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# Comparative Study of Using 5e Learning Cycle and the Traditional Teaching Methods in Chemistry to Improve Student Understanding of Water Concept at Grade Eight Dilchibo Primary School

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**June, 2021**

**Bahirdar, Ethiopia**

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**By**

**Tamene Atsbiha**

A thesis submitted in Partial Fulfillment of the Requirements for the Degree of Masters of Science in teaching chemistry

Principal Advisor's Name Dr. Asrat Dagnew



June, 2021

Bahirdar

## Declaration

I hereby declare that this thesis entitled “comparative study of using 5e learning cycle and the traditional teaching method in chemistry to improve student understanding of water concept among primary school chemistry students in Bahirdar, Ethiopia has been written by me and it is a record of my own research work. It has not been presented in any previous institution and application for higher degree. All quotation marks or indentation and the sources of information are specifically acknowledged by means of references.

**Name of the author: - Tamene Atsbiha Tegegne**

**Place: - Bahir Dar University, Ethiopia**

**Date of submission: June, 2021**

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## Approval Thesis for Defense

I hereby certify that I have supervised, read, and evaluated this thesis titled “comparative study of using 5e learning cycle and the traditional teaching methods in chemistry to improve student understanding of water concept at grade eight Dilchibo primary school**”** by Tamene Atsbiha Tegegne prepared under my guidance. I recommend the thesis/dissertation be submitted for oral defense**.**

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## Approval of thesis for defense result

As members of the board of examiners, we examined this dissertation/thesis entitled "comparative study of using 5e learning cycle and the traditional teaching methods in chemistry to improve student understanding of water concept at grade eight dilchibo primary school" by Tamene Atsbiha Tegegne. We hereby certify that the thesis/dissertation is accepted for fulfilling the requirements for the award of the degree of "Masters".

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## Abstract

*The aim of this study was to compare the 5E learning model with traditional learning methods in terms of their effect on students' conceptual understanding of water subtopics such as water hardness, water softening, water pollution and water purification. The study adopted Pretest Posttest non-equivalent quasi-experimental design. The participants of the study were 8th grade section A 54 students registered for second semester 2013 E.C academic year at dilchibo primary school in Bahirdar. While 27 of them were randomly assigned to the experimental group, the other 27 were assigned to the control group. The researcher continuously taught both groups for one month. The experimental groups were taught with 5E instructional model of the constructivist approach whereas the students in the control group were taught with the traditional approach. Both qualitative and quantitative research methods were used in this study. The data collection instruments were tests (pretest-posttest), observation, as well as informal assessment. A Chemistry Achievement Test (CAT) consisting of 20 questions were developed by the researcher to apply before and after treatment to both groups. The informal assessment also administered before and after intervention. Besides, the observation was conducted from the first day up to the last day of the intervention. Chemistry Performance Test on water concepts which also tested retention with a reliability index of 0.653 was developed, validated and used for data collection. Research questions were answered using mean and Standard deviation, while the null hypotheses were tested using t-test at 0.05 level of significance. The data obtained from pre- and post-tests of both groups was compared with the independent sample t-test and paired sample t-test. The results from pre-tests showed that there was no significant difference between control group and experimental group. On the other hand, the post-test results showed that there was a significant difference between groups in favor of the experimental group. Also, the experimental group's perception of motivation in classroom learning environment during the treatment was higher than that of the control group. It is essential that teachers should develop their skills for designing a constructivist-learning environment within class. With this aim, teachers should be given in-service training.*

**Key words***:* 5E instructional model, Traditional teaching, Conceptual understanding, wate*r*

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## LIST OF ABBREVIATIONS

**5Es**: Engagement, Exploration, Explanation, Elaboration and Evaluation

**ANOVA**: Analysis of Variance

**BSCS:** Biological Science Curriculum Study

**CAT**: Chemistry Achievement Test

**NECO**: National Examination Council

**SCIS**: Science Curriculum Improvement Study

**SPSS**: Statistical Package for Social Science

**WAEC**: West African Examination Council

# CHAPTER ONE

# 1. INTRODUCTION

## 1.1 Background of the study

Constructivist learning theory is based on a philosophical understanding quite different from objectivist methodology, in terms of what knowledge is and what it means to know something. The objectivist view lies at the foundation of the perspective in the belief that knowledge or meaning does not exist in the external world independent of the individual; that is, it is not passively transmitted from the outside world into the mind of the individual but, rather, it is effectively constructed by the individual in the mind (Duffy & Jonassen, 1991). In designing teaching processes based on the constructivist theory of learning, one of the most useful forms used is the 5E instructional model developed by Bybee, a leading scientist in the Biological Science Curriculum Study (BSCS) (Bybee, 1997). This model is based on 5 different stages of learning: Engage Explore, Explain, Elaborate and Evaluate. In the process of meeting the goals defined in science education, it can be seen that the 5E teaching model is preferred by educators, due to its foundation in the constructivist theory of learning and its status as a planned methodology in science education that offers students effective learning opportunities. Research on the 5E instructional model supports the view that this methodology can result in significant gains in the process of learning science. Some of the positive behavior and skills achieved by using the 5E instructional model in science education have been expressed in terms of attaining increased success in teaching science with the model, helping students to retain better concepts in their minds, achieving the development of improved attitudes and behavior toward lessons, developing reasoning skills and superior processing skills (Brooks & Brooks, Boddy, and Watson & Aubusson, 2003). Most of the research in Ethiopia and international literature on the 5E instructional model has engaged with students' academic achievement, their attitudes toward their lessons, conceptual changes and the adequacy of learning environments designed within the framework of the 5E model. In the instruction based on the 5E instructional model designed by Evans (2004), it has been reported that students actively participated in the classes while the units were studied, so taking on responsibilities. However, it was also stated that the teacher needed more time for classroom preparation in order to implement the 5E instructional model. Newby (2004) finds that the implementation of the 5E instructional model renders students more comfortable in the learning environment and that their achievement levels increase when experiments are included in the lessons. Boddy, Watson & Aubusson (2003) have developed a unit study based on the 5E model which students found to be interesting and entertaining and then exhibited improvements in the scientific processing skills as an outcome of their work with the model. Similarly, Liu, Peng, Wu and Lin (2009) found, in their research, that a student group exposed to the 5E model recorded improvements in their scientific knowledge and perceptions. At the same time, Wilder & Shuttleworth (2004) found that, at the end of an instructional period using this model, students inquired into the knowledge they had already brought into the learning environment. That is, when they were exposed to real-life situations, the students used their observations and data to offer scientific explanations, and that, with regard to scientific concepts; they passed through an accurate interpretation process. Ergin (2006) has also made a comparison of students being exposed to the 5E model of instruction as opposed to those who have been taught by traditional methods, finding a significant positive difference in the group of students learning the material via the 5E model. In the Turkish literature, Balcı (2005) has designed an instruction based on the 5E instructional model finding, at the end of the instruction, that students registered significant learning and exhibited conceptual changes independent of content. In a parallel study by Çepni, Küçük and Bacanak (2004), materials were developed for and used in different stages of the model. In learning settings designed in keeping with the 5E model, students are more active than the teacher; it has been concluded that, in this situation, students are able to use their critical thinking, problem-solving, discussion and teamwork skills more effectively, and that the social communication in which the students engage with their peers is at its highest levels. Again, other research conducted in this area has shown that students interact with their friends, using what they have learnt in similar situations (Arends, 2001). It may be said that the 5E instructional model not only increases the curiosity to explore, but encompasses skills and activities that satisfy students' expectations, leading them to focus on active learning and understanding. Research has shown that the 5E instructional model engages students in the activity at hand at every stage, so supporting them in making their own conceptualizations (Martin, 2000).

Education involves the total efforts of the community to raise its political, social and economic standard of living (Tebabal&Kahssay, 2011). The implication of this is the development of a nation which depends on largely the level of its scientific and technological literacy. Thus, the importance of chemistry as a subject cannot be related especially in Ethiopia where the national income rests on irrigation and chemical industries.

Despite these arrays of teaching methods being advocated in literature, there is no one universally accepted method. There is still uncertainty on which of these teaching methods contribute to failure or success of students' performance especially in developing countries like Ethiopia where the causes of poor performance in primary school chemistry is not well understood.

Chemistry, the branch of science that deals with the study of the composition and properties of matter, changes in matter, the laws and the principles that govern these changes has been characterized as the most utilitarian of all the experimental sciences and is one of the subjects that is offered in the Ethiopian primary school curriculum. Since chemistry is the science that has the most direct and dramatic impact on our lives and the science that shapes the world we will live in tomorrow, the performance of students especially primary school in the subject is a major concern to Ethiopia as a developing country (Melese, 2015). This uniqueness of chemistry and the central role that it stands to play in the development of any nation, when considered are however not evident in the performance of students.

Due to this, teachers are expected to advice ways of motivating their students to develop positive attitudes towards science and science related disciplines and in order to facilitate the process of knowledge transmission, teachers are expected to apply appropriate teaching methods that best suit specific objectives and level exit outcomes (Andrew,.2007). Quit regularly, regular poor academic performance by the majority of students in chemistry is fundamentally linked to application of ineffective teaching methods by teachers to impact knowledge to learners (Adunola, 2011). Teacher variables, student's variables and environment-related variables contribute greatly to poor performance of students in chemistry. These teacher variables and students' variables are almost always closed linked to teaching methods used to impart knowledge to students (Adunola, 2011).

## 1.2 Statement of the Problem

Chemistry being a core subject in the study of sciences and engineering should be given a special consideration. Many students find chemistry to be a hindrance in attaining their aims and objectives. For example; students wishing to read medicine cannot do so unless they perform well in chemistry. It is therefore necessary to properly guide and teach the students better in order for them to perform better in chemistry for a better attainment of their future career. Despite many years of behavioral learning theories to teaching, academic performance in chemistry is on the decline with no sign of promoting interpersonal and group interaction. Reasons for the poor performance have been attributed to the teaching method (Guloba, Wokodola, &Bategeka, 2010). This inadequacy of the teaching methods employed is partly responsible for the inability of chemistry students to perform well in the subject during required summative assessments and ministry examinations. Lecture method which is the commonly used traditional teaching method has thus proven ineffective as its adoption by most teachers is geared towards overcoming the bulky chemistry syllabus and has even led the chief WAEC Examiner Report 2015 to note that the rush over the topics could be responsible for the poor performance of students in chemistry (Ibrahim, Hamza, Bello &Adamu, 2018). This is particularly the case in primary schools within Ethiopia where majority of students have not shown good performance in chemistry examination results in summative evaluation.

Although, several studies have been conducted about teaching methods in primary schools in many parts of the world on students' performance, for example Pakistan (Sajjad 2011), Uganda (Guloba, Wokadala&Bategeka, 2010) and Ethiopia (Melese W, 2015) These studies indicated that the type of teaching methods used by teachers have an impact on students' performance. Thus, to reverse the problem of students' poor performance in chemistry and meet societal and industrial needs, there is need for innovative and more effective instructional techniques to be used by teachers in all chemistry classrooms.

It is against this backdrop that this study examines the comparison of 5e learning models and traditional teaching Methods on Ethiopian grade 8$^{th}$ Dilchibo primary school students understanding of water concepts in Amhara regional state, Ethiopia.

## 1.3 Objectives of the Study

### 1.3.1 General objective

To compare the effectiveness of teaching chemistry by using 5e learning cycle models with that of the traditional teaching methods to improving grade eight students' conceptual understanding of water.

### 1.3.2 Specific objectives

- To examine the effect of using the 5e instructional models on improving students' conceptual understanding of water.
- To check the significant difference in the achievement of those students who thought by 5E instructional model with those students who thought by the traditional teaching methods.
- To determine the degree of engagement of students between those who thought by the 5e instructional model with those who thought by traditional methods.

## 1.4 Research Questions

1. What is the effect of the 5e instructional models in improving students' conceptual understanding of water concepts?
2. Is there a significant difference in the achievement of those students taught with 5e instructional models and those students who thought with traditional teaching methods about water concepts?
3. How is the engagement of students when they are taught by the 5e instructional models and traditional methods?

## 1.5 Null Hypothesis

The following null hypotheses are formulated for testing at $p \leq 0.05$ level of significant.

**$Ho_1$:** There is no significant difference between the pre- test mean scores of experimental and control groups used for the study

**$Ho_2$:** There is no significant difference between the mean score of Chemistry Students conceptual understanding when exposed to the 5Es Learning Cycle Model and those taught with traditional method.

## 1.6 Significance of the Study

The result of this study is expected to be an input towards fulfilling the need for experimental and design-based studies, which should investigate the effectiveness of teaching chemistry at elementary level to understand water concepts. The findings will hopefully be of benefit to; primary school students, Science/Chemistry Teachers and Educators, Education Planner and Curriculum Designers.

**Chemistry Students: -** Inspiring Upcoming science student will benefit from the study if it is proved that the 5Es Learning Model of Science instructions lead to higher achievement in water Chemistry and increase interest in chemistry. It will encourage the students to interact intimately with the subject matter of Chemistry through constructing their own knowledge from preexisting ones thereby engaging them in productive high cognitive processes and thinking. It is hoped that the students will develop better knowledge and understanding of water chemistry concepts which would be very useful in both academic and career counseling.

**Chemistry Teachers: -** this study might be used to provide guidance to elementary school teachers regarding a more effective way to teach chemistry topics. it is hoped that this study would cause an increase in the interest of chemistry teachers in developing and employing new and exciting science teaching methods, as the study explores the effectiveness of Discovery Inquiry-Based Teaching Method based on the Constructivist Theory, and, thus, it keeps pace with the contemporary educational trends in using educational strategies derived from learning theories to encourage high order thinking and enhance students conceptual understanding of water chemistry. Furthermore, it can act as a stepping-stone to further studies in the field of water chemistry and contribute little to step forward the status of 5e learning models in the Ethiopian context.

**Science curriculum Developers and Educational Supervisors: -** due to its practical research significance because the study elements and procedures were described using a modified learning cycle, which provides natural Science teachers and students, and educationalists in general, with the opportunity to know the procedures of the learning cycle, its application methods and its effect on the educational achievement. Hence it would help to redefine the curriculum in sequences of potential experience that emphasizes on student centered approach to learning. Furthermore, curriculum developers might see a benefit by designing activities and experimental procedures on student text books and teacher guides based on 5e instructional cycle models.

## 1.7 Context and Scope of the Study

This study focuses on the elementary level of water concepts in primary schools found in the Amhara regional state of Ethiopia. In the Ethiopian primary schools, water concept is taught starting from grade one and continues to grade eight under the chapter of environmental chemistry. The topic in grade eighth comprises air, water, soil and coal. Hardness of water, softening of water, water pollution, and water purification are included under water sub-topics.

In the present study, the researcher is interested on teaching water concepts for grade eight students; because water is the most essential topic for students. Moreover, elementary students have more relation with water in their day-to-day activities. For example, they use water for drinking, washing, cooking and for other many purposes.

Therefore, the researcher uses the 5e instructional models and the traditional teaching methods to compare the effectiveness and engagement of grade eight students while learning about water concepts.

## 1.8 Theoretical and conceptual Framework of the Study

### 1.8.1 Theoretical Framework

Constructivist ideals have been with us for a long time, but have been described by other terms. Constructivism, as a theoretical framework, was set forth by psychologists Piaget and Bruner. It is an epistemology, used to explain how we humans learn. According to constructivism, knowledge cannot be transferred from the teacher to the student intact, the student constructs knowledge for him or herself based on prior experience and understanding. According to Sigel, Piaget noted that knowledge is not merely transmitted verbally but must be constructed and reconstructed by the learner, and that for a child to know and construct knowledge of the world, the child must act on objects and this action which provides knowledge of those objects (Sigel, 1977).

The 5E Learning Cycle has evolved from instructional models that date back to the early 1900s. In 1901 Johann Friedrich Herbart's instructional model proposed two ideas that he believed are the basis of teaching: student interest and conceptual understanding. He believed students should be interested in what they are learning in order for instruction to be effective. Next, he thought that each new idea should be connected with an existing one. His model also included a social piece that provided students opportunities for social interaction with their peers and their teachers (Bybee et al., 2006).

In mid-1980s, Biological Science Curriculum Study (BSCS) designed the 5E Learning Cycle. There are five phases in the 5E Learning Cycle. First, the engagement stage initiates the learning task. The activity should connect past and present learning experiences (Coe, 2001). By the end of this phase, students should be mentally engaged. Examples of engaging activities include asking questions, showing discrepant events, and defining or acting out a problem. Discrepant events are counterintuitive outcomes that create cognitive disequilibrium that surprises observers and temporarily throws them mentally off-balance (O'Brien, 2010). During the engagement phase, students should ask and respond to questions and show interest in the lesson. The teacher should generate interest and curiosity, raise questions and problems, and discover students' prior knowledge (Barufaldi, 2002). After the students are engaged, they have time to explore their ideas in the exploration phase. The activities in the explore phase are designed so that students share similar experiences and build more of their own ideas of the concepts. Students and teachers use their experiences from this phase to make meaning of concepts. Students are given time to investigate and manipulate materials throughout this stage. In the time that is given, students should think creatively, try a variety of problem-solving strategies, make predictions, listens to peers, records observations and ask questions. The teacher's responsibility is to act as a facilitator (Barufaldi, 2002).

After the students have had enough time to explore, the teacher begins the explanation phase. During this stage, the teacher discusses the engagement and exploration activities. Throughout the explanation, the concepts and ideas should become clear. The stage begins with the students explaining their findings. Then the teacher provides direct instruction to clarify the concepts and information. While the students and the teacher are explaining, the students should listen and ask questions, discuss the experiences in the prior stages, and communicate new understandings. Teachers provide definitions to new vocabulary, use previous stages to explain concepts, encourage questions and participation, and ask students to clarify thoughts. After the students and teacher have explained their experiences, it is important to elaborate on the concepts. During the elaborate phase, the teacher provides opportunities for the students to apply their learning in different contexts. Students apply new definitions and skills, ask questions, propose solutions and develop experiments to test their theories. Teachers expect students to use new vocabulary and encourage them to apply their new skills to different situations (Barufaldi, 2002).

The final E is evaluation. The evaluation to determine each student's level of understanding can be formal or informal. At this point in the cycle, the students receive feedback on their explanations. Based on the evaluation, teachers can determine if their students met their performance indicators. During the evaluate phase, students demonstrate their level of understanding of concepts, answer open-end questions, and assess his/her progress. Teachers ask open-ended questions and evaluate his/her students' knowledge (Barufaldi, 2002).

Traditional instruction the epistemology that is dominant in most classrooms today is influenced by objectivist philosophy; most teachers view knowledge as something outside the student for the teacher to give to the student. Knowledge is out there to be had, residing in books and independent of human beings (Ahmad & Aziz 2009). The philosophy of objectivism posits that the Universe exist independent of consciousness. The function of consciousness is not to simply create reality, but to apprehend it (PeikofF, 1997). Objectivity is a major component of the search for truths which underlie reality; learners are encouraged to view objects, events and phenomena with an objective mind, which is assumed to be separate from cognitive processes such as imagination, intuitions, feelings, values, and beliefs (Johnson, 1987). Teachers supply textbooks, and through note taking and lecture, the students "learn" the information. There is usually only one way to arrive at the "truth" or correct answer. How a student arrived at the answer is not very important, just that he or she did. Traditional teaching also has been called Instructivism. Finn and Ravitch, coined the term "instructivism" to describe traditional teaching practices, focusing on teacher-centered instruction, which in their opinion, is superior to constructivism) (Finn & Ravitch, 1996).

### 1.8.2 Conceptual framework

The study was modeled by a conceptual framework which depicted a representation of dependent and independent variables and the relationships between them as shown by arrows in figure 1.1. In this conceptual framework, the teaching method and students' conceptual understanding are the two main variables. It is supposed that the dependent variable (the students' conceptual understanding about water) might be affected by the independent variables (the traditional teaching method and the 5E instructional cycle approach) and would improve after the treatment by developing appropriate or effective teaching method. In other words, if the teacher is to take an effective teaching strategy, then the students have to improve their conceptual understanding. This study claims that the implementation of 5E leaning cycle models significantly improves the conceptual understanding of students than the traditional teaching method.

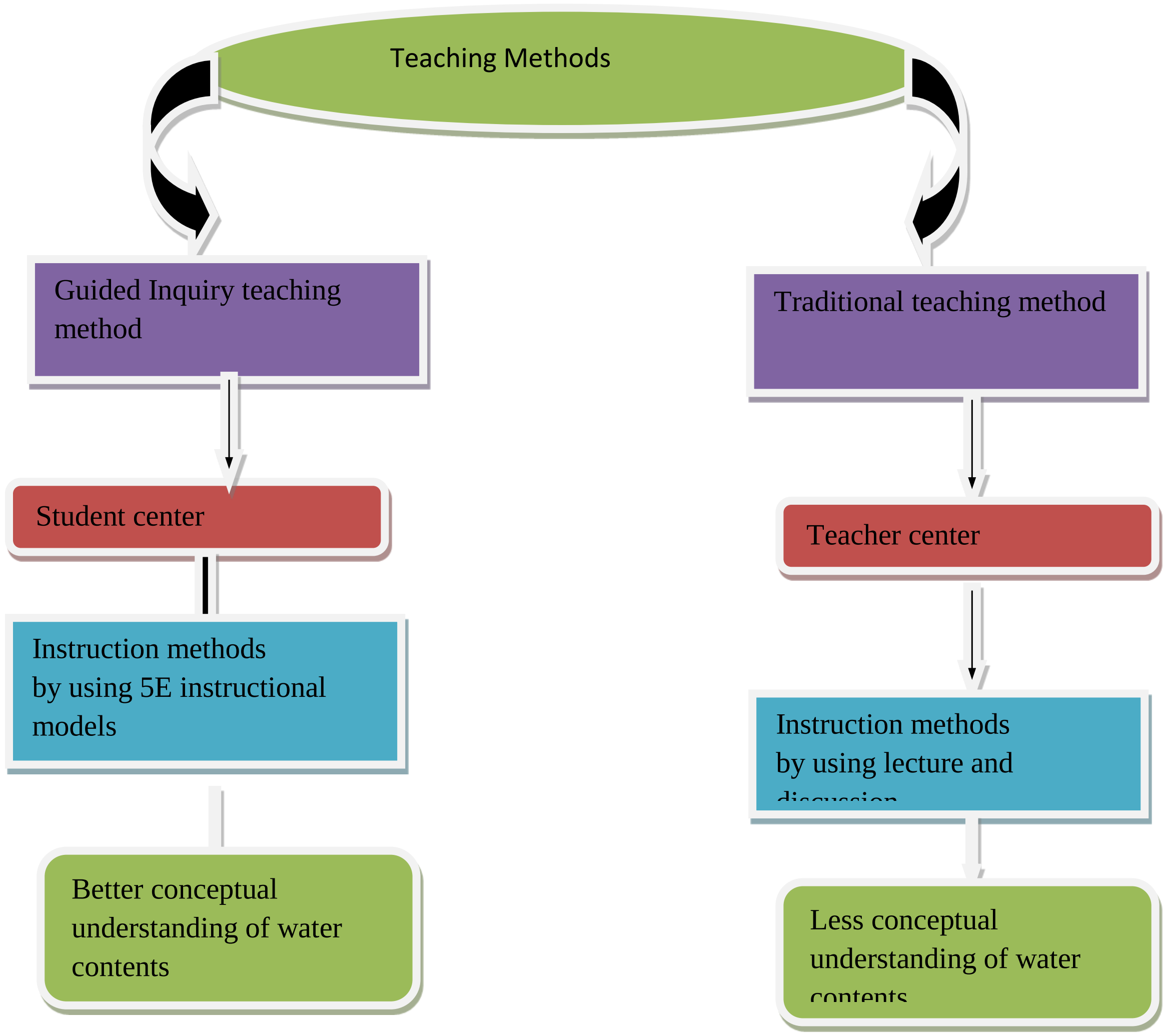


**Figure 1: Conceptual framework model**

## 1.10 Operational definitions

**5E instructional model**: It is a design in constructivist learning approach or it is constructivist instructional strategy that process through five phases these are; Engage, explore, explain, Elaborate and evaluate. Each phase covers hands-on and minds-on activities. Constructivist teaching approach:

**Constructivist teaching** is based on the belief that learning occurs as learners are actively involved in a process of meaning and knowledge construction as opposed to passively receiving information.

**Traditional teaching methods:** the process of teaching by lecture and direct instruction whereby teachers are the center of the lesson and dispense knowledge for the students to acquire through transmission.

**Conceptual understanding:** refers to the pupils‟ knowledge of the chemistry and physical aspect of the world. Students‟ comprehensions toward science concepts, in the current study the concerned science concepts is water.

**Water ($H_2O$):** a substance composed of the chemical elements' hydrogen and oxygen and existing in gaseous, liquid, and solid states.

**Hardness of water:** is a measure of the amount of calcium and magnesium salts in water.

**Water softening:** the process of removing hardness of water is called softening of water

**Water purification:** the removal of contaminants from untreated water to produce water that is pure enough for an intended use.

**Water pollution**: is the decrease in the quality of water caused by the discharge harmful substances in to it.

# CHAPTER TWO

# 2. REVIEW LITERATURE

This study sought to compare the 5Es learning cycle model and traditional teaching methods on conceptual understanding of elementary school students in water chemistry.

## 2.1 Teaching of Chemistry in primary Schools

Chemistry is one of the natural sciences taught at the primary school level. As defined by Ababio (2005) chemistry is the study of substance, what it is made of, how it behaves, its properties and how it changes during chemical reaction. Salman, Olawoye&Yahaya, (2011), describe chemistry as the central science that forms the essential foundation of many disciplines such as Biology, physics, cosmetics, medicine, plant science, engineering and environmental science. The importance of chemistry cannot be over emphasized, it appears that without chemistry there can hardly be science because, the scientific development of any nation is determined by the quality of chemistry education in its schools (Okafor, 2003).

The knowledge of chemistry in our ever-increasing innovative world is a prerequisite because achievement in chemistry is important for ensuring economic competitiveness. This entails that lack of conceptual understanding of chemistry concepts like water, beginning from elementary school level may impact negatively on students in a world that is becoming more global, innovative, and dynamic and requires quality and proficiency in the workforce. The main objectives of chemistry teaching at primary Schools are to enable the students to develop their knowledge and skills in chemical Science and project their efforts in education so as to be useful to themselves and the society in general. In spite of the importance of chemistry, observation of students‟ performance in chemistry in the primary school examination reveal that only a very negligible number of students perform well in the examinations (Melese W, 2015). This frequent poor performance of students in the examination is just pointing to one singular fact that, something is wrong with either the quality of the subject matter which refers to; what the students are taught or the instructional method which is; way they are taught.

The main aim of teaching is to transfer knowledge to the learners. Chemistry teaching is supposed to be result oriented and students centered, using the appropriate methods and resources in teaching the students. In the teaching of chemistry, students are exposed to learn both concepts and skills, some of which maybe abstract or difficult. Colburn (2009) and Uce (2009) noted that chemistry teachers are aware that students often struggle with the abstract concepts they are teaching, and yet, pedagogy in most chemistry classrooms does not address the students‟ needs to develop appropriate mental models of abstract chemistry concepts. For the students to have a complete grasp of the abstract concepts of chemistry, teachers must choose the appropriate teaching method. Martins and Oyebanji (2000) stated teaching methods affects the response of the students and determine their interest level, motivation and involvement in the lesson.

Teaching method has been defined by Afolabi and Adesope (2010) as a specific instructional process which differs from any other by the diversities of specialized activities. This implies that each teaching method has its own peculiar characteristics and steps which differ from another teaching method. Teaching method is very important in the impartation of knowledge in teaching-learning processes and the type adopted determines to a great extent what the student assimilate. In actual fact if the appropriate method is adopted, knowledge acquired can be accelerated.

The abstract nature of chemistry along with other content learning difficulties means that chemistry teaching and learning require a high-level skill and thinking, (Taber, 2006). For this study, the discovery teaching method will be considered using the guided inquiry-based learning which is a constructivist approach. According to Nadelson (2009), Guided inquiry-based learning holds great promises in assisting students to learn science free of alternative conceptions. Furthermore, based on the researches by Oliver (2007) and Prince and Felder (2007), the inquiry-based teaching style presents students with a problem to be solved and causes an increase in their motivation. However, the inquiry–based learning actively involves the students in the learning process and allows the students to learn the contents on their own, which provides more opportunities for the students to gain a deeper understanding of the concepts and become better critical thinkers (Wang & Posey, 2011). In this study, the constructivist teaching approach (5e learning models) and traditional teaching methods will be employed to compare the effectiveness on students understanding of water concept at elementary level.

### 2.1.1 Understanding chemistry problems associated with the teaching and learning of chemistry

Chemistry like all science subject is dynamic and activity oriented. It comprises of four basis components which are; the processes used to obtain (discover or create) chemical knowledge; the general concepts and specific ideas so produced; the applications of that knowledge in understanding and changing the world; and the implications of that understanding and change for individuals and societies (Cheng & Gilbert, 2009). They also argued that understanding chemistry requires understanding: the nature of chemistry, its norms and methods; the key theories, concepts and model of chemistry; how chemistry and chemistry-based technologies relate to each other; and chemistry-related technologies on society. As a result of these, Aikenhead (2005) affirmed that young learners should be taught how to acquire these chemistry skills and assimilate those abilities which will prompt them to taking responsibilities for expansion of their own knowledge and learning, they become self-reliant as they can easily apply the learned tools in new situations. It was again observed by Aikenhead (2005), that chemistry learning often occurs by rote learning of factual knowledge using lecture method and avoiding the use of instructional method that provides students first-hand experience and opportunity to solve problems.

According to Bransford, Brown and Cocking (2000), meaningful learning occur when students not only remember but are able to make sense of and are able to apply what they have learned effectively in new situation. Knowledge-construction by students for meaningful learning as stated by Bybee et al., (2006) is a challenging process which is actually stimulated by student centered activities involving a mental effort or activity. Cuttance (2001) opined that capturing students'' interest in chemistry at primary School level is a crucial aspect to improving the uptake of chemistry at secondary levels. For this reason, it is suggested that there is a need to improve the way chemistry is taught in schools so that students are more engaged and recognize the relevance of the Science through more real-life practical activities. Minds-on as well as hands-on activities that engage students in active learning are important in any chemistry classroom. Likewise, Njoku (2004) stressed that the teacher needs to be trained how to use activities that will make learners do and experience Science instead of just reading about Science. Contemporary learning theory indicates that students need to be actively engaged in learning tasks if they are to develop a meaningful understanding of Chemistry.

Research findings had however, revealed that, a large proportion of science teachers, chemistry inclusive, still resort to the use of traditional/lecture method rather than the activity-oriented strategies advocated for, such as demonstration method problem-solving and others (Olorukooba, 2001). Hence the prevalent teaching method in Nigeria, Kenya and Ethiopia is talk and chalk approach (Kurumeh, Omenka& Mohammed, 2013; Kamau, 2012 & Derebssa, 2006). Njelita(2007) from his research found out that innovative teaching strategies such as (inquiry, problem, solving, cooperative, demonstration methods) are better than the conventional method in acquisition of science skills. Professional teacher does not just transmit knowledge to the students, but has to adapt strategies as the need arises. According to Fisher (2003), science is generative in the sense that it is about constructing meaning out of knowledge. On this ground the constructivist teaching approach (which encourages learners to be active thinker to construct their knowledge) employing the 5Es learning cycle developed by Bybee (2006) will be adapted to improve the conceptual understanding of primary students on water chemistry.

## 2.2 Application of constructivist teaching approach to chemistry teaching and learning.

The constructivist teaching approach to education has become the leading theoretical position in education and a powerful driving force in science education. Constructivism has been proven by research to act as a powerful theoretical referent to build a classroom that maximizes student learning (Treagust, Duit& Fraser, 1996). Constructivism in the classroom incorporates three important dimensions: valuing the student’s point of view, using higher level questions to elicit student thoughts and valuing the process of student thinking rather than student answer or product (Freiburg&Driscoll, 2000).

Constructivism is one of the theories of learning which became well developed in the recent year and became the most significant and dominant prospective in science education (Taber, 2006). The constructivist model focuses on constructing the knowledge in the learner‟ mind.

Constructivists believes that objective knowledge cannot exist, rather all of us are involved in constructing our own words, part of which we take as being shared by others. Constructivist believes in truth but not in a truth that has been constructed by somebody. It maintains that individuals create or construct their own new understandings or knowledge through the interaction of what they already know and believe and the ideas, events, and activities with which they come in contact. Knowledge is acquired through involvement with content instead of imitation or repetition. Constructivism is not accepting what you are told but your prior knowledge about what you are taught and your perceptions about it. The new idea is not imposed on the learner. Teaching and learning must be an interactive process that engages the learners in constructing knowledge. The learner is actively re-structuring his past and present experiences. Students" active involvement is emphasized in constructivism; the knowledge is then rooted into their memory. Learning is primarily an individualistic enterprise. This is a child-centered approach that seeks to identify, through scientific study, the natural path of cognitive development. According to this approach students come to classrooms with ideas, beliefs, and opinions that need to be altered or modified by a teacher who facilitates this alteration by devising tasks and questions that create dilemmas for students. Working through these dilemmas results in construction of knowledge. "Discovery learning" and hands-on activities, such as using manipulative; student tasks that challenge existing concepts and thinking processes; and questioning techniques that probe students' beliefs and encourage examination and testing of those beliefs are included in instructional practices. Individuals construct knowledge in transaction with the environment, and in the process both the individual and the environment are changed.

### 2.2.1 Constructivist teaching approach vs. traditional method

Constructivist teaching approach is different from the traditional view of learning in the sense of view of the real world. The traditional view focuses on instructional goals such as recalling facts, generalization, defining concepts and performing procedures (Almala, 2005). Therefore, the view ignores the difference of preexisting knowledge of individual. On the other hand, it has been showed that constructivist teaching approach is effective in enhancing students understanding and achievement, teachers would spend less time on lecturing, drilling the students on basic concepts and rote learning (Andrew, 2007). Teachers can use the information of the students preexisting knowledge to create the instruction which can avoid the misunderstanding of concepts. In a study by Treagust, (1996) concluded that constructivism allows for greater learning success. Active participation has been shown to lead both greater understanding and greater interest in the subject. Caprio (1994) examined the effectiveness of the constructivist approach compared with the traditional lecture-lab method. It was concluded that students taught by constructivist methodology seemed more confident of their learning. They had significantly better exam scores. As a result of this, constructivist teaching and learning approaches lead greater understanding of concepts. It was concluded that students were more active in the learning process. Students had opportunity to see and control their thinking and they constructed correct knowledge more confidently and became more confident in their understanding of science. In addition to these, Akkus, Kadayıfçı, Atasoy&Geban, (2003) examined the effectiveness of the instruction based on the constructivist approach by focusing on the in-class teacher- student and student-student interaction within small groups over traditional method. It is indicated by the results that students instructed by constructivist approach acquired chemical equilibrium concepts better than the students instructed by traditional method. This research study also determined that students‟ previous knowledge and science process skills had an influence on their understanding of the concepts related to chemical equilibrium. Carlson (2003) supports a strong emphasis on identifying, building upon and modifying the existing knowledge (prior knowledge) students bring to the classroom, rather than assuming they will automatically absorb and believe what they read in the textbook and are told in the class. Research like that of Caprico, (1994) indicates that better exam grades were obtained by students taught using constructivist methodology. Supporting this finding, Saigo (1994) concluded that "the constructivist model has been found to slightly influence students‟ achievement in a positive way". The constructivist model is capable of getting students more involved in learning. Kurt &Somchai (2004) in their own research study on constructivism also found that students used for their study participated more in the classroom activities and gained in content knowledge when a constructivist approach was used. Brad (2000), in his study, found that students in the constructivist instruction showed higher degree of academic achievement than students in the traditional instruction in all conditions. In a research study by Gatlin (1992) he found out that there was no significant difference in students‟ scores at the posttest between students of the constructivist group and traditional group. He reported that students‟ scores of those who received the constructivist approach showed a slight decrease on the delayed posttests, while students taught using the traditional approach showed a greater decrease over time. Students who received the constructivist instructional approach have a higher relation over time. It can be said that students taught by traditional means, who rely on memorization to pass tests, over time often do not remember much of the information learned. Makanong (2000) corroborated Gatlin's finding in his research study when he found that there was no significant difference in achievement between students in constructivist group and traditional group.

## 2.3 The concept of 5Es learning cycle model approach

The learning cycle is a model for teaching in all subject areas; it provides a basis for thematic and integrated instruction and offers many opportunities to measure real learning. It is proposed to help students progress from concrete to abstract thinking about context. Learning cycle is a teaching model based on the knowledge organization process of mind. It helps student to apply concept and make their scientific knowledge constant. A well-known model of science teaching and learning is called "the learning cycle" or by an alternative model is called "the 5Es". Robert Karplus (1962) wrote the first reference to this as a part of the Science Curriculum Improved Study (SCIS) in the 1960s. In the exploration phase of the learning cycle, students discover new concepts with guide of the teacher. The students confront with their previous experiences and existing knowledge in this phase. During concept introduction, students are introduced to a new concept. In the concept application phase, student applies their new concept into new situations. Bisbee's 5E model is as follows: Probably one of the earliest and foremost supporters of the learning cycle was the SCIS program which adapted it and included it in its science curriculum. Although there are several "E" versions (e.g. 3E, 4E, 5E, and other modifications) the basic premise is that children have an experience with the phenomena in the learning of the concept/topic. When implementations of constructivist approach are examined, some operators transformed three staggered circle model into five staggered circle model. The 5E model consists of Engage, Explore, Explain, Elaborate, and Evaluate Phases (Wilder &Shuttleworth, 2005). The five phases, as explain by Bybee, (2006), the 5Es model is based on both a conceptual change model of learning and a constructivist view of learning as shown in figure 1.

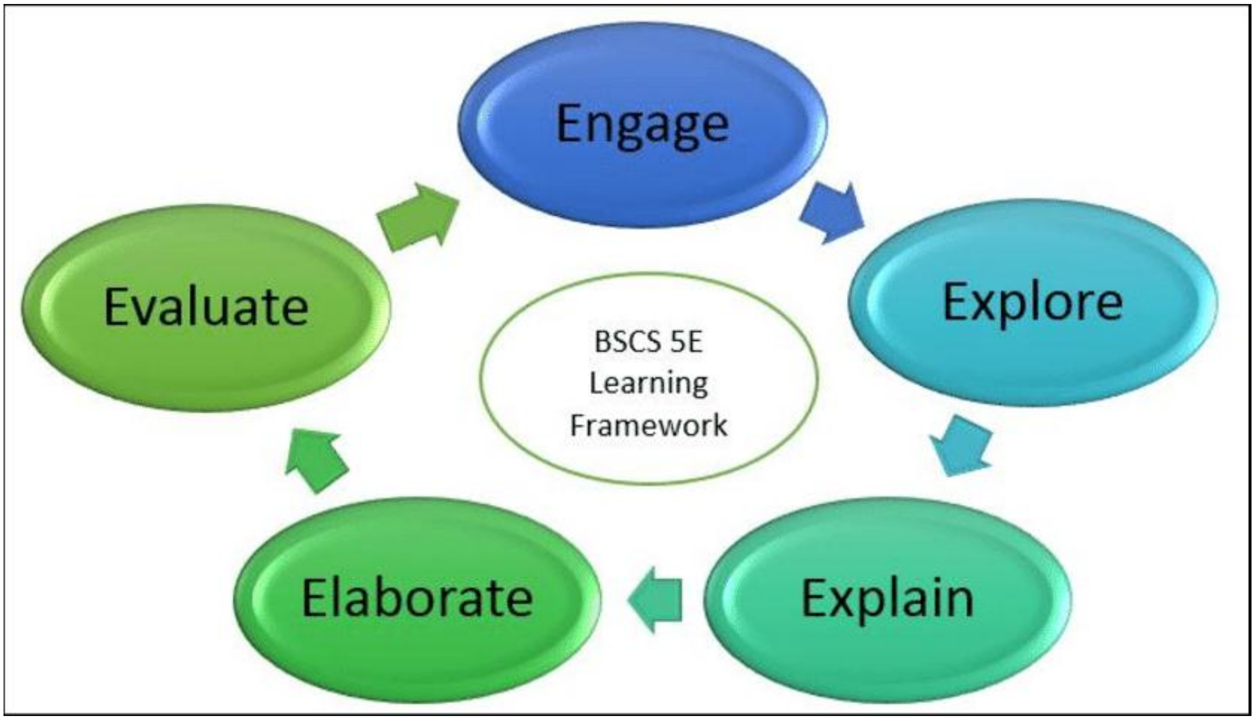


**Figure 2: Phases of 5E instructional model by (Bybee et al., 2006)**

**Engagement**

The teacher accesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities. (Bybee et al., 2006).

**Exploration**

Exploration experiences provide students with a common base of activities within which current concepts (particularly misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation. (Bybee et al., 2006).

**Explanation**

The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. This phase also provides opportunities for teachers to directly introduce a concept, process, or skill. Learners explain their understanding of the concept. An explanation from the teacher or the curriculum may guide them toward a deeper understanding, which is a critical part of this phase. (Bybee et al., 2006).

**Elaboration**

Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities. (Bybee et al., 2006).

**Evaluation**

The evaluation phase encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives. (Bybee et al., 2006).

## 2.4 Traditional teaching approach in science

In traditional teaching approach classes are usually driven by teacher talk and depend heavily on textbooks for the structure of the course. Teachers serve as channels and seek to transfer their thoughts and meanings to the passive student. In the context of traditional teaching instruction refers to the usual methods used by educators to teach science subjects, which could involve occasional reference to real-life applications of science (Hackling et al., 2011). Studies suggest that the traditional ways of teaching science often fail to sufficiently develop learners understanding of scientific concepts (Taasoobshirazi & Carr, 2008). The opinion of Taasoobshirazi and Carr (2008) traditional ways of teaching science, which usually involve memorization of concepts and computations, often result in learners‟ failure to comprehend the deeper conceptual connections within the problems. According to these authors, traditional way of teaching encourages poor conceptual understanding and limited comprehension of learned in science concepts and ideas. According to Adunola (2011), teacher-centered methods of traditional teaching does not apply activity-based learning to encourage students to learn real life problems based on applied knowledge. Since the teacher controls the transmission and sharing of knowledge, the lecturer may attempt to maximize the delivery of information while minimizing time and effort. As a result, both interest and understanding of students may get lost. Ahmad and Aziz (2009) observe that teacher-centered teaching is the traditional teaching method where teachers are at the center of the class activities: teach, talk and explain all the way. That means in traditional classrooms, students have a definite and fixed perception and idea of their own roles and those of their teachers as custodians of knowledge. Their experiences show that teachers behave in certain ways and have particular roles in the process.

In general, Traditional teaching approaches make science subjects appear irrelevant, uninteresting and difficult to learners. These perceptions could reason for the hopelessness, poor performance and poor conceptual understanding in science education especially in chemistry.

## 2.5 Overview of Related Studies

This study compares the effectiveness of teaching chemistry of constructivist approach based on 5Es learning model and traditional teaching methods on understanding of water concepts among primary school chemistry students in Bahirdar, Ethiopia.

Ehtegebreal (2019), evaluate guided inquiry (GI) pedagogical strategy for conceptual understanding of eighth-grade students in elementary optics. Simultaneously, it explored and quantified students' conceptions of elementary optics before and after instructions. The design employed in this study was quasi-experimental research design, which had experimental and control groups (40 students in the experimental and 39 students in control group). The study took place in Atse Serste Dingle primary school in Bahir Dar town, Ethiopia. GI pedagogical strategy was employed for the experimental group students; whereas, conventional instruction (CI) was applied to control group students, for almost two months. The data collected through open-ended conceptual test and simple drawings and analyzed with the facet- scheme hierarchical organization, abundance and gain of it to determine and quantify students' conceptions. Before instruction, students in both groups showed misconceptions which described as nonscientific facets of knowledge. This study revealed students' conceptions from a developing country: Ethiopia

Udogu and Njelita (2010) investigated the effect of constructivist based instructional model on students‟ conceptual change and retention on some difficult concepts in chemistry, Anambra State, Nigeria. Quasi experimental, non-equivalent group control design involving two intact classes was used. The target sample population was SS2 Chemistry students with a sample size of 170 students from four secondary schools purposefully in Idemili south local government area of Anambra State. A Teacher Made Achievement Test Chemistry (TMATC) was used as the instrument drawn from some chemistry concepts namely; electrolysis, redox reaction, calculations involving mass and chemical equilibrium. Analysis of co-variance statistical tool was used to test the null hypothesis. From the finding, it was observed that experimental group performed better than the control group. This was an indication that constructivist-based approach is effective in enhancing meaningful learning among chemistry students.

Also, another study on chemistry students was carried out by Kilaruz (2005), who compared the effectiveness of 5Es learning cycle model a constructivist instructional based approach over traditional design chemistry instruction (Lecture method) on ninth grade students understanding of acid-base concept in Ankara, Turkey. Quasi experimental design with control group was employed for the study. Acid-base concept achievement test (ABCAT) was administered to both groups in order to assess their understanding of concept related to acid-base. Students were also given Attitude Scaled towards Chemistry Questionnaire (ASCQ) at the beginning and end of the study. Science Process Skill Test (SPST) was administered to measure their Science Process Skills. Hypotheses were tested by using Analysis of Co-variance (ANCOVA) and t-test. Result indicated that instructional based on constructivist approach caused significantly better acquisition of scientific concepts related to acid-base. Students showed statistically equal development in attitude towards chemistry as a school subject due to the treatment with 5Es learning cycle.

Aligarh (2016) investigated the effectiveness of 5E instructional model of constructivist approach on ninth-grade students‟ conceptual understanding of solutions. In this study, a pretest-posttest control group quasi-experimental design was used. The participants included 60 students, who were enrolled in ninth grade and belonged to two different sections during the session 2014-15, in a secondary school in Kisangani, Bihar, India. These two sections were randomly assigned to traditional instruction and 5E instructional model of constructivist approach respectively. One section, subjected to traditional instruction, was considered as control group and the other section, subjected to 5E instructional model of constructivist approach, was considered as experimental group. Both the groups were subjected to their respective instructional method for one week. They attended six periods per week. Each period was of 35 minutes duration. These groups followed the same instructional sequence and had the same learning objectives. The data gathering instrument of this study was achievement test. After the analysis the data, the results showed that 5E instructional model of constructivist approach is a good supplementary method for traditional instruction in chemistry at secondary school level.

Yadigaroglua and Demircioglub, (2012) conducted a study to investigate the effect of activities developed based on 5Es model on grade 10 students understanding of general properties of gases in chemistry. The study was conducted in a high school in Akcaabat province of Trabzon, Turkey in 2010-2011 academic years. The study used the quasi-experimental design. 40 grade 10 students in two classes were selected for the study. While one of the classes was randomly assigned as experimental group (13 boys, 7 girls), the other was determined as control group (11 boys, 9 girls). In the study, Concept Achievement Test (CAT) was used to collect the data. The collected data were compared by using the independent sample t-test. A statistically significant difference in favor of experimental group was detected. It is essential that teachers should develop their skills for designing constructivist learning environment.

Dinkale(2019) conducted the study to investigate the effectiveness of 5E instructional model of constructivist approach on grade seven students' conceptual understanding of muscular and skeletal system concepts in biology. The study was conducted in primary school in Bahirdar, Ethiopia in 2019 academic year. In this study Quasi-experimental research design was employed. Out of four grade seven sections, two sections (N=122) were selected randomly and assigned as experimental (N=61) and control (N=61) groups. The students in the experimental group were instructed with the 5E instructional model of constructivist approach, and students in the control group were instructed with traditional teaching instruction for three weeks. Muscular and skeletal system concepts test, classroom observation and informal classroom assessment were used as data collection instruments. Pretest and posttest were analyzed quantitatively (descriptive statistics and t-tests) while classroom observation and informal classroom assessment were analyzed qualitatively. The pretest results indicated that there was no significant mean difference between experimental and control group students. The posttest comparison of students in the experimental group exhibited significant changes in conceptual understanding of the concepts compared to control group students.

Cynthia (2017), conducted a study to determine if students' chemistry knowledge and interest can be increased by using the 5E learning cycle in a middle school with a high population of English language learners. The participants were eighth-grade middle school students in a large metropolitan area. Students participated in a month-long chemistry unit. The study was a quantitative, quasi-experimental design with a control group using a traditional lecture style teaching strategy and an experimental group using the 5E learning cycle. Students completed a pre-and post-student attitude in science surveys, a pretest/posttest for each mini-unit taught and completed daily exit tickets using the Expert Science Teaching Educational Evaluation Model (ESTEEM) instrument to measure daily student outcomes in main idea, student inquiry, and relevancy. Analysis of the data showed that there was no statistical difference between the two groups overall, and all students experienced a gain in content knowledge overall. All students demonstrated a statistically significant difference in their interest in science class, activities in science class, and outside of school. Data also showed that scores in writing the main idea and writing inquiry questions about the content increased over time.

In conclusion, the findings on 5Es learning model of most studies reviewed were carried out on performance, attitude, retention and conceptual change in the area of physics, biology and chemistry. Constructivist instructional approach base on 5Es was not considered. The aspects of chemistry covered for the study were taught using science process approach by Cynthia. It is in the light of this, study investigate the comparison of 5Es learning model and traditional teaching methods on grade eighth students conceptual understanding of water concepts like hardness, purification, softening and pollution of water in dilchibo primary school Bahirdar, Ethiopia.

## 2.6 Implications of literature reviewed to the present study

The related literature reviewed so far has given some insight into the effects of constructivist instructional approach on academic performance, interest and conceptual change in difference science subjects. It also gave an insight to the impact of instructional method (science process approach) and the engagement of students when they learn by 5e instructional models. This has some implication on the present study.

Majority of the studies revealed by Udogu and Njilita (2010), Kilaruz (2005) and Cynthia (2017) showed that subjects exposed to constructivist instructional approach based on 5Es learning model recorded higher academic performance and interest span when compared with those taught using traditional method. It is in the light of this, that this study considered it necessary to enhance chemistry learning and teaching using 5Es learning model.

Furthermore, researches showed that the ways chemistry is usually taught (traditional teaching approaches) make chemistry subject appear irrelevant, uninteresting and difficult to learners. These perceptions could account for the despondency and poor performance apparent in science education. With respect to 5e instructional teaching approaches, the literatures suggests that while researchers agree on the motivational effect of these approaches, their effect on learners conceptual understanding and expose study materials to learners this leads to skills development.

## CHAPTER THREE

# 3. METHODOLOGY

## 3.1 Research Design

This study was a design-based research that employed quasi-experimental study method with control and experimental groups. A simple random sampling technique was used in assigning the experimental and the control group. According to Vanderstoep and Johnson (2009), quasi-experiment is an empirical study used to estimate the causal impact of an intervention on its target population.

The quasi-experimental design that has been chosen for this study was the Pretest-Posttest non-equivalent group strategy. The purpose of this strategy was to use qualitative data and to assist results in explaining and assigning reasons for quantitative findings. The study involved systematically designed 5e instructional model lessons to be taught for experimental group and traditional teaching methods on water concepts for control group of eighth grade students and then to compare the effectiveness of each method on the students conceptual understanding about the topic.

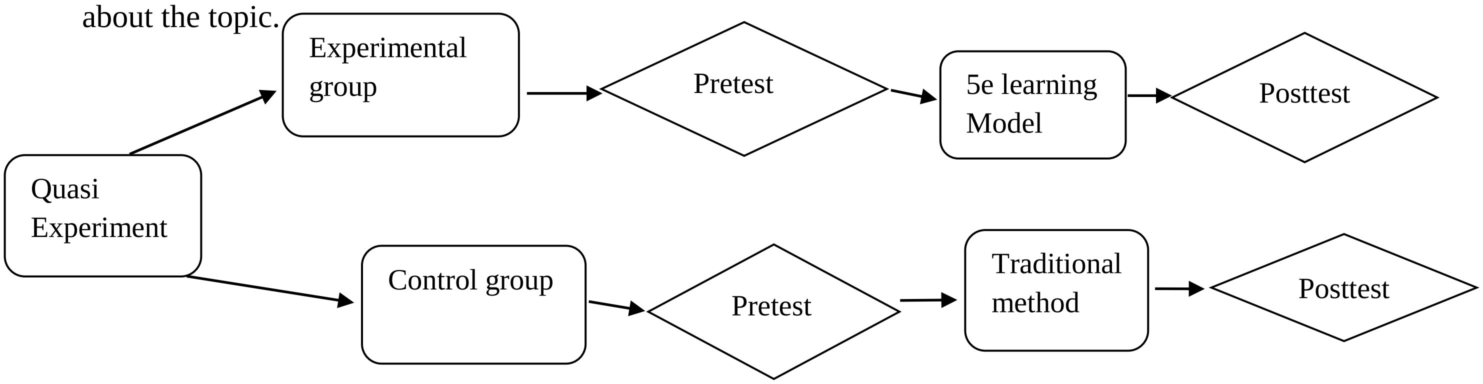


**Figure 3: Research design (Fraenkel, J. R 2012)**

## 3.2. Research Setting and targets

The research was conducted at Dilchibo primary school located in the city of Bahir Dar, Amhara region in the northern part of Ethiopia. The students are from the main city of Bahir Dar. According to the information obtained from record office 2013 E.C, the school has 1034 elementary students, and 48.5 percent of the school's population is male, and 51.5 % of the school's population is female. The eighth-grade class consists of 4 sections and a total of 186 students. From those students 100 are males and 86 are females. The researcher selected one class of eighth grade students randomly from four possible classes in Dilchibo elementary school. 54 eighth grade students that have involved 17 male and 37 female students who were participated in this study. The researcher divided those students into two groups as control and experimental groups. The control group was consisted of total 27 students out of which 8 of them were male and 19 of them were females. The other was the experimental group consisted of total 27 students i.e. 9 males and 18 females respectively

The effect of a new teaching method on learning was implemented in the study, equalization of the groups in gender and previous achievement was crucial and considered in the research according to (Büyüköztürk et al., 2008). For control groups the researcher taught about water concepts by traditional teaching methods. On the other hand, for experimental groups, the researcher taught about water concepts by 5e learning model. Both groups were taught for one month and 3 periods in a week.  Each Periods has 40 minutes in length and age of Students range from 14-16 years of old.

## 3.3 Source of Data

For this study, I employed purposive sampling technique to select the school. The school has four eight grade sections from which the particular section for the study was selected based on random sampling technique. But the experimental and control groups were assigned after their pretest was analyzed. Their pretest has revealed that both groups of students had similar conceptions of the intended concepts; then, the researcher assigned the two groups randomly as an experimental and control group. Consequently, participants of this study were 54 eighth-grade students from Dilchibo primary school. Out of 27 students 9 of them were males and 18 females) both of them were assigned randomly to the experimental group (EG), the other 27(there were 8 males and 19 females) students were assigned to be control group (CG). The researcher has 10 years of experience in teaching chemistry at primary and college level and has taught both groups.

## 3.4 Data collection methods and procedure

The main instruments that used for data collection were chemistry achievement test (pretest and posttest), informal classroom assessment and observation.

### 3.4.1 Chemistry achievement test (CAT)

Chemistry achievement test was used to collect necessary data for the statistical analysis of research problem and to compare teaching chemistry by traditional method and 5E learning cycle model in teaching the concept of water for students. First, to determine a baseline of students' prior knowledge for both groups the researcher gave pretests consisting of 20 questions from sub topics of water concepts (water hardness, water softening, water purification and water pollution). Questions included different parts, which included, water concepts and critical thinking. At the end of the subtopics, they take the same post test questions to determine how much they learned and retained.

This academic achievement test was used for several purposes: first of all, as a pre-test, it is applied to students in order to determine their background knowledge and readiness about water concepts (hardness, softening, pollution and purification). Moreover, as a post-test, it is used in order to determine the effect of teaching methods. (see in Appendix F)

### 3.4.2 Class room observation

The researcher observed all over all activities of students, teaching learning procedure in the class and identifies students' alternative conceptions from the given contents. Students' misconceptions were recorded by asking informal questions at the beginning, at the middle and at the end of the lesson.

### 3.4.3 Informal classroom assessment

Before intervention the researcher observes student's prior knowledge by giving 7 open ended pre assessment questions and after intervention the researcher conducted similar questions to assess and evaluate students' misconceptions, and to know students conceptual understanding of current topic.  The assessment questions were drawn from water sub topics include water hardness, water softening, water purification and water pollution.

## 3.5 Intervention plan

The intervention program of this study was continued for one month (4 weeks) in each week (3 periods) and in each period lasts for 40 minutes. Multiple choice and fill the blank pre-test questions were administered before carry out any intervention of instructional design, during intervention; twelve different sessions were implemented by two different instructional designs, that means intervention program for 5E model instruction was applied on experimental group and traditional instruction also applied on control group and post-test after intervention for both groups. The classroom interventions for all groups were given by the researcher and both groups taught in classes using the same textbook, teaching materials and the same duration of time. In general, the intervention design was prepared on four subtitles of water topics according to the two instructional approaches and also includes the pretest before intervention and posttest after intervention were given for both experimental and control groups of eighth grade students and compare their effectiveness to bring better conceptual understanding about water concepts (Intervention plan see in Appendix B).

### 3.5.1. Teaching approach used for the experimental group

5E learning cycle model was used to teach water concepts in experimental group. In this method, the instruction was designed with respect to 5e learning cycle model to help students realize that some of their preconceptions are wrong and help them to maximize students' interest by embedding some kind of activities such as demonstration, hands on activities, laboratory activities in certain phases of 5e learning cycle model. In addition, instruction is designed to maximize student active involvement in the learning process. Moreover, the water concepts are instructed in experimental group 3 periods a week, over 4 weeks period (12 chemistry lessons). One intact chemistry class containing 27 students was used. Topics which were given for experimental group includes water hardness, water softening, water purification and water pollution in grade $8^{th}$ chemistry subject. During the implementation of these topics the researcher used 5E learning cycle instruction consists of five phases, in the first, Engagement phase, the researcher tried to assess students' prior knowledge and students' misconception about water concepts. And also, the researcher motivates students to create interest.

In the second, Exploration phase, Students were encouraged to apply process skills, such as observing, questioning, investigating, testing predictions, hypothesizing, and communicating, with other peers about water concepts. In addition, Learners will complete hands-on activities with guidance that enable them make use of prior knowledge to generate new ideas, explore questions and possibilities and conduct a preliminary investigation about water topics.

In the third Explanation phase, students describe important concepts of water and had the opportunity to share their own explanations. The teacher clarifies the concept and defines relevant vocabulary as needed, in the fourth Elaboration phase, gave the students opportunity to extend their knowledge of concepts to other contexts. Students may conduct additional investigations, develop products, share information and ideas, or apply their knowledge and skills to other disciplines.

And finally in Evaluation phase, the researcher had the opportunity to assess students' current knowledge and provide feedback on performance about water concepts. Students may also have the opportunity to conduct self-assessment or peer-assessment. Based on this procedure the researcher designed lesson plans and implemented the lessons on water sub topics for 12 periods. (See in Appendix D).

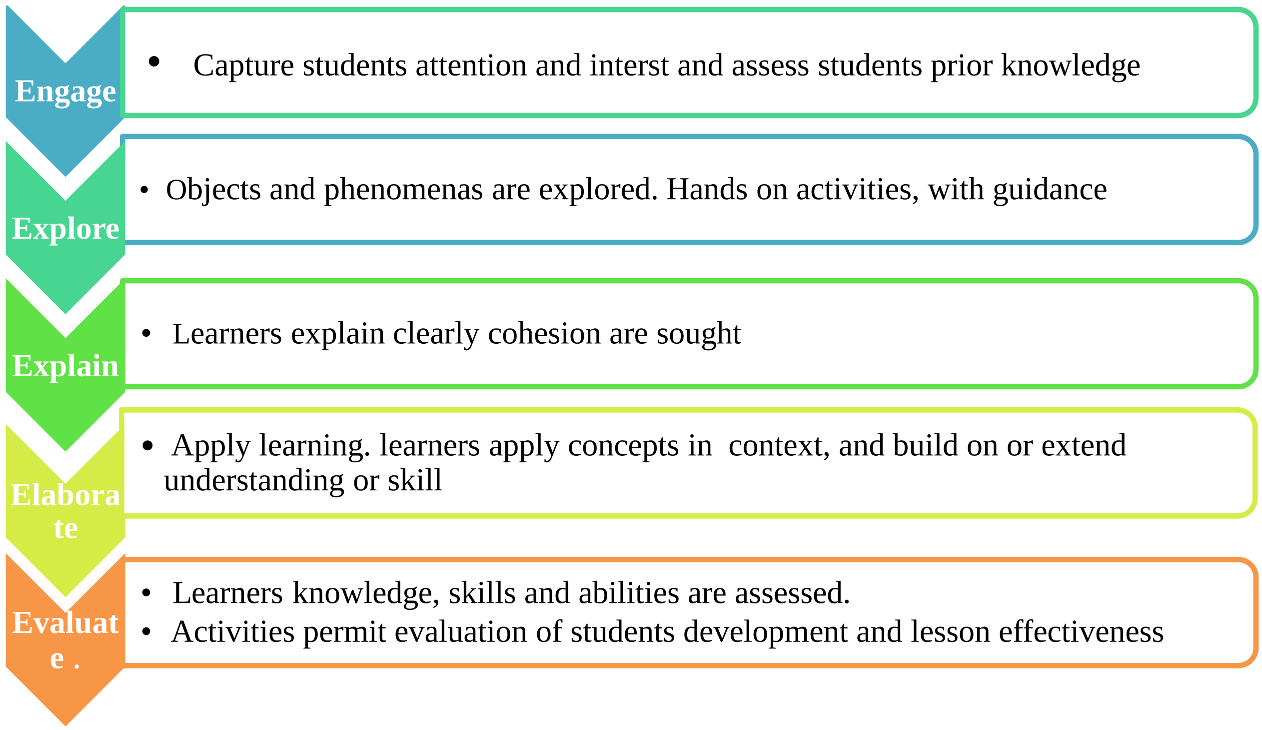


**Figure 4: Flow Chart illustration the 5Es Learning Model**

Source: BSCS. Bybee, (2006).

### 3.5.2 Teaching approach used for the control group

The traditional method that was used in control groups consists of lecture and demonstration method to taught water concepts for 27 students. The students were instructed with respect to teaching strategies that are related to teacher explanation and text books without consideration of students' alternative concepts and their own learning. In this talk and chalk teaching approach, most of activities of a lesson were presented by teacher. The students were expected to listen to the teacher and take down note presented on the black board. The contents which were implement for control group includes water hardness, water softening, water purification and water pollution. Those contents were given on for one month (12 periods) duration by designing traditional lesson plans done by the researcher (see in appendix E).

## 3.6 Variables

### 3.6.1 Independent variables

In this research, the independent variables were two different types of treatments; instruction based on 5E instructional model of constructivist approach (5E learning cycle model) and traditionally designed chemistry instruction (traditional classroom instruction) were the independent variables.

### 3.6.2 Dependent variable

The dependent variable was students' conceptual understanding of water concepts.

## 3.7 Data Analysis techniques

The quantitative data was analyzed using SPSS software using descriptive and inferential statistics. In inferential statistics the data was analyzed using t-test (independent sample t-test and paired sample t-test) through SPSS software. The data collected through observation and informal assessment was analyzed using a narrative description of words qualitatively. Pretest and posttest were analyzed through both Descriptive and inferential statistics to find the mean and standard deviation scores of each group. And also, independent sample t-test was used to compare pretest and posttest results of the two groups to decide the effectiveness of 5E learning models and traditional teaching methods to get better understanding of water concepts. Both tests were also analyzed through paired sample t-test to compare the mean scores of pre and posttest in the same group and used to answer the research questions. The qualitative data which were gathered qualitatively through observation and informal assessment was analyzed thematic analysis method. It also used to answer the 3$^{rd}$ research question.

## 3.8 Pilot study

The pilot Study was carried out using the instrument, Chemistry achievement Test (CAT) on one school called Ewket fana grade 8th students of Governmental elementary School in Bahirdar, Amhara regional State. The trial school is not part of the sample school of the study to prevent the students from having an idea of the instrument. The purpose of the pilot study was to ascertain the feasibility and reliability co-efficient of the instruments constructed through a trial run. Data collected from the pilot study was used for Reliability of the instrument and item analysis. The CAT consisting of 20 questions were administered to the students, instructions on how to answer the questions were read and explained verbally by the researcher and students were allowed ask questions for further clarification. A period of 40mins was allocated for the test to ensure that students answer the questions carefully. From this also, the actual time for the CAT was obtained by observing the time duration it took majority of the student to finish.

### 3.8.1 Reliability of the Instrument (CAT)

To test the reliability of the measuring tool conducted using a trial testing, piloting it on one of the governmental schools called Ewket fana primary school in the similar setting of the sampled schools. The students which received a test were 56 in number. The selected school was similar to those that featured in the main study in terms of the location and status. Similarly, these selected students are similar to the subjects of the study in respect of age and exposure to instructional resources and learning of the chemistry subject.

The instrument reliability coefficient gotten through the use of Cronback's alpha was 0.653 and ensures the internal consistency of the instrument used. Thus, the instrument was deemed reliable for use in this present study. Based on the results the questions were powerful to measure students' understanding about water concepts.

### 3.8.2. Validation of the Instrument

In an attempt to establish the validity of the Chemistry Achievement Test (CAT) in relation to the aim of the study, the 20 test item questions were subjected to scrutiny by two primary School chemistry teachers with B.Sc. in chemistry (dilchibo) and one MSc in chemistry University

Lecturer in the Department of chemistry at Bahirdar University. The Chemistry Achievement test (CAT) was administered to both the experimental and control group as pretest to determine the academic equivalence /performance levels and as posttest to compare the group for significant difference after treatment.

## 3.9 Ethical Consideration

Proper permission was requested from college of education and behavioral science and the letter was written to the school (Appendix A). In conducting the research, the researcher should announce that the study will never harm respondents' academic program as it will never be for other purposes. It was made clear that without the students' permission, no data would be disposed for other party. Additionally, the researcher asked and got permission to conduct this study under the stated area from a responsible body of the government. During interaction with students, the researcher respected their humanity regardless of their age, sex, religion and economic states.

# CHAPTER FOUR

# 4. RESULTS AND DATA ANALYSIS

## 4.1. Statistical analysis of pretest and posttest results

### 4.1.1. Descriptive statistics analysis of pre and post test results for both groups

**Research question one:** What is the effect of the 5e instructional models in improving students' conceptual understanding of water concepts?

To answer this research question, the pre-test scores of students mean, standard deviation, minimum and maximum of pre-test and post-test for both experimental and control groups of water concept test scores were presented in Table 1. Both experimental and control group students pretest and post test results out of 20% has been presented in appendix part (See in Appendix G).

**Table 1** Descriptive statistics of pretest and posttest results for both experimental and control groups

| Test | Group | N | Sum | Mean | St. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|---|---|
| Pretest | Experimental | 27 | 118 | 4.37 | 2.022 | 0 | 9 |
| | control | 27 | 120 | 4.44 | 1.93 | 0 | 9 |
| Posttest | Experimental | 27 | 312 | 11.48 | 3.34 | 7 | 20 |
| | control | 27 | 214 | 8.67 | 2.37 | 4 | 14 |

As shown in Table 1, before intervention the pretest means and standard deviation scores of experimental groups were 4.37and 2.02 respectively. On the other hand, the pretest mean score and standard deviation of control group was 4.44 and 1.93 respectively. The pretest scores of mean and standard deviations in both groups were relatively the same. Depending on their results, the prior knowledge or their understanding of water concepts was similar for experimental and control groups.

The results of water concept tests after treatment of experimental group by 5e learning cycle model and control group by traditional teaching method was listed below. Posttest mean scores of experimental groups were 11.48 and standard deviation 3.34, while the posttest means scores of control group was 8.67 and standard deviation 2.37. Based on the results the understanding of water concepts after treatment was gradually changed in each group. Because the mean and standard deviation posttest scores of experimental and control groups were varied and there was significance difference between the two groups. The understanding of water concepts after intervention on experimental groups that were learned by 5e learning model of teaching approaches had resulted better understanding on the control groups which were learnt by traditional teaching methods about water concepts. This implies that the 5e learning model approach was an effective method to improve the conceptual understanding of students about water concepts than the traditional teaching methods.

## 4.1.2 Inferential Statistics analysis of pre-test and post-test

### *4.1.2.1 Independent t-test analysis of pre-test and post-test result for both groups*

***$Ho_1$:*** *There is no significant difference between the pre- test mean scores of experimental group and control group students used for this study*

**Table 2** Comparison of pre-test results in both groups through independent sample t-test

| Group | t-test for Equality of Means | | | | | |
|---|---|---|---|---|---|---|
| Experimental & Control | T | df | Sig. (2-tailed) | Mean difference | 95%confidence interval of the difference | |
| | 0.138 | 52 | 0.891 | 0.74 | Lower case | Upper case |
| | | | | | -1.005 | 1.153 |

Not Significant at P>0.05

Table 2 shows that the independent t-test analysis of the pre-test score for both experimental and control groups. The result of the t-test has been presented as the mean difference between two groups was 0.74, Level of significance α value is 0.05, Sig. 2-tailed (p-value =0.891) and t (52) =0.138; P>0.05. Since the P value greater than α value thus, we have enough evidence not reject the homogeneity of the two groups in the pre-test that is the mean is approximately equal with a minimum mean difference. Therefore, this result showed that there was no significant difference between the mean score of the experimental and control groups in the pretest or before treatment.

The hypothesis also the t-calculated (0.138) is less than the t-critical (2.009), while the p-value is 0.891(p >0.05). The null-hypothesis which stated that there is no significant difference between the pre- test mean scores of experimental group and control group students used for this study. This null-hypothesis was accepted.

***Ho$_2$:*** *There is no significant difference between the mean score of Chemistry Students conceptual understanding when exposed to the 5Es Learning Cycle Model and those taught with traditional method.*

**Table 3** Comparison of post-test results in both groups through independent sample t-test

| Group | t-test for Equality of Means | | | | | |
|---|---|---|---|---|---|---|
| | T | df | Sig. (2-Tailed | Mean Difference | 95% Confidence Interval of the difference | |
| | | | | | Lower case | upper case |
| Control & Experimental | 3.569 | 52 | 0.001 | 2.815 | 1.232 | 4.397 |

Significance at P<0.05

Table 3 shows that the independent t-test analysis of the post-test score for both experimental and control groups. The result of the t-test is presented as, the mean difference between the two groups was 2.815, Level of significance α value = 0.05, Sig. 2-tailed (p-value =.001) and t (52) = 3.569; P< 0.05. Since the P value less than alpha value thus, we have enough evidence to reject the homogeneity of the two groups in the post-test that is the mean is not equal with a wide mean difference. Therefore, this result showed that there was a significant difference between the mean score of the experimental and control groups in the post-test or after the implementation of the treatment. As this result, experimental group students taught with 5e learning models performed better mean score than the control group students taught with traditional methods.

The hypothesis also showed that the t-calculated value of 3.569 is greater than the t-critical value of 2.009, while the p-value is 0.001 ($p < 0.05$). The null-hypotheses which describes There is no significant difference between the mean score of Chemistry Students conceptual understanding when exposed to the 5Es Learning Cycle Model and those taught with traditional method in Dilchibo primary school. The null-hypothesis result was rejected.

**Research question two:** Is there a significant difference in the achievement of students taught with 5e instructional models and those students who thought with traditional teaching methods about water concepts?

#### *4.1.2.2 Paired sample t-test for both group between pre-post test scores*

**Table 4** Comparison of pre-post result for the experimental and control group through paired samples statistics

**Paired Samples Statistics**

| Group | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Experimental | Pretest | 4.37 | 27 | 2.022 | 0.389 |
| | Posttest | 11.48 | 27 | 3.344 | 0.644 |
| Control | Pretest | 4.44 | 27 | 1.928 | 0.371 |
| | Posttest | 8.67 | 27 | 2.370 | 0.456 |

As shown in Table 4, the result of the paired sample t-test indicates that there was a significant difference in the mean score of both experimental and control group in their pre-test and post-test. The experimental group the mean increases from pre-test (Mean=4.37, standard deviation =2.022) to post-test (Mean= 11.48, Standard deviation =2.370). The control group pretest-posttest mean scores and standard deviation were also obtained as (pre mean= 4.44 post mean= 8.67, pre standard deviation=1.93 post standard deviation=2.370). Based on the results experimental group students taught by 5e learning models achieved better mean and standard deviation scores in the post test than their pretest. Control group students taught by traditional teaching methods also had better post test scores than that of their pretest scores, but the change was relatively smaller than experimental groups in both mean and standard deviation results. As this result, experimental group students taught with 5e learning models performed better understandings about water concepts than the control group students taught with traditional methods.

**Table 5** Comparison paired differences of pre-post result in both groups

| Paired difference | | | | | | T | Df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| Group | mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | Lower | Upper | | | |
| Experimental group | 7.111 | 1.928 | .371 | 6.348 | 7.874 | 19.163 | 26 | .000 |
| Control group | 4.222 | 1.08 | .209 | 3.793 | 4.652 | 20.201 | 26 | .000 |

As shown in Table 5, the experimental group mean difference between pre-test and post-test was 7.111 with a 95% confidence interval ranging from 6.348 to 7.111. In this group at t (26) =0.000; P< 0.05. The control group mean difference between pre-test and post-test was 4.222 with a 95% confidence interval ranging from 3.793 to 4.652. In this group at t (26) = 0.000; P<0.05. Therefore, this shows that there is a significant difference in pretest and post-test result in favor of the post-test. However, experimental group students recorded a higher mean score with 7.111 mean differences between pre and post-test but control group students recorded relatively low mean score with 4.222 mean differences between pre and post-test.

Summarization of the pretest and post- test mean scores in both experimental and control groups before and after intervention.

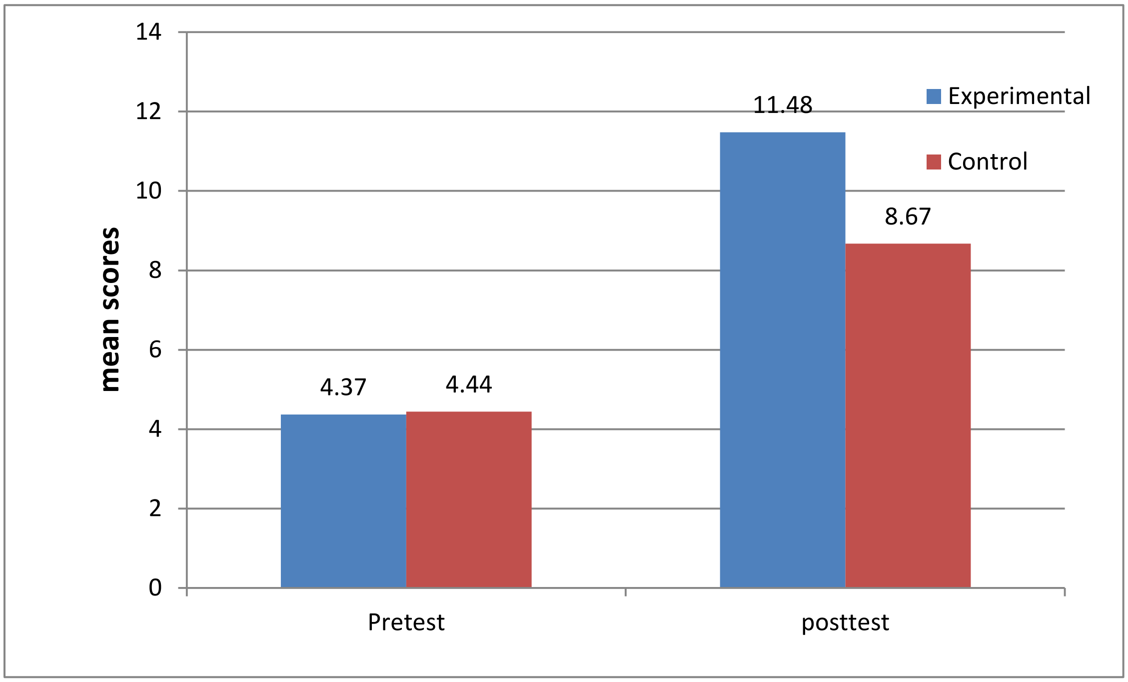


**Figure 5 pre-test and post- test mean scores of both experimental and control groups**

## 4.2. Result obtained from informal classroom assessment

**Research question three:** How is the engagement of students when they are taught by the 5e instructional models and traditional methods?

The researcher has also conducted open-ended questions for both experimental and control groups at the beginning and at the end of the implementation periods used as pre and post classroom conversation on water concepts. Before intervention the researcher has identified students back ground knowledge and alternative concepts on water topic. The questions were prepared from sub topics water that includes water hardness, softening of water, water pollution and water purification.  Before and after lesson implementation period, open ended questions were used as pre and post informal classroom assessments were conducted to gain detailed data on the students understanding of water concepts. Pre informal classroom assessment was served to determine their prior understanding they already have. The purpose of post informal classroom assessment was to compare the effectiveness of teaching approach on students' conceptual understanding to change their concepts on water. Students from experimental group and control group were asked the concepts orally and they answered orally and worked on paper for the following seven questions. Define the hardness of water and give an example? What ions cause hardness of water? What is the difference between temporary and permanent hardness of water? What are methods of water softening? What are the causes of water pollution? what are the advantages of pure water? How to purify dirty water? What are the effects of dirty water? All these questions were used to expose students' misconception and prior understanding on the topics that related to water concepts before lesson implementation as pre informal classroom assessment and what conceptual understanding was occurred to them after lesson implementation as post informal classroom assessment during classroom conversations.

**Pre informal classroom assessment result**; Students answered questions on water concept before implementing teaching methods for both experimental and control group students.

The first question the researcher asked for the students: *define the hardness of water and give an example?* Before implementing periods on water concepts, the researcher had asked the above question both for experimental and control groups. In both groups, students have participated to answer the questions, but they couldn't explain this question properly. There for students had difficulty to define the hardness of water meaning that students' background knowledge on the concept of water hardness was very low. Students had also misconceptions about hardness of water. For example, students answered that hard water is contaminated; rain water is contaminated because it is untreated and flood water is hard water.

The second question: *what ions cause hardness of water?* The researcher asked this question for both experimental and controlled students. For this question both experimental and control group of students had confusions on water hardness that causing ions. Students also experienced some misconceptions for this question. For example, some students say that flood, animals' urine and oil are hardness causing ions. But their response was not correct.

Students' ideas on the third question: *what is the difference between temporary hardness and permanent hardness?* When the teacher asked this question for both group students the majority of the students from both groups couldn't describe the meaning and difference between temporary hardness and permanent hardness.

The fourth question: *What are methods of water softening?* The answer of some students on this question was adding chlorine and filtration makes water to be soft. This shows these students had misconceptions on water softening. The remining students in both groups had also confusion and remined silent meaning that they didn't participate on the question.

The researcher asked the fifth question: *What are the causes of water pollution?* Most of students in both groups participated actively on this question. From the participants, some students described properly the causes of water pollution. But some students had limitation to answer the question perfectly.

The sixth question*: what are the advantages of pure water?* The responses of both experimental and control group of students answered the question by the following way. Water is used for drinking purpose, to prevent personal hygiene, for industrial purpose, for food preparation, for planting trees, and for medical purpose. Based on their participation, controlled group students were better than experimental students'. most of control group students were explained actively to answer the given questions. But in experimental group student only some students were answered the question. Even if some students had some misconceptions on this question.

The last question: How to purify dirty water? What are the effects of dirty water? Students in both groups answered the effects of contaminated water properly. They couldn't answer water treatment methods. So, they have difficulty on the concept of water purification and effects in both experimental and control group.

Generally, most of the students in both groups showed some misconceptions before intervention. Pre informal assessment showed that both experimental and control groups had approximately the same prior knowledge about the concept of water.

**Teaching approach:** After students' misconception of water that has been elicited and identified by the above pre informal assessment, the next procedure was reconstruction of students' misconception through the intervention of different teaching strategies. That means the experimental groups were treated by the guided inquiry teaching method while the control groups were treated by the traditional teaching methods.

### Teaching Experimental group

As mentioned above, the researcher conducted intervention through 5E learning instructions on the experimental group. In this method, students were engaged on different guiding questions and hand on activities. In order to eliminate the above misconceptions obtained from pre informal assessment and to improve the conceptual understanding of students about the concepts of water hardness, softening of water, water pollution and water purification, the researcher asked students to do a simple experiment in the class like removing temporary hardness of water by boiling and removing permanent hardness of water by adding washing soda ,compared the hardness of rain water and tap water, purification of water by using cotton and sand in the school compound that are locally available materials through their own procedure. The activities involved in each phase of learning cycle are as follows:

**Engagement:** In this first phase of learning cycle, the researcher captured the students' interest on the lesson by showing hands on materials used for teaching water concepts like tap water, distilled water, rain water, flood water, sodium carbonate (washing soda) and other materials like soap, cotton, stone, chlorine etc. After that the researcher asked some questions related to the current topic to understand the back ground knowledge of the students like, *what is water hardness? What are the types of water hardness? What is the advantage of water? What are the sources of water? Which water is softer? What is water softening? Which is safer for human use? What are the main types water pollutants in our village? How can we treat contaminated water? What are the effects of dirty water?* These questions aimed to connect the topic with students‟ daily life activity and elicit students‟ prior knowledge, and ask themselves: "What do I already know about these topics?" The researcher had opportunity to assess students‟ prior understanding and identify possible misconceptions on water sub topics. Students mentioned the basic terminologies like water hardness, softening of water, water pollution and water purification, water treatment methods, advantages of water. This student-centered phase should be a motivational period that can create a desire to learn more about these topics. The researcher did not present the correct answers of these questions but asked more questions to extend their ideas as shown in figure 6.


**Figure 6 teaching materials in the engagement phase**

**Exploration:** In this phase students interact with hands on activities cooperatively the researcher was designed explore activities and taught students in the class to had common, concrete experiences about water concepts. Engagement brings about disequilibrium; exploration initiates the process of equilibration. During the activity, the students had time in which they can explore objects, situations. As a result of their mental and physical involvement in the activity, the students establish relationships, observe patterns, identify variables, and question events. In this phase, the following experiments were conducted in grade 8$^{th}$ chemistry water lessons.

**Experiment-1** determination of water hardness

Water hardness can be readily determined by titration with the chelating agent EDTA (ethylene diamine tetra acetic acid). But, in lower grades hardness of water is determined by soap.

**Materials required:** rain water, distilled water, ground water, soap, scissors, three test tubes and graduated cylinder

**Procedure**

1. pour about 20ml of rain water in the first test tube, 20ml of distilled water in the second and 20ml of ground water in the third test tube
2. cut apiece of soap with scissor and add
3. Shake each of the test tubes by closing their mouth with your thumb turn by turn.

   Observation and analysis

   a. In which test tube does water form lather more rapidly?
   b. In which test tube does the water form a lather slowly?
   c. Which water sample is (i) soft water (ii) hard water?

**Figure 7 students discussion on experiment one**

**Experiment -2:** removal of temporary hardness

**Materials required:** Temporary hard water, beaker, test tube, wire gauze, tripod, Bunsen burner, and soap

**Procedure:**

1. Pour 50ml temporary hard water in to a beaker and about 20ml of it into a test tube
2. Put the water in a beaker in a wire placed on a tripod and heat it using a Bunsen burner flame until it boils.
3. Put about 20ml of it in to an empty test tube
4. Add a slice of soap in each of the test tubes containing boiled and cold-water samples and shake well.

**Observation and analysis**

a. Which water sample forms lather with soap (i) slowly (ii) rapidly
b. What makes them differ in the duration of time they form lather

Write a report in groups and submit in to your teacher

**Figure 8 students discussion on experiment two**

**Experiment-3**: removal of permanent hardness

**Materials required:** hard water, two beakers, graduated cylinder, washing soda, soap, glass road and spatula.

**Procedure:**

1. Measure and pour about 30ml of hard water in to each of the two beakers
2. Add a spatula full sodium carbonate only in one of the beakers and stir until all the sodium carbonate dissolves
3. Add pieces of soap in to both beakers and stir

**Observation and analysis**

a. What did you observe as sodium carbonate dissolve in the water in step 2?

b. Did the two beaker samples form lather with soap at the same speed? if not, explain why this happened?

Write a report in groups and submit in to your teacher

**Figure 9 students discussion on experiment three**

**Experiment-4:** water pollution

**Materials required:** A bottle of polluted water, two evaporating dishes, graduated cylinder, beam balance and PH indicator paper

**Procedure**

1. Compare the clarity and smell of the pure and polluted water and record your observation
2. Insert a PH indicator paper in to the sample of pure water and record the PH.
   Repeat the same procedure for the polluted water.
3. Weigh the evaporating dishes separately, record their masses and level them 1 and 2.
4. Pour 100ml of pure water in to the first evaporating dish and the same volume of polluted water into the second separating dish 2.

5. Place the two separating dishes in sunlight until all the water evaporates
6. Weigh the two evaporating dishes after dryness and compare their masses with those you recorded in step 3. To get the mass of dissolved solids in each sample use the relation:
   Mass of dissolved = mass measured in step 6 - mass measured in step 3

**Observation and analysis**

a. Do the two beaker samples have the same clarity, smell and PH?
b. Which water sample contains a large number of dissolved solids?

Write a report in groups and submit in to your teacher

**Experiment-5:** water treatment techniques

The easiest physical treatment method is filtration. The researcher needed to conduct this process in the following procedures.

**Materials required:** polluted water, cotton, sand, charcoal, two beakers, water bottle, gravel, clean cloth

1. Place the top half of the water bottle upside-down (like a funnel) inside the bottom half. (Make sure the cap is off). The top half will be the filter and the bottom half will hold the filtered water.
2. Layer the filter materials (sand, gravel, charcoal, cotton balls, clean cloth.) inside the top half of the bottle. Make Your Pollution.
3. Make a concoction of polluted water. Use any of the “pollution” materials provided to you.
4. Pour the polluted water through the filter.

**Observation and analysis**

Observe what the filtered water looks like. Write down the results on your note book.

Students were collaborated with their partners and worked together the above experiments in making predictions, finding the difference in their predictions and they observed the main results of water experiments on their groups and mad conclusion.

In general, those experiments were conducted to teach water concepts in explore stage for grade eight experimental group children at Dilchibo primary school.


**Figure 10 students discussion on experiment five**

**Explanation**

Students share results of their experiments with other groups so all students have the results of the experiments performed.

The explanation activities will become much more engaging for the class once they have completed the exploration phase. During the explanation phase, the researcher has been clearing up any misconceptions about the concepts of water with an anchor charts, and interactive notebook activities. Based on the above experimental results the researcher has demonstrated the main concepts of water hardness, water softening, water pollution and water purification by showing flow charts and experimental results as follows.

**Water hardness:** is a measure of the amount of calcium and magnesium salts in water.

The water that doesn't readily forms lather with soap is hard water as shown in figure 11.

**Figure 11 determination of hardness of water with soap**

There are two types of water hardness those include

a. **Temporary hardness: -** it contains carbonate, bicarbonate ions
b. **Permanent hardness: -** it contains chloride, sulphate ions

**Softening of water:** the process of removing hardness of water is called softening of water

The water that forms lather, readily with soap is soft water.

Temporary hardness is removed by boiling

When temporary hard water is boiled, soluble by carbonate is changed in an insoluble carbonate. The insoluble solid carbonate settles down to the bottom of the container and forms lime scale.

$$Ca\ (HCO_3)_2 \xrightarrow{heat} CaCO_3(s) + CO_2(g) + H_2O(l)$$

$$Mg\ (HCO_3)_2 \xrightarrow{heat} MgCO_3(s) + CO_2(g) + H_2O(l)$$

When we boil water the soluble salts of Ca $(HCO_3)_2$ is converted to $CaCO_3$ which is insoluble and hence gets precipitated and is removed. After filtration, the water we get is soft water as shown in figure 12.

**Figure 12 removal of temporary hardness by boiling**

Permanent hardness is removed by adding washing soda

$CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3(s) + Na_2SO_4$

$MgCl_2 + Na_2CO_3 \longrightarrow MgCO_3(s) + NaCl$

When the soluble salts of magnesium and calcium are present in the form of chlorides and sulphides in water, we call it permanent hardness because this hardness cannot be removed by boiling.

We can remove this hardness by treating the water with washing soda. Insoluble carbonates are formed when washing soda reacts with the sulphide and chloride salts of magnesium and calcium and thus, hard water is converted to soft water as shown in figure 13.

**Figure 13 removal of permanent hardness by adding washing soda ($Na_2CO_3$)**

**Water purification:** the removal of contaminants from untreated water to produce water that is pure enough for an intended use. There are three water treatment methods. Those are physical treatment, chemical treatment and biological treatment.

**Physical treatment**-involves processes that are carried out using no chemical or biological change.

**Filtration-** used to remove suspended small particles from water

**Screening-** used to remove larger piece of particles from water

**Chemical treatment-** uses chemical reactants like chlorine to break down pollutants.

**Biological treatment**- removal of suspended solids by microorganisms such as algae, fungi, or bacteria under aerobic or anaerobic conditions.

**Water pollution**: is the decrease in the quality of water caused by the discharge harmful substances in to it.

**ELABORATION**

Students were provided with activities and opportunities to practice their new knowledge, create new problems, and suggest solutions. This was just to extend what they learnt in the earlier phases of the cycle thus: They worked in groups also in this phase the researcher has given extra activities to expand the students understanding about water concepts.

i) Students asked to Compare hardness of tana water with rain water by using soap in experiment one

ii) Students asked to determine the white precipitate formed by boiling of temporary hard water in experiment two.

iii) Students asked to determine the white precipitate formed when added washing soda to permanent hard water in experiment three. Also, they asked to write the chemical equation of the substances.

iv) Students asked to conduct an experiment about screening water treatment method by the same procedure with filtration process. After the experiment, students concluded their results

v) Students asked to State any five causes of water pollution.

vi) Students identify other groups with the same chemicals and different chemicals used to discuss about results after experiments were completed.

The elaboration section of the 5E method of instruction was intended to give students choice on how they can prove mastery of the concepts. In this phase, the researcher gave extra activities to expand students understanding about water concepts.

Students analyzed results of the class's experiments, and have taken into account the other factors involved to make their final conclusion (choice) as to which chemicals they will choose in order to design their final project (self-warming clothing).

The elaboration project allowed students to create a presentation to teach about the hardness of water, softening of water, water pollution and water purification.

Students revised procedures necessary to ensure reliable results, no steps were missing, and safety precautions were followed by.

**EVALUATION**

The final piece of the 5E model was to evaluate student comprehension. Included in every 5E lesson is a homework assignment, assessment, and modified assessment. The researcher gave open-ended assessments to truly engage the student's comprehension and to check student's understandings of water concepts based on the learning objectives. The following questions have been conducted in this step.

- What is the difference between temporary hardness and permanent water hardness?
- What is common metal ion causing water hardness?
- The removal of Ca and Mg ions from hard water is known as ___.
- How can remove permanent and temporary hardness?
- What are the most common water pollutants in our local community?
- Explain how water pollution is prevented.
- List the three water treatment methods and write their difference?
- Define the terms of filtration, screening and chlorination.
- $Ca(HCO_3)_2 \xrightarrow{heat}$ ______, _________ and ________

Students also, assessed their own understanding by themselves and compare their understandings with other students.

**Teaching control group**

During the course instruction, traditional teaching method was limited to the control group I started the lesson by introducing, and explaining the topics that were going to be taught; water contents such as; water hardness, softening of water, water pollution and water purification and these all activities were explained by the teacher, teaching aids were used to explain and demonstrate by the teacher. Students followed teacher's instruction, without allowing time for students to reflect on the material presented, related to previous knowledge or applied it to the real-life situations. Students followed teacher explanation and did activities suggested in the textbook. Therefore, in traditional teaching approach, students were passively involved in the lessons as shown in Figure 14.

**Figure 14 control groups classroom seating**

**Post informal assessment**: After the implementation of the intervention, in such a way the researcher also asked seven open-ended oral questions for students to discuss and answer that was administered before the intervention. The aim of this post informal assessment was to check the effect of the treatment and to compare the conceptual understanding of both experimental and control groups on the title of water.

1. *Define the hardness of water? What ions cause hardness of water? What is the difference between temporary and permanent hardness of water?* When students were asked about open-ended questions about water hardness, most of students in the experimental group could reduce their alternative conceptions and answered correctly. Some examples of student's answers include:

"Water hardness is the amount of calcium in the water."

"Water hardness is the presence of Ca in the water."

"Temporary hardness is caused by in the presence of chloride and sulphate ions in water''

"Permanent hardness is caused by carbonate and hydrogen carbonate ions in water"

"Calcium and magnesium ions caused water hardness"

Other few students were even less familiar providing such answers as:

"Water hardness is when the water has many small particles in it, even after treatment."

"High mineral content"

"Not sure what it is. My educated guess is that it clogs pipes."

They also reversed the definitions of temporary and permanent hardness of water.

But when the researcher asked the above questions for the control group, only some students answered correctly and they said that "hardness of water is caused in the presence of calcium and magnesium ions in it", "hardness is classified as temporary and permanent hardness'', "calcium and magnesium are water hardness causing ions", but students could not identify permanent and temporary hardness. Other students in this group had still misconception about water hardness. And also, most of students could not answer the questions. This result showed that in the experimental group in most of students explained correctly and briefly but in the control group only some students got the correct answer, however, they couldn't explain briefly and, the majority of the students were still under confusion about the questions and they believed hardness of water meant flood water.

2. *What are methods of water softening?* When students were asked this question most of them answered correctly, but not all the students in the experimental group could eliminated their misconception and they explained briefly about methods of softening water with example. Students described softening methods by the following way:

"Temporary hard water is softened by boiling" and "permanent hard water is softened by adding washing soda ($Na_2CO_3$). Students also could compare water sources as hard or soft. They could give soft water example. Students said rain water is naturally soft water. But, few students in this group had still some misconceptions. They believed that water could softened by filtration and decantation. This question was also asked for controlled group students. Some of control group students could answer water softening methods partially. But most of this group of students didn't explain it properly and they also exercised some misconceptions like "water could soften by filtration" and "boiled water will be changed in to gas substance".

*3. What are the causes of water pollution? How can we prevent the pollution of water?* This question was suitable for both experimental and control group students. Most of the students could answer the question correctly, because they could identify causes of water pollution and polluted water prevention methods. For example, students said "water could be polluted by domestic wastes, industrial wastes, temperature, pathogens animals and agricultural chemicals). But some students in control group did not respond the question correctly.

*4. How to purify dirty water?* For this question, most students in the experimental group got the correct answer, and they explained their reason. They said water can be treated by three methods those are physical treatment, chemical treatment and biological treatment. They also described the difference between in each treatment methods. But most of control group students could not demonstrate water treatment methods. Experimental group students defined water purification as follows. "Water purification is the removal of contaminants from untreated water. Students also described some water treatment methods like filtration, screening and chlorination. They said that "filtration is a physical treatment method used to remove fine suspended particles'', "Screening is a physical treatment method used to remove larger pieces of solid wastes" and "chlorination is the addition of chlorine to water to kill harmful micro-organisms". But majority of the students in control group could not demonstrate water treatment methods.

In general, the result of this post informal assessment data showed that both experimental and control group students changed in the progress of the intervention when we compare to the pre informal assessment but there was a difference between the two groups on their participation and understanding about the concept of water. Most of water related questions listed above were answered by experimental group of students in a good manner. But majority of students in control group did not answer the open-ended questions properly. Some students had still confusion about water concepts. That means experimental group students explained briefly with reason by using their observation from the experiment and their hands on activity as evidence.

This means that they understood the concept. But control group students explained simply by memorizing what they read from the textbook and what they listened from their teacher presentation in the classroom. Therefore, the result of this informal assessment shows that the 5e learning cycle models teaching approach was more effective than traditional teaching methods like, lecture and discussion methods to improving students' conceptual understanding of water concepts at primary level of students.

## 4.3 Result obtained from classroom observation

Classroom observation was used to evaluate various aspects of lesson presentation with regard to students‟ roles in the 5E instructional model of constructivist approach and traditional instruction on water lessons. Therefore, during the intervention program, the researcher did self-observation on students‟ classroom activities based on the observation checklists (See in Appendix C).

### 4.3.1. Observation in experimental group classroom

In this study, classroom observation was employed as tools to assess the reaction of students within a class and what actually happened in the class when students taught about water concepts through 5E learning models. The researcher has collected data through observation about the reaction of experimental group students in water class from the beginning of the intervention up to the last day of the intervention by using the observation checklist (about students' participation, their confidence when they reflect their idea, their reaction with each other, interest and their discussion habit).

During 5E instructional model of constructivist approach implementation, the researcher observed the participation of students in each water concept lessons. Students participated highly, students' raise their hand and presented the concepts like, water hardness, types of hardness, hardness causing salts, water softening methods, water pollutants and water treatment methods. Learners participated highly in the lessons that were observed. The use of 5E instructional model of constructivist approach in water lesson had a positive effect on students' willingness to be actively engaged in the learning process.

When the researcher observed the students' interaction with the teaching material in water topics implemented by 5E learning cycle model, most of the students‟ were greatly allowed to interact with the teaching materials. Students used the appropriate teaching material that related to the topic of the lesson such as, tap water, rain water, distilled water, flood water, washing soda, soap, sand and cotton, chlorine, these teaching materials that used to explain water related concepts. all of the lessons, learners were sufficiently allowed to interact with the teaching aids as shown in Figure 15

**Figure 15  student's interaction with teaching aids**

The researcher observed the students interact with each other; students were greatly interacting among the group in all of the water lessons implementation with 5E lesson design. This was possible because learners were directly involved in the group discussion during the exploration phase and the teacher only served to facilitate them. The water lessons were, characterized by high involvement of the student within the groups and encouraged collaborative learning. Various form of thoughtful discussion and dialogue among the group members as shown in Figure 16.

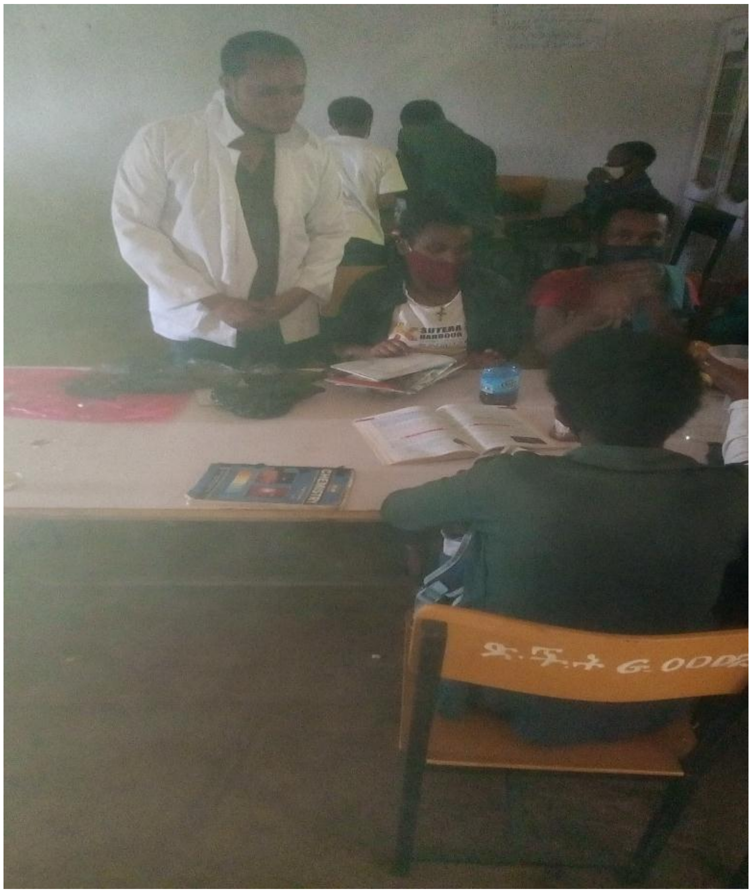

**Figure 16  Experimental groups collaborative learning**

## 4.3.2. Observation in control group classroom

During the intervention process when the control group students taught about water concepts through traditional teaching methods like, discussion and lecture method, the researcher collected data through observation about student's participation, interest, the interaction with each other during the discussion and their confidence. The researcher observed that most of students had less participation and they were passively received information from the teacher and less interesting. When the teacher asked question during the lecture rather, they were a passive listener, they simply assimilate the teacher demonstration and take notes given by the teacher but they didn't able to answer conceptual questions. In addition to this the teacher also observed that the interaction of students during the discussion and their confidence when they reflect their idea was not convincing as shown in figure 17.

**Figure 17 control group students class room condition**

Classroom observation result indicated that, students in experimental group taught water concepts by 5E instructional model of constructivist approach were actively involved in the classroom that compared with students in control group taught by traditional teaching instruction.

# CHAPTER FIVE

# 5. DISCUSSION AND IMPLICATIONS OF RESULTS

## 5.1 Discussion of results

The findings of the results will be discussed as follow:

The main objective of this study was, to compare the effectiveness of teaching chemistry by using 5e learning cycle models with that of the traditional teaching methods to improving grade eight students' conceptual understanding of water, at Dilchibo primary school Bahirdar town Amhara region Ethiopia.

According to the pre-test data result in **table 1** experimental and control group students had approximately equal mean score and standard deviation with minimum mean difference or they have the same background on the concept of water but, after the treatment, experimental group students performed higher mean score than the control group. This implies that the 5E instructional model is an effective teaching approach to improve the conceptual understanding of students about water than the traditional teaching methods.

According to **table 2**, the P value is 0.891 which is greater than the value of alpha (0.05), the mean scores of both control and experimental group had similar and t calculated (0.138) is less than t critical (2.009). Therefore, we can conclude that there is no significant difference between the mean score of the experimental and control group before the implementation of the treatment. After the implementation of the intervention, experimental groups were taught by 5E learning models and control groups were taught by traditional teaching methods, the researcher administered the post-test for both groups to compare the effectiveness of the teaching methods on students' conceptual understanding of water contents.

As shown in **table 3** the result of the post-test data revealed that experimental and control group students recorded different mean score and standard deviation that means experimental group students recorded higher mean score than the control group students. This indicates that the two groups were not equivalent in the mean score of the post-test. This was also checked by using an independent t-test. In this result, the p-value is 0.001 which is less than the value of alpha (0.05) and t calculated (3.569) is greater than t critical (2.009). Therefore, we have enough evidence to say that there is a significant difference between the mean score of the two groups in favor of the experimental group. This clearly indicates that 5E learning models had a significant effect on improving the students' conceptual understanding of water than the traditional teaching methods.

According to **table 4** paired sample t-test was implemented in the same group in order to compare the mean score of the pre-test and the post-test. The result of **table 5** showed that in both experimental and control group there is a significant difference between pretest and posttest result in favor of the post-test. However, when we compare the mean score of the experimental and the control group, experimental group of students recorded higher mean score with 7.111 mean differences between pre and post-test but control group students recorded relatively low mean score with 4.222 mean differences between pre and post-test. Because of this reason, experimental group students were beneficial than control group students, in other words, 5E learning cycle models improving the conceptual understanding of students in the concept of water (water hardness, softening of water, water pollution and water purification contents).

In general, the result on the effect of using 5e learning cycle models in improving students conceptual understanding of water contents in grade eight chemistry class at Dilchibo primary school showed that there is a significant difference in the mean scores of students taught the concepts of water using 5E learning cycle models and traditional teaching methods. Students taught through guided inquiry teaching method recorded better mean score than those students taught through traditional teaching methods. Since the pretest result in experimental and control group produce relatively equal with a very small difference in the recorded mean score but, the post-test result produces a wide mean difference between the two groups. This difference was due to the effect of the treatment. This indicates that the implementation of instructions by 5e learning model was more effective on improving the conceptual understanding of students in water than the traditional teaching methods. This result supports the observation by Anderson and Krathwohl (2001), have shown that learners cognitive process and conceptual understanding can be enhanced through effective method of instructions. The suitability of 5Es learning cycle model as a means of promoting high academic performance may be attributed to the nature of the instruction which is inquiry based and student-centered and thus provides a wide range of activities for the students to control, take responsibility for their action in the process of learning and form their own idea from already existing facts (Aksela, 2005). It presents students with a problem to be solve and causes an increase in their motivation (Oliver (2007) and Prince & Felder (2007).

The 5Es learning model instructional method actively involves students in the learning process and allows the learner to gain a deeper understanding of the concepts and become better critical thinker (Wang & Posey, 2011). The learning cycle model is based on the knowledge organization process of mind when students apply concepts and make their scientific knowledge is constant due to the engagement by capturing their attention and interest, exploring the student by providing students with a common based of activities that helps them to use prior knowledge to generate new ideas. Explanation which requires a linking to other concepts. Elaboration which the teachers challenge and extend students conceptual understanding and skills. Evaluation which requires a feedback from the student on the concept taught. The relatively poor performance of the subjects in the control group is an indication that the traditional teaching method adopted in teaching science by science teachers is not effective in promoting cognitive processes in students in primary school as observed by Mekonnen (2019) and (Dinkale, 2019) that subjects do not acquire cognitive skills unless concerted effects are made to identify and used instructional strategic that promotes its development and lecture method does not as it is not student centered. The finding of these researchers revealed that students who were treated by 5E instructional model approach had a better conceptual understanding of the lesson than other students who had been taught the traditional teaching method. In addition, the study by Mekonen (2019) found that 5E instructional model approach is more effective in improving the performance of students than traditional teaching methods as this study also showed. As briefly shown earlier result obtained from informal assessment before the intervention process the researcher assessed his students through informal assessment orally by preparing seven open-ended questions for both experimental and control group students. The result of this pre informal assessment showed that most students in both groups had a common misconception.

As Mekonnen and Shiwaye (2019), inquiry-based teaching is successful teaching strategies to develop conceptual understanding and to eliminate students' misconception in science. However, in the control group, most students couldn't eliminate their misconception and they also couldn't improve their conceptual understanding. The result of these researchers revealed that teacher-centered teaching method and textbook-based instruction fail to improve students' conceptual understanding of the concept of water and could not change the misconceptions of students. The other result obtained from informal assessment in open-ended questions revealed that the explanation of students in the concept of water who were treated by guided inquiry class significantly improved in contrast to the explanation of students who were treated by lecture method. This finding is also in line with the finding of Dinkale (2019), the result of these researchers' study showed that students treated with 5E instructional models could explain open-ended questions in a good way than students who were treated by lecture method.

Results obtained from the observation, showed that many students in the experimental class were passive in their participation, and they were not confident when they reflect their idea and do different activity by their own. They had less habit interaction with each other, and were less interested in the discussion.

But when the intervention process was going on those students showed a change on their interaction in different class room activities.

Then this classroom observation also revealed that many students were interested, actively participate and they had a good interaction with their peer to do experiments and to discuss on the given problem when they taught about water through 5E leaning cycle models. This result supports the observation by Martins and Oyebanji (2000), that teaching methods affect the response of students and determine their interest level, motivation and involvement in the lesson. This finding agrees with the finding obtained by Choirunnisak (2018), who found that many students were very interested towards the inquiry teaching method, they were very eager or actively participated to do different activity or experiments within a group through a discussion on water concept. The other result obtained from observation showed that students who were taught by 5E teaching approach became confidential over time when they perform different activities or experiments and when they reflect their idea about the given problem by using their result from their investigation as evidence. This finding is supported by Audu et al., (2017), it described 5E learning model instructional approach increase student's confidence and develop a deep understanding of water concepts. However, the data obtained from classroom observation in the control group students who were taught by lecture method revealed that most students in this class were less participant and less interested and they were a passive listener, their interaction during the discussion was not well. As Muhammad (2016), stated that lecture method is important to students by increasing their listening skill to attend attentively what the teacher says, however, the method also affects student's participation as it makes them too passive listener.

In short, this study showed that 5E learning cycle model is an effective teaching strategy. On the contrary, traditional instruction does not seem to be effective in developing students' understanding of water concepts. 5E learning cycle model can provide teachers with many insights into how students can learn about and appreciate science. By using this teaching strategy, better acquisition of scientific concepts could be observed. 5E learning cycle model is useful not only improving student's achievement but also help students construct their views about science and develop thinking ability to advance questioning activates relevant to their prior knowledge and promotes meaningful learning.

## 5.2 Implication of the study

In light with the findings of the present study, the following educational implications could be offered:

In instruction based on 5E learning cycle model, students' prior knowledge should be taken into account and integrated with the new knowledge. As it was indicated, it is very difficult to understand concepts in meaningful way when the prior conceptions are inconsistent and students cannot link the new knowledge with existing knowledge. Students' misconceptions should be examined by teachers at the beginning of the instruction to avoid students' misconceptions in their mind. The notion that "students do not come an instruction with blank slates, they usually come to classrooms with some conceptions about the subject matter gathered during their past daily life experiences and other lessons should not be forgotten.

Teachers should get training on how to develop an instruction based 5E learning cycle model. The principles and the fundamentals of 5E learning cycle model should be explained for science and chemistry teachers in in-service teacher training programs. Teachers should apply all the principles of 5E learning cycle model completely when designing their lessons with respect to this model. In addition, teacher education programs in universities especially science teaching methods courses should involve and give examples about how to develop an instruction based on

5E learning cycle model. Science education departments in primary schools should work together to design instruction based on 5E instruction model for other chemistry and science concepts. Moreover, researchers in science education departments should investigate which subjects in chemistry in elementary schools is appropriate to apply this model and also school administrators should encourage teachers to use learning cycle-based instruction. There is also the implication for learners to be engaged in an active process of learning such as hand-on, minds-on and discovery. This approach is learner-centered as students search for knowledge, meaning or create a product by themselves with the teacher being facilitator or guide.

Well-designed instruction based on 5E learning cycle model can lead better acquisition of scientific concepts. Therefore, the phases of 5E instructional model should be embedded to instruction carefully.

The implication for government is that Ethiopian government, especially Amhara regional state government should provide adequate infrastructures and materials for the laboratory so that primary school students can interact with this apparatus to enhance their ability to explore and construct their own understanding by avoiding their misconceptions.

# CHAPTER SIX

# 6. SUMMERY, CONCLUSION AND RECOMMENDATION FOR THE STUDY

## 6.1 Summery of the study

The main purpose of this study was to compare the effect of using 5E learning cycle model and traditional teaching methods in improving grade eight students' conceptual understanding of water contents (water hardness, softening of water, water pollution and water purification) at Dilchibo primary school Bahir Dar town Amhara region Ethiopia. In order to guide this study, the researcher forwarded the following research questions. What is the effect of 5E learning cycle models in improving students' conceptual understanding of water? Is there a significant difference in the test score of students taught with 5E learning cycle models and traditional teaching methods about water? What is the engagement of students when they taught by 5E learning cycle models?

The quasi-experimental design that has been chosen for this study was the Pretest-Posttest non-equivalent group strategy. The study was involved systematically designed 5e instructional model lessons for experimental group and traditional teaching methods for control group to taught water concepts to eighth grade students and compare their effectiveness to bring better conceptual understanding about water concepts. Eighth-grade class consists of 4 sections and a total of 186 students. From those students 100 are males and 86 are females. The researcher selects one class of eighth grade students randomly from four possible classes in Dilchibo elementary school. 54 eighth grade students that involve 17 male and 37 female students were participated in this study. The researcher divides those students into two groups as controlled (27) and experimental groups (27).

The main instruments used for data collection were a conceptual understanding test (pretest and posttest), informal assessment and observation. The data obtained from pre and post tests were analyzed quantitatively through descriptive statistics and t-tests and data obtained from classroom observation and informal classroom assessment were analyzed qualitatively. The treatment lasted for one month (12 periods). The treatment covers of water topics include; water hardness, softening of water, water pollution and water purification.

Before the beginning of the treatment both group students were tasted multiple choice and fill blank space pre test20 questions and 7 open ended questions from water topics to know prior understanding and misconceptions of students. The CAT with a reliability coefficient of 0.81 was used to collect relevant data which were analyzed using t-test. The conducted analyses of independent sample t- test result revealed that, there is no significant difference between control and experimental group based on their pre water conceptual understanding tests score.

During the course of instruction, experimental group students received the 5E learning cycle instruction which involves hands-on and minds-on activities. On the contrary, the control group was taught by using traditional teaching instruction based on teacher introduction, explanation and summarization, students followed teacher introduction, explanation, demonstration and activities suggested in the textbook. During treatment time the researcher was observed student's engagement, motivation and interest in a given lesson.

At the end of water topics or after four weeks implementation periods, students in both groups re-administered the post-test and post informal class assessment to determine the change and the difference among the groups in terms of understanding of water concepts. The independent sample t- test analysis of posttest result showed that, there is a significant difference between the posttest of the students' taught by 5E instructional model of constructivist approach and those taught by traditional teaching instruction or the experimental groups students had better conceptual understanding of water concepts after the implementation period. And also, the result of classroom observation indicated that, students in experimental group taught by 5E instructional model of constructivist approach highly participated in lesson, interacted with teaching materials and groups, to answer conceptual questions and relate concepts to daily activities that compared with control group taught by traditional teaching instruction.

In general, the following major findings are obtained

- The analysis of the posttest scores indicates that there is a significant difference between students exposed to 5Es learning cycle model compared to those taught with lecture method in favor of the experimental group. That is to say, the experimental group performed better than the control group in their academic achievement after undergoing the experimental treatment of 5Es learning cycle model.

- The analysis of pretest scores indicates that there is no significant difference between control and experimental group students that means the prior understanding of students before treatment is similar.
- Experimental group students which are instructed by 5e learning cycle models show better participation, interest, motivation and interaction than control group students who are instructed by traditional teaching methods.

## 6.2 CONCLUSION

Based on the results obtained from this study, the following conclusion can be made;

The 5E learning cycle model instruction caused a significantly better acquisition of scientific conceptions related to water concepts than lecture method. The pre-test and post-test scores of CAT also showed that both 5E Learning Cycle and traditional method group's achievement was increased. Thus, it can be concluded that there was positive effect in understanding of water concepts which was statistically significant. Consequently, it may be said that the students in the experimental group understood water concepts better than the students in the control group, and that they had fewer misconceptions in this matter. The pretest and post-test scores of CAT showed that both 5E Learning Cycle and lecture method group's achievement was increased. Thus, it can be concluded that there was positive effect in understanding of water concepts which was statistically significant. However, the increase in learning cycle group was higher.

The analysis of the result shows that the experimental group students acquired higher mean and standard deviation scores and hence performed significantly better as a result of the treatment with 5Es model. This is an indication that 5Es learning cycle model is effective in improving students cognitive thinking skills which in turn enhances their academic performance. This also revealed that traditional teaching methods commonly used by teachers in primary school is not quite suitable for meaningful teaching and learning of science concept as it is not a student-centered approach.

Experimental group students exposed by 5E can eliminate their misunderstandings of water concepts when they take informal class assessment questions after treatment. This implies that 5Es learning cycle model is effective in promoting thinking skills of science students, especially in chemistry. Based on this, 5Es learning cycle can be used as an effective instructional tool for eliminating poor performance and a fundamental step towards enhancing students' performance in science learning as it encourages headers to construct their own knowledge out of the prior knowledge. Therefore, from the results of this study, it is possible to conclude that the 5E instructional model of constructivist approach is a more effective method to improve students' conceptual understanding of water concepts (hardness of water, water softening, water pollution and water purification concepts) compared to the traditional teaching approach.

## 6.3 Limitation of the study

The followings were challenges during the investigation of this study:

**Shortage of time;** shortage of time is one of the limitations for the implementation of 5E instructional model of constructivist approach in water lesson; because each phase of the 5E learning cycle needs more time but in primary school level the time allocated was 40 minutes in one period in this case it was difficult to apply all activities in a given time. There was no time to give feedback, to listen student's presentation and to assess students understanding in each period.

**Insufficient school materials:** teaching materials such as text books, charts, teaching aids and laboratory materials were not sufficiently available, these shortages in the supply of resources couldn't create good learning environment. Shortage of resources during the research process was one of the limitations to implement water topics at dilchibo primary school.

**COVID-19**: COVID-19 being the most basic challenge to the education system at large has affected the inquiry-based teaching method in the class. Students couldn't use group discussion to help each other and speak freely and clearly due to mask they wore. So, this affects to make the lesson participatory and inclusive in the teaching water concepts at elementary level.

## 6.4 RECOMMENDATIONS

The following recommendations are made from the findings of this study;

- A study can be conducted for different grade levels and different chemistry topics to evaluate the effectiveness of the 5E learning cycle model and traditional teaching methods. Because my study is limited on grade $8^{th}$ and water topic.
- Further studies can be carried out to compare the effectiveness of 5E learning cycle approach and traditional teaching methods in understanding science concepts in different schools. So, more accurate results can be obtained. My study is conducted only at dilchibo primary school.
- This study can be conducted with larger sample size out in order to obtain more accurate results.
- Similar studies can be conducted to investigate the effectiveness of instruction based on 5E instructional model of constructivist approach on students' understanding of concepts and learning strategies in other subject areas such as biology and physics.
- Science teachers should be adequately equipped with the skills needed to create an environment where all kinds of students can learn meaningfully individually or in groups especially in a chemistry class.
- Ethiopian universities and colleges of education as well as secondary school and primary school educational planner should be encouraged to design educational programs that will equip teachers in training with skills for the use of 5E instructional cycle models for effective teaching and learning of chemistry.
- Curriculum developers should incorporate constructivist strategy such as the 5E learning cycle model into the chemistry curriculum as an instructional model for teaching chemistry in primary and secondary school. Educational policy makers should take into consideration the desperate need for better policy, regulations, and laws that are geared toward the attainment of more meaningful chemistry education in Ethiopia.

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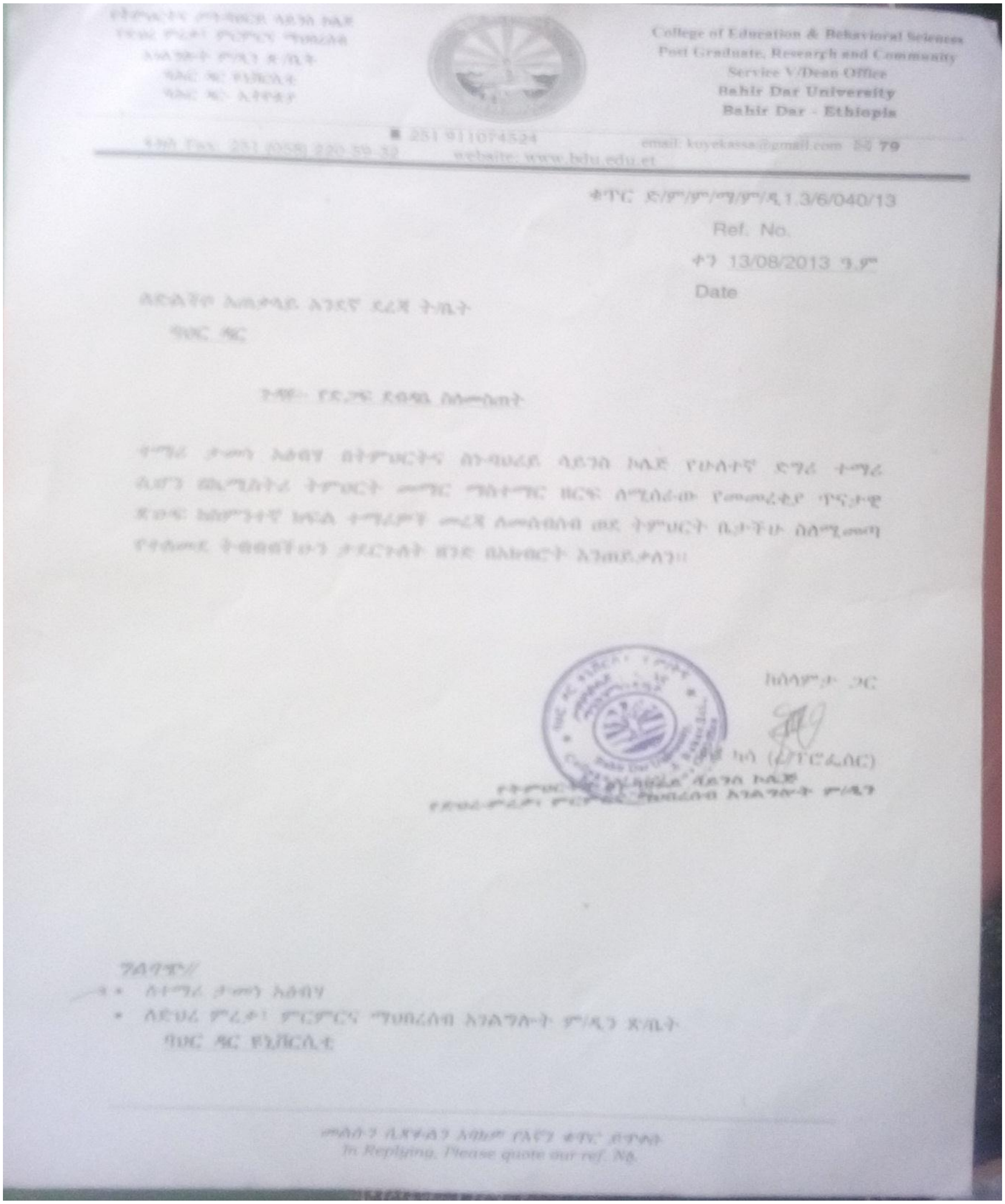
# APPENDICES

**Appendix A:** permission paper form college of behavioral science department.



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**Appendix B:** Appendix Intervention plan for both groups

| Intervention program | Sessions for both groups | Time duration | Lesson | Lesson topics | Learning out comes<br><br>After studying this topic students will be able to |
|---|---|---|---|---|---|
| Before intervention | 2 class session | 40x2 | 1 | Pretest | Measure student's prior knowledge of water concepts |
| During intervention | 6 class session | 40x2 | 2 | water hardness | Identify about water hardness<br>list water hardness causing metal ions |
| | | 40x2 | 3 | | Differentiate temporary and permanent hardness |
| | | 40x2 | 4 | | List hardness causing salts and group them as temporary or permanent hardness when they dissolve in water. |
| | 4 class session | 40x2 | 5 | Water softening | Describe softening methods to remove hardness of water |
| | | 40x2 | 6 | | Identify how soap purify hard water<br>Describe the removal of hard water by boiling |
| | 4 class session | 40x2 | 7 | Water pollution | Describe the main sources of water pollution, the main types of pollutant and how each type may be controlled |
| | | 40x2 | 8 | | Identify the causes and effects of water pollution |
| | 6 class session | 40x2 | 9 | Water purification | Identify the treatments of water under the following headings; chlorination, screening, filtration and biological treatment |
| | | 40x2 | 10 | | Describe the advantages of pure water for living organisms, especially for humans. |
| | | 40x2 | 11 | | List and describe the major physical, chemical and biological characteristics of clean fresh water, and explain their effects on aquatic organisms |
| After intervention | | 40x2 | 12 | Post test | Measure students understanding on the concept of water after the two different instructional treatment implementations |

## Appendix C: Classroom observation checklist

The objective of this observation checklist is to get additional information on the study

| No | Activities of classroom self-observation |
|---|---|
| 1 | Participation of students on the topics of water during teaching process |
| 2 | Students interest they learn water concepts by 5e instructional models |
| 3 | Students interest when they learn water concepts by traditional teaching methods |
| 4 | Students' interaction in with teaching materials |
| 5 | The ability of students understanding when they learn water concepts by 5e instructional model approach |
| 6 | Students' interaction with other students when they do collaborative activities in a class |
| 7 | Students' teacher interaction during implementation of the lesson |

## Appendix D: Daily lesson plan sample for experimental group

Daily lesson plan format based on Bybee et al. (2006) 5E learning cycle (5E instructional model) teaching strategy. This model includes five stages these are: Engage –Explore –Explain –Elaborate –Evaluate respectively.

**Lesson 1**

Group: Experimental

Name of school dilchibo

Grade 8th section A

No of students M 9 F 18 Total 27

Name of teacher: Tamene Atsbiha

Subject: chemistry

Main topic: unit four Environmental chemistry

Sub-topic: water

Lesson topic: water hardness

Duration: 40'

**Learning Objective**: After the end of the lesson, students will be able

- Define hard water as water that does not form lather with soap
- State soluble salts of calcium and magnesium as the causes of hardness of water
- Conduct an experiment to demonstrate the effect of hardness of water by talking rain water, tap water and ground water

**Resources:** tap water, rain water, ground water, soap, test tub, measuring cylinder and scissors

| Duration of time | Models | Teachers' activity | Students' activity | Assessment |
|---|---|---|---|---|
| 5 min | Engage | Create the interest of the students and promote curiosity by showing different water samples in the class.<br>raise question, Elicit prior knowledge about water hardness | Demonstrate prior knowledge, be engaged and motivated, formulate questions and hypotheses | Oral questions |
| 12 min | Explore | Arrange students in groups and give learning materials for each group to do the experiment based on listed procedures of their text book.<br>Give water hardness the following questions for the students<br>1. What is water hardness?<br>2. What problems does hard water cause?<br>Facilitate student's discussion and record student's misconception | Think freely do within the limits of the activity about water hardness. Based on their observation students record the results cooperatively and predict alternative explanations. Discus about the results and they try to define and answer water hardness questions.<br>Students prepare short report to present their work for the whole class | Hands on activities and observing their group discussion |
| 10 min | Explain | Give students opportunities to demonstrate their conceptual understanding, correct and clarify, challenge student's explanations and finally the researcher introduce | Explain possible solutions based on prior experiences and activities, makes use of recorded | Reflection |

| | | | | |
|---|---|---|---|---|
| | | scientific concepts about water hardness by correcting students' misconceptions. | observation about water hardness, and Begin using "scientific" language. | |
| 8 min | Elab orate | Develop themes and help students place into context, Movie towards a scientific understanding, clarify or challenge how acquired knowledge can be applied to new/other contexts Give a chart which has both temporary and permanent water hardness | Apply new understanding of concepts to new activities; make sense of explorations and Expanding conceptual understanding. Students identify both temporary and permanent water hardness | By giving open ended extra questions |
| 5 min | Eval uate | The teacher asks the following questions and make shore all students will participate<br>1.write at least 2 soluble salts of magnesium and calcium causes water hardness<br>2. what is the difference temporary and permanent hardness | Answer the questions and compare their understandings with other classmate students<br>They take home works | Oral questions |

Teacher's name: Tamene atsbiha signature date 11/08/2013

Department head name: signature date 11/08/2013

## Appendix E: Daily lesson plan for control group

Daily lesson plan sample for control group exposed to lecture method. Traditional Instructional Method

**Lesson 1** Group: control

Name of school dilchibo

Grade 8th section B

No of students M 8 F 19 Total 27

Name of teacher: Tamene Atsbiha

Subject: chemistry

Main topic Unit Four: Environmental chemistry

Sub-topic: water

Lesson topic: water hardness

Duration: 40’

Date: 11/08/201

**Learning objectives:** At the end of the lesson the student will be able to:

- ✓ Define hard water as a water that does not form lather with soap
- ✓ State soluble salts of calcium and magnesium as the causes of hardness of water
- ✓ Conduct an experiment to demonstrate the effect of hardness of water by talking rain water, tap water and ground water

**Resources:** tap water, rain water, ground water, soap, test tub, measuring cylinder and scissors

| Duration | Stage | Teachers’ activity | Students’ activity |
|---|---|---|---|
| 5min | Introduction | Greeting and review the previous lesson by asking some questions Introducing the new topic and forwarding the objective of the lesson. | Greeting and review the previous lesson by answering questions. |
| 10min | Main activity | Conducting an informative lecture about meaning and types of water hardness by showing water sample and pictures to the students.<br>demonstrate the main ideas of water hardness and give some activities to group water solutions as temporary hardness or permanent hardness | Based on teachers orentation students will think and write ion containig water types then group them as temporary hardness or permanent hardness and they shair their ideas for the class |
| 15min | Conclusion | Finally summarize the lesson by | . Students record the notes in their |

| | | | |
|---|---|---|---|
| | | correcting student's misconceptions on a topic and answering student's questions | exercise books.<br>Listen teacher's lecture. |
| 5min | Evaluation | Take some homework activities. | It is a time to asking questions and homework |

Teacher's name: Tamene Atsbiha signature date 11/08/2013

Department head name signature date 11/08/2013

**Appendix F:** Chemistry achievement test questions and their answers

Water conceptual understanding test Pre and post- test for both experimental and control groups (20%).

Name: ------------------------------------------sex………. Age---------------- Group: ----------------
----------- School: ------------------------------ Time allowed 40'

**Instruction: I. Choose the best answer from the given alternatives**

1. Which one of the following salts is the main cause of permanent hardness of water?
   A. magnesium sulphate
   B. magnesium bicarbonate
   C. magnesium carbonate
   D. calcium carbonate
2. Temporary hardness is caused by due to
   A. calcium sulphate
   B. magnesium sulphate
   C. magnesium chloride
   D. magnesium carbonate

3. Which one of the followings are the primary causes of water pollution?
   A. Plants B. Animals C. Human activities D. None
4. Dissolving soap in to hard water there is a formation of an insoluble solid called_______
   A. Scum B. Foam C. Lather D. Lime scale
5. Which hardness is removed by boiling?
   A. Temporary hardness B. Permanent hardness C. Total hardness D. All
6. The purest form naturally occurring water is
   A. River water B. ground water C. rain water D. lake water
7. Which of the following substance is commonly used in water filtration?
   A. Sand B. Charcoal C. Cotton D. All
8. Both temporary and permanent hardness of water can be removed by
   A. Boiling B. Distillation C. Filteration D. Decantation
9. A physical treatment method used to remove larger pieces of solid wastes is called_______
   A. Chlorination B. Screening C. Filtration D. Decantation
10. Which one of the following is a water pollutant?
    A. Domestic wastes B. industrial wastes C. Agricultural chemicals D. All
11. _______ is the decrease in the quality of water caused by discharge of waste materials in to it.
    A. Water purification
    B. Water pollution
    C. Water hardness
    D. Water softening
12. Which ion forms hardness of water?
    A. $Ca^{+2}$ B. $Al^{+3}$ C. $Na^{+}$ D. $K^{+}$
13. The addition of chemicals to water to improve its quality is
    A. Physical treatment B. Biological treatment C. Chemical treatment D. All
14. Which one of the following is the advantage of water?
    A. For drinking B. Industrial process C. medical purpose D. All
15. The water that doesn’t readily form a lather with soap is called___
    A. Soft water B. pure water C. Hard water D. None

**I. Fill in the blanks with the appropriate words or phrases**

16. Harmful substances which contaminate water are collectively called_________________

17. The process of removing calcium and magnesium ions from hard water is __________________

18. Treatments carried out in water purification are ___________, _____________ and ________________

19. List 3 ways that water becomes polluted ________________________________________________________________________ ________________________________________________________________________ ____________

20. Hardness of water is classified as______________ and_____________________

**Answer**

1. A 2. D 3.C 4.A 5. A 6.C 7.D 8.B 9.B 10.D 11.B 12.A 13.C 14.D 15. C

16. Pollutants

17. Water softening

18. Physical, Chemical and Biological treatment

19. Industrial wastes, Temperature, domestic wastes, crude oil etc

20. Permanent Hardness and Temporary Hardness

## Appendix G: pretest-posttest results of experimental and control group students

**Experimental group students' pretest and posttest result out of 20% (Group A)**

| No | Students name code | Sex | Age | Pretest result (20%) | Post test result (20%) |
|---|---|---|---|---|---|
| 1 | E1 | M | 16 | 5 | 11 |
| 2 | E2 | F | 14 | 2 | 9 |
| 3 | E3 | F | 15 | 5 | 13 |
| 4 | E4 | M | 16 | 8 | 20 |
| 5 | E5 | F | 14 | 3 | 8 |
| 6 | E6 | F | 14 | 3 | 10 |
| 7 | E7 | M | 15 | 7 | 10 |
| 8 | E8 | F | 15 | 6 | 13 |
| 9 | E9 | F | 14 | 4 | 12 |
| 10 | E10 | M | 14 | 4 | 11 |
| 11 | E11 | F | 14 | 2 | 7 |
| 12 | E12 | M | 15 | 5 | 14 |
| 13 | E13 | F | 14 | 6 | 15 |
| 14 | E14 | F | 14 | 5 | 11 |
| 15 | E15 | F | 14 | 5 | 12 |
| 16 | E16 | M | 14 | 3 | 8 |
| 17 | E17 | F | 16 | 9 | 20 |
| 18 | E18 | F | 15 | 4 | 10 |
| 19 | E19 | F | 16 | 2 | 9 |
| 20 | E20 | F | 14 | 2 | 9 |
| 21 | E21 | M | 15 | 4 | 9 |
| 22 | E22 | F | 14 | 0 | 7 |
| 23 | E23 | F | 16 | 7 | 16 |
| 24 | E24 | F | 14 | 4 | 10 |
| 25 | E25 | M | 14 | 3 | 12 |
| 26 | E26 | M | 14 | 5 | 11 |
| 27 | E27 | F | 15 | 5 | 13 |
| Total score | | | | 118 | 312 |

**Control group students' pretest and posttest results out of 20% (Group B)**

| No | Students name code | sex | Age | Pretest result (20%) | Post test result (20%) |
|---|---|---|---|---|---|
| 1 | C1 | F | 14 | 0 | 4 |
| 2 | C2 | F | 14 | 2 | 6 |
| 3 | C3 | F | 14 | 4 | 9 |
| 4 | C4 | F | 16 | 7 | 10 |
| 5 | C5 | M | 14 | 3 | 7 |
| 6 | C6 | M | 14 | 4 | 8 |
| 7 | C7 | F | 14 | 6 | 10 |
| 8 | C8 | F | 15 | 5 | 9 |
| 9 | C9 | F | 15 | 6 | 11 |
| 10 | C10 | F | 14 | 4 | 8 |
| 11 | C11 | M | 15 | 4 | 7 |
| 12 | C12 | F | 16 | 5 | 11 |
| 13 | C13 | M | 14 | 6 | 12 |
| 14 | C14 | F | 16 | 5 | 10 |
| 15 | C15 | F | 14 | 5 | 10 |
| 16 | C16 | F | 15 | 7 | 12 |
| 17 | C17 | F | 15 | 9 | 14 |
| 18 | C18 | M | 14 | 4 | 7 |
| 19 | C19 | F | 14 | 3 | 7 |
| 20 | C20 | M | 14 | 3 | 9 |
| 21 | C21 | M | 15 | 4 | 6 |
| 22 | C22 | F | 14 | 1 | 5 |
| 23 | C23 | F | 16 | 7 | 10 |
| 24 | C24 | F | 15 | 4 | 7 |
| 25 | C25 | F | 14 | 3 | 7 |
| 26 | C26 | F | 14 | 4 | 7 |
| 27 | C27 | M | 14 | 5 | 11 |
| Total score | | | | 120 | 234 |