimental group outperforming the control group. Importantly, the 4MAT system has been found to be beneficial in the development of scientific thinking abilities and ideas in the teaching of other disciplines.

In a study by Jassim, Mahdi, and Kareem, the benefits of using the 4MAT model on improving understanding of biological ideas and retention for female students in secondary biology classes were investigated (2016). There were 83 students who took part in the study. The researchers utilised a two-group experimental design with experimental and control groups. Importantly, both groups were statistically equal in terms of age, IQ, prior knowledge, prior information, and parental education. The study's findings revealed that the experimental group outperformed the control group. As a result, the findings recommend that biology teachers notice and explore incorporating more traditional techniques in their college teaching. Tezcan and Güvenç (2017) investigated the impacts of the 4MAT system and the Whole Brain Model on academic achievement in science, comparing the effects of the 4MAT system and the Whole Brain Model to the effects of inquiry-based education.

5.4 Conclusions

The findings of the study have been concluded as follow:

1. It was concluded that both experimental and control groups were same in the basic abilities and concept of biology before the intervention. From the result, it was found that there was no significant difference in the learning of the students before intervention.
2. Objective 1 is to determine the effect of 4MAT cycle on students' academic achievement in biology at secondary level.From the findings it was revealed

that the experimental group achieved significantly better in the post-test as compared to the pre-test. It was concluded that the students at secondary level can be developed in learning by applying 4 MAT cycle model in the class room.

3. Objective No.2 of the study is to find out the effect of traditional teaching method on students' academic achievement in biology at the secondary level. It was concluded that the achievement scores through traditional teaching methods in control group indicated the significant difference of scores before and after the treatments. The significant difference in the scores of the pre-test and the post-test confirms that students achieved significantly in the post-test.
4. Third objective of the study is to compare the achievement of students in biology based on 4 MAT teaching cycle and traditional teaching method on academic achievement of students at the secondary level, it was concluded that the significant academic achievement difference in the experimental and control group was found after intervention through 4 MAT teaching cycle and traditional teaching methods respectively. Students of experimental group performed better because the 4MAT strategy has several advantages like encouraging students to develop their own understanding and perceptions. It also allows the teaching environment to be organized around targeted concepts and supports the use of different strategies by facilitating an integrated teaching approach. It developed interest in learning of the students due to student centered. It is concluded that if teachers have a framework for eight – stage learning activities in a systematic 4 MAT cycle students performed better as compared to lecture method. It also respects student's differences,

ensures the transition from subjectivity to objectivity for integrated learning, and improves the holistic thinking style.

5. Objective 4 concluded that Retention test confirmed the effect of 4 MAT cycle of teaching method. After the results of post test and comparison of achievements, Retention test was conducted in experimental and control group after three months of post test. The purpose of the retention test was to check the stability and deep learning of the students. It was concluded that there was no significant difference in experimental group.
6. Objective 5 concluded that lecture method enhance rote memorization and surface learning because there was a significant difference in control group between post test and retention test after the period of three months. Students have no ability for deep understanding.
7. Through the analysis of variance, it was concluded that all the ability levels of experimental groups (HAE, AAE, LAE) achieved better significantly than the ability levels of control groups (HAC, AAC, LAC) in biology at the secondary level in Balochistan. High achievement of experimental groups is due to the application of 4 MAT cycle teaching method through the interactive learning environment. It was concluded that science students at the secondary level in Baluchistan performed better in their academic achievement by applying 4 MAT cycle of teaching method.

5.5 Recommendations

The conclusions of this experimental study illustrate that students of experimental and control groups had the same academic ability before the intervention but after the treatment, a significant difference was found in the academic achievement of both the groups. It proves that 4 MAT teaching method improved the

deep learning in students. Henceforth, it has been proved that 4 MAT teaching method is a useful model which helps the students to enhance their academic achievement to reach their highest level of learning. The recommendations are specified as follow:

1. Teachers at the secondary level may be equipped with 4 MAT cycle teaching method to apply these skills in the classroom. Moreover, it is recommended that the content of this teaching method may be included in the pre-service as well as in-service teachers' training. Teachers need to links the concept of the lesson and capture student's attention, teacher may ask learners to think about the experience and share it with others, immediate reflection from teacher, may give information and say students to practice and teacher guide, analyze and encourage the practice and creativity of students. Provincial institute for teacher education (PITE) Baluchistan may develop module of 4 MAT cycle for teacher training.
2. The subject content need to be developed based on 4 MAT cycle of teaching method so that the students can follow it automatically. The assessment exercises in the textbooks need to reflect all the steps of 4MAT cycle of teaching method of the learners that will affect the educational achievement of the students. Such type of recommendations can be achieved by professional development of curriculum developers and text book writers. Text book board Baluchistan is responsible for implementation.
3. For future researchers it is recommended that subject of biology was used for this study at the secondary level to determine the effect of 4 MAT cycle teaching method. This method can be investigated in other subjects

of science, arts, or humanities at the same or different levels. For deeper analysis, qualitative research can be carried out to explore the effect of 4 MAT teaching method. The same study having a different population can be repeated to verify the findings of the present study.

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APPENDICES

Appendix 1

Lesson Plan No 1 (Experimental Group)

WEEK ONE

(24-28 May 2021)

Subject: Biology

Topic: Mineral Nutrition in Plants

Class: 9th

Duration: 200 minutes (40 minutes/ class)

Specific Objectives: At the end of the lesson, the students should be able to:

1. Define mineral nutrition in plants
2. Differentiate macronutrients and micronutrients
3. State the importance of Nitrogen and Magnesium for the synthesis of protein and chlorophyll respectively.
4. Describe the effect of lack of nitrates and magnesium ions on plant growth.
5. Describe the importance of fertilizers (manure and chemicals) in agricultures.
6. Identify the environmental Hazards related to use of chemical fertilizer
7. Differentiate between chemical and organic fertile

Entry Behaviour: It is assumed that students have a previous knowledge of living things and their characteristics.

Test of Entry Behaviour:

1. What do you know about nutrition?
2. What are the minerals?
3. What is the use of minerals?

Instructional Materials: A chart of names and function of minerals, nitrogen fertilizer, potted plants

Instructional Procedure:

steps	content	Teacher's activities	Students	Instructional

			activities	strategies
1 connect	Introduction of minerals	The teacher captures student's attention by starting with a situation that is familiar to students and builds on what they already know about the topic thus: What do you know about nutrition? What are the minerals? What is the use of minerals? All these questions can be answered by just looking at the transport system. The teacher guides and monitors the students as they answer the question	The students listen carefully, take down notes, answers the teacher's question and ask questions.	Brainstorming, listening, speaking, minds mapping, drawing, idea generating, and role play
2 Attend	Meanings of nutrition and nutrients, Mineral and non-mineral nutrients.	The teacher asks learners to think about the experience regarding Mineral Nutrition in Plants step 1 and share it with others. Here the teacher finds out	The students share their perceptions and beliefs about the Mineral Nutrition in Plants to create and reinforce the meaning that	constructivism, brainstorming, and questioning

		what current perception, construction or misconception Students bring with them about the Mineral Nutrition in Plants. The teacher guides the students to reflect and analyze their experience in step 1. By defining Mineral Nutrition in Plants	brings real understanding and the reason to learn components of food.	
3 Imagine	Integration of previous knowledge of students with the topic	With the help of a well labelled diagram illustrating the Mineral Nutrition in Plants the teacher asks the students question to find out what they found from the illustration about Mineral Nutrition in Plants in step 1 and step 2 The teacher further deepens the connection between previous knowledge and the new topic. What the students	The students see relationships and connections between the illustration and what they found about Mineral Nutrition in Plants in step 1. The students answer the teachers question regarding Mineral Nutrition in Plants.	Creating analogy, metaphors, and non-verbal or spatial experimentation, observation and discussing

		already know to what experts have found out by explaining further about the topic.		
4 Inform	Teacher will inform the student and will deliver lecture regarding mineral nutrition in plants, Differentiate macronutrients and micronutrients, importance of Nitrogen and Magnesium for the synthesis of protein and chlorophyll respectively. effect of lack of nitrates and magnesium ions on plant growth ,the importance of fertilizers	The teacher asks the students if they know mineral nutrition in plants, Differentiate macronutrients and micronutrients ,importance of Nitrogen and Magnesium for the synthesis of protein and chlorophyll respectively. effect of lack of nitrates and magnesium ions on plant growth ,the importance of fertilizers (manure and chemicals) in agricultures, Identify the environmental Hazards related to use of chemical fertilizer . The teacher gives the students	The students listen attentively and ask questions where necessary and take down note	Lecture, Questioning, demonstration Classroom interaction patterns, Discussion and activity

	(manure and chemicals) in agricultures, Identify the environmental Hazards related to use of chemical fertilizer	conceptual and factual information from experts and provides information regarding the topic through lecture, and visual charts. The teacher also explains. The teacher will also answer the question asked by the students.		
5 Practice	Hand on Practice	Teacher provides hands-on activities for practice to check understanding and mastery of lesson. The teacher asks the student to draw and label the diagrams of the different concepts regarding the topic.	Students will follow the instruction of the teacher. Students will draw and label the diagram of the given topics. The students will ask the questions where necessary.	Exploration, Manipulating, lab work, adapting knowledge to personal use, demonstrations, worksheets, diagrams, conversations with peers.
6 Extend	(Extend or Integra ting Material with Self)	The teacher shows some charts to the students consists of different parts of the contents.The teacher will ask the	The students add their contribution to the lesson by extending what is leant the	Questioning, discussion, Brainstorming and mind mapping

		students to label the given the diagram and define the function of that parts given in the diagram.	answer the question asked by the teacher and define those charts and diagram. The students observe and record their observations, share their observation with others in a meaningful way.	
7 Refine	Function of carbohydrates, protein and fats, function of vitamin A, C and D (Refine or Analyzing for Usefulness or Application)	In this stage the teacher will make some groups in the class and assign different topics. Define mineral nutrition in plants Differentiate macronutrients and micronutrients, State the importance of Nitrogen and Magnesium for the synthesis of protein and chlorophyll respectively. Describe the effect of lack of nitrates	The learner moves beyond simple practice and uses the information provided by the teacher about the contents in creative way to analyze what they have planned as their "proof" of learning based on relevance to content.	Brainstorming, discussion, project and cooperative learning.

		and magnesium ions on plant growth. Describe the importance of fertilizers (manure and chemicals) in agricultures. Identify the environmental Hazards related to use of chemical fertilizer Differentiate between chemical and organic fertile why Transpiration is a necessary Evil Elaborate how water is transported in steam, How translocation take place in Plants. The teacher gives guidance and feedback to encourage, refine, and help them where necessary.		
8 Reform	(Perform or Integrating Application and Experience)	This is also the time for the teacher to celebrate the learner's accomplishments by	The students perform the original example of their learning,	Questioning, presentation and sharing

		examining what the students have done and reinforcing them appropriately. The teacher asks the students to draw and label the diagrams of different topics given to them and state their function. The teacher moderates the students' activities.	sharing it with others in a meaningful way. As this step moves from individual, private acts to more open and public exhibits. The students will draw and label the given diagrams and state their function before the class.	

Evaluation: the teacher evaluates the student's learning outcome by asking them the following question:

1. Define mineral nutrition in plants
2. Differentiate macronutrients and micronutrients
3. State the importance of Nitrogen and Magnesium for the synthesis of protein and chlorophyll respectively.
4. Describe the effect of lack of nitrates and magnesium ions on plant growth.
5. Describe the importance of fertilizers (manure and chemicals) in agricultures.
6. Identify the environmental Hazards related to use of chemical fertilizer
7. Differentiate between chemical and organic fertile

Summary: the teacher gives the major points of the topic after evaluation correcting the students where they got it wrong

Appendix 2

Lesson Plan No.1 (Control Group)

Date May 24, 2021
Class 9th
Period 40 minutes
Subject Biology
Topic Introduction to Nutrition

General objectives	The general objectives of this lesson will be to: 1) Organize conventional instructional strategies for the students to reproduce the concepts present in text book. 2) Develop a passive environment among learners studying at secondary level. 3)Maximize the role of rote-learning and control benefiting from critical thinking standards for inculcation of biological concepts.
Specific objectives	After going through this lesson , the students will be able to: Unde 1) Memorise the concepts related to Minerals Nitration in Plants. 2) Understand the concept Minerals Nitration in Plants.
Material	Text books, White Board Marker
Introduction (03 minutes)	Teacher will ask the students to open the books and page number. Allow the students to note the main points during lecture.
Statement of aim (Announcement of topic) (01 minute)	Minerals Nitration in Plants
Presentation (20 minutes)	**Lecture Method**. Teacher will ask students to open Biology textbook at page No. 149 where topic is given. Teacher will explain all the same by writing the main points on the white board. He will also perform following activities.
Explanation Teacher will explain the terms given in the text book (10 minutes)	Asking forcibly all students to copy one by one all concepts written on whiteboard □□Explanation with the help of some examples and students writing them on whiteboard □□Showing resentment/anger/displeasure on a) poor attention b) copying slowly/ imperfectly/ differently c) talking/laughing with one another d) making mistakes e) questioning during teaching or writing sessions f) Seeking permission to have water during teaching session by the students. Teacher will ask all students to give a tight look to above the

	terms within 5 minutes. After 5 minutes, teacher will order all class to be attentive to note down the question given in textbook. Teacher will revise and explain most of the terms given in textbook at page No. 149 At the end, teacher will assign students to reproduce classroom tasks in written form on notebooks.
Review Questions . The purpose of these questions is to practice the student's learning (05 minutes)	Define minerals? Define Minerals in Plants?
Home assignment At the end of the lesson, home assignment is given to the students on the same teaching unit. (01minute)	Write the answers of this topic in your note books .

Lesson Plan No.2 (Control Group)

Date May 25, 2021
Class 9th
Period 40 minutes
Subject Biology
Topic Role of micronutrients in Plants

General objectives	The general objectives of this lesson will be to: 1) Organize conventional instructional strategies for the students to reproduce the concepts present in text book. 2) Develop a passive environment among learners studying at secondary level. 3) Maximize the role of rote-learning and control benefiting from critical thinking standards for inculcation of biological concepts.
Specific objectives	After going through this lesson , the students will be able to: Unde 1) Memorise the concepts related to Role of micronutrients in Plants. 2) Understand the concept, of the functions of micronutrients in Plants.
Material	Text books, White Board Marker
Introduction (03 minutes)	Teacher will ask the students to open the books and page number. Allow the students to note the main points during lecture.
Statement of aim (Announcement of topic) (01 minute)	Role of micronutrients in Plants
Presentation (20 minutes)	**Lecture Method.** Teacher will ask students to open Biology textbook at page No. 150, 151 where topic is given. Teacher will explain all the same by writing the main points on the white board. He will also perform following activities.
Explanation Teacher will explain the terms given in the text book (10 minutes)	Asking forcibly all students to copy one by one all concepts written on whiteboard □□Explanation with the help of some examples and students writing them on whiteboard □□Showing resentment/anger/displeasure on a) poor attention b) copying slowly/ imperfectly/ differently c) talking/laughing with one another d) making mistakes e) questioning during teaching or writing sessions f) Seeking permission to have water during teaching session by the students. Teacher will ask all students to give a tight look to above the terms within 5 minutes. After 5 minutes, teacher will order all

	class to be attentive to note down the question given in textbook. Teacher will revise and explain most of the terms given in textbook at page No. 150,151 At the end, teacher will assign students to reproduce classroom tasks in written form on notebooks.
Review Questions . The purpose of these questions is to practice the student's learning (05 minutes)	Define the role of micronutrients in Plants? Define the function of micronutrients in Plants?
Home assignment At the end of the lesson, home assignment is given to the students on the same teaching unit. (01minute)	Write the answers of this topic in your note books.

Lesson Plan No.3 (Control Group)

Date May 26, 2021
Class 9th
Period 40 minutes
Subject Biology
Topic role of Magnesium for Chlorophyll Formation and role of Nitrogen in Protein syntheses.

General objectives	The general objectives of this lesson will be to: 1) Organize conventional instructional strategies for the students to reproduce the concepts present in text book. 2) Develop a passive environment among learners studying at secondary level. 3) Maximize the role of rote-learning and control benefiting from critical thinking standards for inculcation of biological concepts.
Specific objectives	After going through this lesson , the students will be able to: Unde 1) Memorise the concepts of role of Magnesium for Chlorophyll Formation Plants. 2) Memorise the role of Nitrogen in Protein syntheses.
Material	Text books, White Board Marker
Introduction (03 minutes)	Teacher will ask the students to open the books and page number. Allow the students to note the main points during lecture.
Statement of aim (Announcement of topic) (01 minute)	Minerals Nitration in Plants
Presentation (20 minutes)	**Lecture Method**. Teacher will ask students to open Biology textbook at page No. 151, 152 where topic is given. Teacher will explain all the same by writing the main points on the white board. He will also perform following activities.
Explanation Teacher will explain the terms given in the text book (10 minutes)	Asking forcibly all students to copy one by one all concepts written on whiteboard □□Explanation with the help of some examples and students writing them on whiteboard □□Showing resentment/anger/displeasure on a) poor attention b) copying slowly/ imperfectly/ differently c) talking/laughing with one another d) making mistakes e) questioning during teaching or writing sessions f) Seeking permission to have water during teaching session by the students. Teacher will ask all students to give a tight look to above the

	terms within 5 minutes. After 5 minutes, teacher will order all class to be attentive to note down the question given in textbook. Teacher will revise and explain most of the terms given in textbook at page No. 151, 152 At the end, teacher will assign students to reproduce classroom tasks in written form on notebooks.
Review Questions . The purpose of these questions is to practice the student's learning (05 minutes)	Define the role of Magnesium for Chlorophyll Formation Define the role of Nitrogen in Protein syntheses.
Home assignment At the end of the lesson, home assignment is given to the students on the same teaching unit. (01minute)	Write the answers of this topic in your note books.

Lesson Plan No.4 (Control Group)

Date May 27, 2021
Class 9th
Period 40 minutes
Subject Biology
Topic Effect of Lake of Nitrate and importance of fertilizer in Agriculture

General objectives	The general objectives of this lesson will be to: 1) Organize conventional instructional strategies for the students to reproduce the concepts present in text book. 2) Develop a passive environment among learners studying at secondary level. 3) Maximize the role of rote-learning and control benefiting from critical thinking standards for inculcation of biological concepts.
Specific objectives	After going through this lesson , the students will be able to: Unde 1) Memorise the concepts Effect of Lack of nitrate and Magnesium ions in plant growth. 2) Understand the concept of importance of fertilizer in Agriculture.
Material	Text books, White Board Marker
Introduction (03 minutes)	Teacher will ask the students to open the books and page number. Allow the students to note the main points during lecture.
Statement of aim (Announcement of topic) (01 minute)	Effect of lake of Nitrate and importance of fertilizer in Agriculture
Presentation (20 minutes)	**Lecture Method**. Teacher will ask students to open Biology textbook at page No. 152 where topic is given. Teacher will explain all the same by writing the main points on the white board. He will also perform following activities.
Explanation Teacher will explain the terms given in the text book (10 minutes)	Asking forcibly all students to copy one by one all concepts written on whiteboard □□Explanation with the help of some examples and students writing them on whiteboard □□Showing resentment/anger/displeasure on a) poor attention b) copying slowly/ imperfectly/ differently c) talking/laughing with one another d) making mistakes e) questioning during teaching or writing sessions f) Seeking permission to have water during teaching session by the students. Teacher will ask all students to give a tight look to above the

	terms within 5 minutes. After 5 minutes, teacher will order all class to be attentive to note down the question given in textbook. Teacher will revise and explain most of the terms given in textbook at page No. 152 At the end, teacher will assign students to reproduce classroom tasks in written form on notebooks.
Review Questions . The purpose of these questions is to practice the student's learning (05 minutes)	Define Effect of Lack of nitrate and Magnesium ions in plant growth? Define importance of fertilizer in Agriculture? Define organic and chemical fertilizer?
Home assignment At the end of the lesson, home assignment is given to the students on the same teaching unit. (01minute)	Write the answers of this topic in your note books.

Lesson Plan No.5 (Control Group)

Date May 28, 2021
Class 9th
Period 40 minutes
Subject Biology
Topic Environmental Hazards related to chemical fertilizer use

General objectives	The general objectives of this lesson will be to: 1) Organize conventional instructional strategies for the students to reproduce the concepts present in text book. 2) Develop a passive environment among learners studying at secondary level. 3) Maximize the role of rote-learning and control benefiting from critical thinking standards for inculcation of biological concepts.
Specific objectives	After going through this lesson , the students will be able to: Unde 1) Memorise the concepts Environmental Hazards related to chemical fertilizer use. 2) Understand the concept of what are the problems created by chemical fertilizer.
Material	Text books, White Board Marker
Introduction (03 minutes)	Teacher will ask the students to open the books and page number. Allow the students to note the main points during lecture.
Statement of aim (Announcement of topic) (01 minute)	Environmental Hazards related to chemical fertilizer use
Presentation (20 minutes)	**Lecture Method.** Teacher will ask students to open Biology textbook at page No. 153, 154 where topic is given. Teacher will explain all the same by writing the main points on the white board. He will also perform following activities.
Explanation Teacher will explain the terms given in the text book (10 minutes)	Asking forcibly all students to copy one by one all concepts written on whiteboard □□Explanation with the help of some examples and students writing them on whiteboard □□Showing resentment/anger/displeasure on a) poor attention b) copying slowly/ imperfectly/ differently c) talking/laughing with one another d) making mistakes e) questioning during teaching or writing sessions f) Seeking permission to have water during teaching session by the students. Teacher will ask all students to give a tight look to above the terms

	within 5 minutes. After 5 minutes, teacher will order all class to be attentive to note down the question given in textbook. Teacher will revise and explain most of the terms given in textbook at page No. 153, 154 At the end, teacher will assign students to reproduce classroom tasks in written form on notebooks.
Review Questions . The purpose of these questions is to practice the student's learning (05 minutes)	Define Environmental Hazards related to chemical fertilizer use? What are the problems created by chemical fertilizer?
Home assignment At the end of the lesson, home assignment is given to the students on the same teaching unit. (01minute)	Write the answers of this topic in your note books.

Appendix 3

Subject Achievement Test (SAT)

Total Marks 40

Dated...../...../.....

Name of the students.....Name of school

Class Date Time allowed 60 minutes

Instruction: Attempts all the questions

Multiple choice (MCQs).

Encircle the correct answer.

1. The organic compound the tis quick source of energy is ;

   Carbohydrates Protein

   Lipids Fats

2. The none mineral nutrients are:

   N,P,K Fe, Cu, B

   O,H,C S, Ca, Mg

3. The immediate source of nutrients for plants is;

   Sunlight Organic fertilizer

   Inorganic fertilizer Dead bodies of animals

4. In the adults, the length of esophagus is usually:

   15cm 25cm

   35cm 45cm

5. The fat soluble are:

   A, C, D, E A, D, B, E

A, E, C, K A, D, E, K

6. Villi located in:

Oral Cavity Oesophagus

Stomach Small intestine

7. The organ that is not the part of digestive system is:

Oral Cavity Traches

Stomach Intestine

8. Digestion of carbohydrates start in :

Oral Cavity Oesophagus

Small intestine stomach

9. Pancreas gives its exocrine secretions in:

Stomach Colon

Liver Small Intestine

10. The amount of energy obtained from one gram of fat is:

5 Kcal/g 9 Kcal/g

13 Kcal/g 17 Kcal/g

11. Saliva consist of

Water, mucous, pepsin, $NaHCO_3$ Mucuous, HCL, NaHCO3

Pepsin, HCL, NaHCO3, Water Water, Mucous, NaHCo3,

amylase

12. The bacteria present in large intestine produce:

Vitamin K Vitamin D

Vitamin A Vitamin E

13. Iron is the essential components of:

Chlorophyll Hemoglobin

Glucose Collagen

14. Night Blindness is due to deficiency of:

Vitamin C Vitamin D

Vitamin A Calcium

15. The Major cause of marasmus is

OIN MDD

Deficiency of iron PEM

16. In the plant food is stored in in the form of:

Glucose Starch

Sucrose Proteins

17. The estimated percentage of transpiration through is

1-2% 5%

50-60% 90%

18. The amount of absorbed water from soil used by plant is

10-20% 1-2%

5-10% 80-90%

19. The Translocation of food in phloem is in the form of:

Maltose Glucose

Sucrose Fructose

20. Plant conducting tissue are

Only xylem Only phloem

Only Xylem & Phloem Cortex

21. The transpiration is not effected by:

Wind Temperature

Humidity Glucose

22. The Direction of food transport in plant is:

Upward	Dawn word
Horizontal	From source towards sink

23. Living organism which can prepare their own food are called:

Heterotrophas	Autotrophs
Parasites	Saprophites

24. Organisms which depend upon the Autrophas

Herbaceous	Carnivores
Omnivores	i, ii, iii

25. Plants take non minerals nutrients from:

H2O	CO2
H2O &CO2	O2

26. One of the following is not macronutrient

Iron	Magnesium
Calcium	Copper

27. Nitrogen is the part one of the following

Carbohydrates	Fats
Protein	Vitamins

28. Which of the following number of amnio acid is present in one molecule of insulin

50	51
52	53

29. The amount of energy obtained from one gram of carbohydrates is:

5Kcal/gm	4Kcal/gm
3Kcal/gm	2Kcal/gm

30. Root hair is the part of

Cortex	Epidermis
Endodermis	pericycle

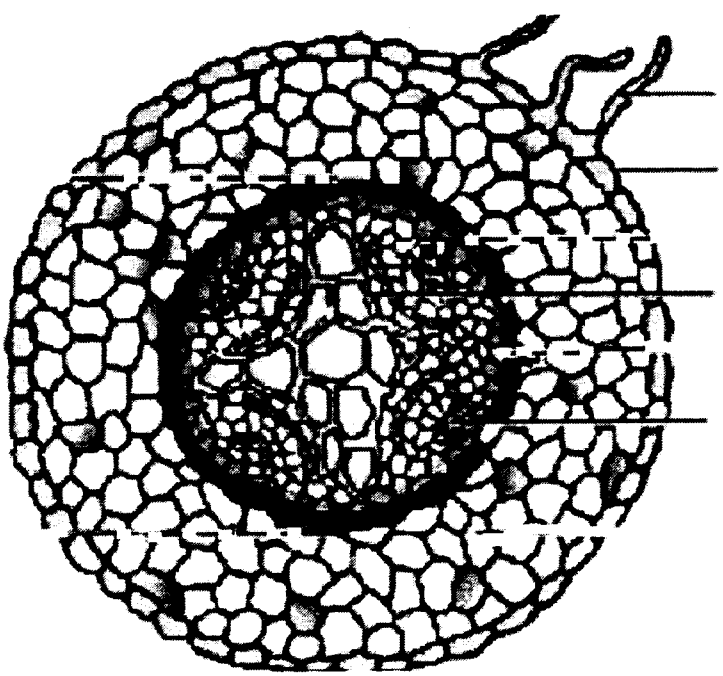
31. Which of the following movement use energy in the form of ATP

Diffusion	osmosis
Active transport	i, ii, iii

32. In the leaves opening and closing of stomata is controlled by

Endodermal cells	Guard cells
Epidermal cells	Midrib

33. Label the following diagram (Marks 4)



34. Label the following diagram (Marks 4)