Learning Biology through 7E Instructional Model with Metacognitive Scaffolding and Students' Motivation

Habtamu Wodaj

A PhD Dissertation Submitted to the Department of Science and Mathematics Education

Presented in Fulfillment of the Requirement for the Degree of Doctor of Philosophy in Biology Education

Addis Ababa University

Addis Ababa, Ethiopia

May, 2020

Addis Ababa University

College of Education and Behavioral Studies

Department of Science and Mathematics Education

This is to certify that this thesis prepared by Habtamu Wodaj entitled: Learning Biology through 7E Instructional Model with Metacognitive Scaffolding and Students' Motivation and submitted in the partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Biology Education** compiled in line with the regulations of the university and met the accepted standards with respect to originality and quality.

Signed by the examining board committee

______________________	______________________	______________________
______________________	______________________	______________________
Supervisors	Signature	Date
______________________	______________________	______________________
Internal Examiner	Signature	Date
______________________	______________________	______________________
External Examiner	Signature	Date
______________________	______________________	______________________
Chair Person	Signature	Date

Declaration

I declare that this dissertation is my original work and all the sources that I have cited or quoted herein have been duly acknowledged and referenced.

Habtamu Wodaj

Date ___________________________

Signature __________________________

This dissertation has been submitted for examination with our approval as supervisors:

Supervisor: Dr Wanja Gitari

Date ___________________________

Signature________________________

Co-Supervisor: Dr Solomon Belay

Date ___________________________

Signature_______________________

Abstract

Learning Biology through 7E Instructional Model with Metacognitive Scaffolding and Students' Motivation

Habtamu Wodaj
Addis Ababa University, 2019

The main purpose of this study was to investigate the effect of 7E instructional model with metacognitive strategies on students' learning biology and motivation compared to conventional instruction. Moreover, the effect of 7E instructional model alone and conventional instruction with metacognitive strategies on these dependent variables were also investigated. The research method was mixed research method with quasi experimental design with pretest – treatment – posttest - delayed posttest. The study consisted of four schools and four classes (one from each) and assigned as treatment group 1, 2, 3 and comparison group randomly. In treatment group 1, 7E instructional model, in treatment group 2, 7E instructional model with metacognitive strategies, in treatment group 3, conventional instruction with metacognitive strategies and comparison group with conventional instruction alone were used to teach human biology for 10 weeks. Human biology achievement test, human biology conceptual understanding test and motivation questionnaires were administered for all groups as pre test, post test and only human biology achievement tests, human biology conceptual understanding tests were administered as delayed post test. After the treatment, 24 students, six from each group, were interviewed semi-structurally. Multivariate Analysis of Variance (MANOVA) and Analysis of Variance (ANOVA) were used for analysis of the quantitative data and the qualitative data were transcribed, coded and categorized. The results showed that 7E instructional model supported with metacognitive strategies had significantly superior effect over 7E instructional model alone, conventional instruction supported with metacognitive strategies and conventional instruction alone for improving students' achievements, conceptual understanding and retention of concepts in learning biology and minimizing misconceptions. Moreover, it was found out that 7E instructional model alone was also superior than conventional instruction supported with metacognitive strategies and conventional instruction alone in improving students' achievements, conceptual understanding and retention of concepts in learning biology and minimizing misconceptions. But conventional instruction supported with metacognitive strategies was not superior to conventional instruction alone in improving students' achievement, conceptual understanding and retention of concepts in learning biology minimizing misconceptions. The interview results supported these findings. In relation to motivation it was found out that 7E instructional model supported with metacognitive strategies had significantly superior effect over conventional instruction supported with metacognitive strategies and conventional instruction alone but not over 7E instructional model. Similarly, 7E instructional model was superior to conventional approach in enhancing motivation. However, there was no significant difference found between male and female students in learning biology.

Keywords: 7E instructional model, metacognitive scaffolding, misconceptions, human biology, achievement, conceptual understanding, retention, motivation, gender.

Acknowledgement

First of all, I would like to thank the Almighty God for enabling me to successfully complete this thesis work.

The completion of this thesis work would have been difficult without the help of many people to whom I am very thankful. I would like to express my deepest gratitude to Dr Wanja Gitari, my supervisor, and Dr Solomon Belay, my co- supervisor, for their guidance, advice, encouragements, feedback, and support throughout this dissertation work.

My sincere gratitude goes to all my colleagues in the Department of Science and Mathematics Education, AAU, especially Dr Kassa Michael, for providing me a multidimensional support and my classmates for their continued support during course and dissertation work. I am very much thankful to those who helped me in developing instruments and teaching materials, particularly the PhD candidate Teshager Ali and in translating some of the instruments in to Amharic language.

I would like to thank my wife Genet Getahun and my two sons Abel and Dawit, who gave me confidence and support to succeed without getting bored on every step of the way. Moreover, my thanks go to my brother Zenebe Wodaj and my sister Worknesh Wodaj, for their encouragement to successfully complete my study.

I would also like to thank the biology teachers in secondary schools who spent hours with me during implementation of the intervention and 9^{th} grade students who participated in this study. I would also express my sincere appreciation to school administrators for their acceptance and facilitation.

Finally, my sincere gratitude goes to Addis Ababa University for providing me with opportunity to for a PhD study and for providing me with the financial support to complete the dissertation work.

Thank you all from the bottom of my heart!

Dedicated to my late mother W/ro Etete Entele and my father Priest Wodaj Tafari

Table of Contents

Appendices

List of figures

List of Tables

List of acronyms and abbreviations

7EIM – 7E Instructional Model

7EIMMS – 7E Instructional Model with Metacognitive Strategies

BSCS – Biological Science Curriculum Study

CI – Conventional Instruction

EA – Examination Agency

ESDP III– Education Sector Development Program III

ESDP IV- Education Sector Development Program IV

HBAT – Human Biology Achievement Test

HBCUT – Human Biology Conceptual Understanding Test

KWHAL – What I **K**now, What I **W**ant to Know, **H**ow I Know, **A**m I Learning, What I Have **L**earned

MAIT – Metacognitive Awareness Test

MoE – Ministry Of Education

MS – Metacognitive Strategies

SMQ – Science Motivation Questionnaire

TGE I - Traditional Government of Ethiopia

UNESCO - United Nations Educational, scientific and Cultural organization

UNICEF – United Nations International Children's Emergency Fund

Chapter One: Introduction

Science education in the twenty first century demands the introduction and proper implementation of modern instructional methods and integration of technology in to school curricula so as to enhance students' science learning. Due to this, exploring appropriate and suitable instructional method and integrating technology in the teaching learning process to improve students' science learning were the work of many educators in the world for the past many years. To this end, varieties of instructional methods and educational technologies that support learning have been developed and their effectiveness in enhancing science learning has been proven with research findings.

Despite such efforts, science learning in Ethiopia has suffered a lot of setbacks. One of the major setbacks is the lack of appropriate instructional method in science classrooms because the predominant teaching method in schools is teacher- centered (Reta, 2017; Teshome, 2012), which has its own drawback in helping students' effectiveness in science learning (Hosseeini, 2012). In order to improve the effectiveness of science learning in Ethiopian classrooms research in this area has become indispensable. This particular study was conducted to investigate Ethiopian Grade Nine students' of biology learning through 7E instructional model (7E IM) combined with metacognitive strategies (MS) and motivations. The 7E instructional model consists of seven phases that start with an English letter "E" (Elicit, Engage, Explore, Explain, Elaborate, Evaluate and Extend). Metacognitive strategies include planning, monitoring and evaluation strategies. In order to triangulate the investigation, the effect of learning biology through 7E IM alone and the effect of learning biology through the combination of conventional method with metacognitive strategies were also examined. The theoretical framework for this study is constructivism.

The study used mixed research method and concurrent embedded research design in which qualitative research is embedded within quantitative research. Within this framework, nonequivalent quasi- experimental research design with pretest, treatment, posttest and delayed posttest were employed.

Once data were generated, organized and analyzed writing of the thesis was arranged in to five chapters. The first chapter covers back ground of the study, the context, statement of the problem, purpose of the study. The second chapter discusses theoretical perspectives (constructivism, metacognition and motivation) that framed this study. The third chapter depicts the research methodology (method and design). The fourth chapter presents results and discussion while the fifth chapter presents summary, conclusion and recommendation.

1.1 Background of the Study

Generally, it is known that education takes the lion's share of the factors that affect the social, political and economic development of any country. In the 21st century, most countries especially the underdeveloped ones, need scientifically literate citizens that contribute for the social, political and economic development of their country. As a result, in countries were education is regarded as priority, it has been taken as a major mechanism for the socio-economic development. Historically, science education most particularly has played a great role in the socio - economic development of nations. However, research indicated that in many places around the world, science education is facing serious challenges as population grows and the demand for technology and development increases (EU, 2007; Osborne & Dillon, 2008; UNESCO, 2008). Among the challenges that developing countries faced in particular are the lack of resources (educational and financial) and adequately trained teachers (ICSU, 2011).

These challenges seriously affected the quality of science education, which in turn affects students' achievements and their interests towards science education. The two large scale survey studies, the Programme for International Student Assessment (PISA) study and the Trends in Mathematics and Science Study (TIMSS), provide sufficient evidences for effects of these challenges on quality of science education. These surveys provided a great variety of information about the status of school science education in the world in terms of test scores and issues related to curricula, time allocation, resources for teaching, teacher education and later professional development, classroom methods and activities. The results of these studies show that "the status of science education in terms of quality, achievements and the interest of young people towards science are low in the emerging and less developed countries" (ICSU, 2011, p.11). Obviously, these lacks of quality, low achievement and interest towards science education affect the ability of educated peoples to apply what they have learned in their day to day life to solve different problem. A research conducted by Wieman & Perkins (2006) in the United States described this problem, in well developed countries as "science classes from elementary school through to university are generally failing to provide most students with a thorough understanding of science that will allow them to live and work successfully in the twenty-first century" (p. 290).

The problem becomes much more serious when scan the situation in developing countries. Research indicated that students in Africa fail to connect what they have learned in classroom to their day today life in order to solve real problems. For instance, Asabere-Ameyaw, Sefa Dei and Raheem (2012) described this condition as: Young learners in Africa either shy away from applying school knowledge, or are not prepared enough to apply what they have learned in their classrooms to everyday community problem solving (p 1). Similarly, Gitari (2008,), described the situation in Africa as:

> *Underachievement and under-representation of girls and women in science and the efficacy of the content knowledge learned in school, that is, the inability of the majority of science graduates to transfer the science knowledge they gained in school to everyday problem-solving situations are key issues in Africa (p.42).*

In addition to lack of resources and adequately trained teachers, lack of the integration of indigenous African knowledge in to modern science education is also a factor that affects the provision of quality education which enable students to solve real problems (Engida, 2008; Gitari, 2008, Faris, 2008, 2012; Asabere-Ameyaw et al, 2012; Emeagwali and Sefa Dei, 2014). Situated in Africa, the problem in Ethiopia is not different from what is mentioned above. In spite of the expansion of higher education in Ethiopia, there were problems in provision of quality education. In addition to the economy of the nation, the graduates' competency and the quality of trainings are determinants of unemployment rate (Oluwajodu, Blaauw, Greylin, and Kleynhans, 2015). According to Mulu (2009) the quality of higher education in Ethiopia has been negatively affected by inadequate schooling at lower levels of the education system including secondary schools and that the tendency to promote students regardless of their performance, including at tertiary level, has become a critical challenge. Hence there is a need to work on quality of education at all level particularly at lower level schools.

These problems resulted in the presence of large number of unemployed graduates and in those who are unable to create job and solve the problem of the society. This may result in loss of interest among the societies on the ability of science education to improve their social and economic status and hence the need to invest on students science learning. The society may prefer other alternatives to solve its day to day problems rather than through learning scientific knowledge. For instance, children from agricultural areas may prefer to spend their time in traditional agricultural activities while children from urban prefer to be engaged in labor activities and small business. This will result in the presence of large number of illiterate citizens that in turn result in poor nation. To alleviate this problem, provision of quality science education that enables to be creative and innovative in science and technology is mandatory.

The concern of this study is, therefore, on the way we deliver creative and innovative science education and the way students learn in secondary schools which affects quality of education and base for the tertiary level. Research indicated that students' effective science learning can be affected by different factors such as the methods of instruction (Munck, 2007), the nature of the subject (Çimer, 2004; Tekkaya, Özkan and Sungur, 2001) and the students themselves (Saavedra, and Opfer, 2012). According to Kennedy (1998), students' conceptual understanding of science is dependent on how their teachers teach science. To be effective, science teachers need to develop the skill to represent important ideas and abstract concepts for students in understandable way. The ability to do this is the root of effective teaching (Munck, 2007). Whenever there is effective science teaching in schools, students can understand science and easily apply it in their environment to solve different types of problems. Therefore, the method of instruction by which education is delivered (the pedagogical approach in teaching learning process) is one of the important factors that affect students' learning of science (Hosseini, 2012).

In another sense, the failure in the instructional approaches used in a classroom is one of the reasons for students' ineffective science learning (Ganyaupfu, 2013; Munck, 2007; Orji and Ebele, 2006; Oloyede, 2010; Umar, 2011). So far, there are two globally recognized types of approaches in teaching learning process. These are traditional (teacher centered) and modern (learner centered) instructional approaches. In the past many years the traditional teacher centered instructional approach has been given a great emphasis.

In the traditional instructional approach, teachers are considered as knowledgeable persons and expected to transfer this knowledge to the students. In this approach, students have little role in the teaching learning process. They are more passive participants, i.e. listen to the information, take notes, and retrieve or recall the information for evaluation purposes (Hake, 1998; Hejazi, 2006; Schiller, 2009). With such traditional approach, the focus is more on acquisition of information than on aiding critical thinking, conceptual understanding and cooperative learning. It also fails to stimulate student motivation, confidence, and interest of learning (Weimer, 2002).Traditional approach does not promote long–term retention of some abstract concepts in biology (Ahmed and Abimbola, 2011; Umar, 2011). More particularly, in a science classroom where students are expected to develop critical observation and analytical skills, the traditional approach is not worthwhile to pursue.

These drawbacks of the traditional approach resulted in the need for exploration of an effective way of teaching approach in science during the 20^{th} century. Scholars emphasized searching on approaches that promote meaningful learning, problem solving, and critical thinking for a diverse students in science education that focuses on students than teachers. This movement resulted in the emergence of an alternative approach which is termed as learner centered approach, a countermovement to traditional teacher-centered approach (Baeten, Dochy, and Struyven, 2012). Hence, since the mid 1980s there has been an extensive reform in science education around the globe, based on findings on how humans learn and the development of science teaching models (Jonassan, 1991; Lewin, 1992). Since then, varieties of instructional approaches have been developed within the learner centered approach under constructivism learning theory.

For instance, learning cycle is one of the learner centered approaches recommended by constructivists. The learning cycle is a systematic approach to instruction proposed during the implementation of Science Curriculum Improvement Study (SCIS) project by J. Myron Atkin and Robert Karplus in 1967 and consists of three phases: Exploration, Invention and Discovery (Byee et al., 2006). Afterward, the most commonly used revised form of the learning cycle is the 5E learning cycle which was later on expanded to 7E learning cycle. The 5E instructional model also known as learning cycle was developed in the late 1980s as a component of the science for life and living curriculum created through the Biological Sciences Curriculum Study (BSCS) (Bybee & Landes, 1990). The instructional model has five phases; Engage, Explore, Explain, Elaborate and Evaluate (Bybee et al., 2006) Subsequently, 5E learning cycle and instructional model has been extended to another instructional model with seven phases (Elicitation, Engagement, Exploration, Explanation, Elaboration, and Evaluation and Extension) and named as 7E learning cycle and instructional model (Eisenkraft, 2003) (see the detail in the literature part, chapter 2).

Unlike the traditional one, learner centered approach resulted in the students' active involvement in classroom (McCombs and Whisler, 1997). It also resulted in change in the role of the teacher from transmitter of information to facilitator of the classroom practices and promoter of learners' involvement in the teaching and learning process (Meece, 2003, Schiller, 2009).

There are wide ranges of evidences to support the view that a learner-centered approach has positive consequences to learning science. Learner-centered teaching produce higher learning achievement and higher motivation, greater retention of knowledge, deeper understanding, higher critical thinking skills, responsibility in their learning and the ability to apply complex ideas in real-life situations and more positive attitudes towards the subject being taught (Burke, 1983; Collins and O'Brien, 2003; Wachanga and Mwangi, 2004; Weimer, 2002). Moreover, research indicated that learner centered approach resulted in significantly better understandings of scientific conception and elimination of misconceptions (Tebabal and Kahssay, 2011).

As mentioned above, in addition to instructional approach, the nature of the subject also affects students learning. Biology is one of the subjects in science education. It deals about living things: the nature, the process and the interaction within and with the physical environment. In biology there are different concepts included in secondary school education. Most of the concepts are difficult for secondary school students to learn. For instance, biology topics like transport in plants and genetics (Bahar, Johnstone and Hanseli, 1999; Johnstone and Mahmoud, 1980), cellular respiration, protein synthesis, photosynthesis, Mendelian genetics, mitosis and meiosis (Anderson, Sheldon and Dubay, 1990; Finley, Stewart and Yarroch, 1982), gaseous exchange (Seymour and Longdon, 1991), and concept of energy (Jennison and Reiss, 1991), were reported among the most difficult biology topics to be learnt by secondary school students. Moreover, Lazarowitz and Penso (1992), identified cells, organelles, organs, and physiological processes, hormonal regulation, oxygen transport and the principle of structure and function as difficult concepts for students in high school biology.

In order to overcome these difficulties and make biology learning more effective, according to Çimer (2012), it is necessary to use varieties of strategies of teaching biology and connect the topics with daily life while teaching. It is because of this hat the identification of suitable instructional approach which will enable all learners to learn effectively became the major concern of science education researchers (Patrick, 2013).

The other factor mentioned above that affects students learning is the student themselves. In relation to students, the 21^{st} century science education requests the learner to be self directed, self regulated and independent learners so as not to depend completely on teachers in knowledge acquisition. In other word, educating students for the 21^{st} century requires teaching them how to learn on their own and hence they need to be aware of how they learn and their own learning (Saavedra, and Opfer, 2012). This implies that students need to monitor themselves and their own work as self-monitoring is important principle in science learning (Donovan and Bransford, 2005). Self-monitoring refers to whether students are metacognitively aware of their learning or not. To do so, emphasis should be given to metacognitive awareness of learners about different metacognitive strategies used in effective learning. Metacognitive strategies include planning, monitoring and evaluation of thinking and learning process (Chauhan and Singh, 2014). Research suggests that those students that are aware of metacognitive strategies are more successful than the others in their learning (Caraway, Tucker, Reinke and Hall, 2003; Dignath et al., 2008; Imani, Sabetimani, Qujurand and Ardestani, 2011).

Furthermore, metacognitive awareness of learners has a relation with personality variables. Research indicated that there is a relationship between metacognition and certain personality variables such as motivation, self-efficacy and academic achievement (Landine and Stwart, 1998). Motivation refers to the initiation, direction, intensity and persistence of behavior (Namasaka, Mondohand Keraro, 2013). Individuals can be motivated from within, by fascinations, inquisitiveness, or a value for the task at hand as well as external factors such as reward systems, grades, exams or punishment (Mahadi and Jafari, 2012). Motivation is a key factor in learning and achievement of students at all levels of school (Rehman and Haider, 2013). It has positive relation with academic achievement and the use of metacognitive strategies

(Landine and Stewart, 1998). According to the research finding of Aydın (2016) the use of metacognitive strategies resulted in a positive and significant prediction of students' motivation to learn biology. This study, therefore, tried to look into how learner centered approach (7E instructional model) and metacognitive strategies affect students' learning biology and motivation compared to conventional/ teacher centered approach.

1.2 Context of the Study

Ethiopia, as a developing country, needs to create a scientifically literate, critical thinker, creative and innovative society in science and technology so as to solve very deep rooted problems in the nation. To do this, science education plays an important role. It enables citizens to have scientific and technological knowledge, helps decisions based on scientific evidence and recognizes the importance of science and technology in the development of the nation which in turn positively affect their lives. Students' effective science learning, therefore, is indispensable in the 21^{st} century.

Modern education in Ethiopia reported to be officially commenced in 1908 with the opening of Menelik II School in Addis Ababa, marked a significant step in the history of modern education in Ethiopia (Bekele, 1991). Modern education expansion continued during Emperor Haile Selassie I and Derge regimes (Bishaw and Lasser, 2012).

Currently, more than any time ever, expansion of education in Ethiopia is at its highest rate in line with the millennium development goals in which all children should go to school by 2015. Nevertheless, there are many problems in delivering quality education for learners. Some of the problems mentioned in the Education Sector Development Program three (ESDP–III) includes: rapid increase in the level of enrolment, lack of a sufficient number of qualified teachers, weak program management and implementation capacity (MoE, 2005). Although there is much improvement, challenges like completion rate and achievement, equity in access, and management capacity that affect quality of education remained to be realized in ESDP IV (MoE, 2010). In addition to expansion, nowadays, Ethiopia has given a great emphasis for science education. An evidence for this is the 70:30 professional mix introduced in Ethiopian in which 70% of students should be enrolled in science and technology and the remaining 30% of students should be enrolled in the social science and humanities streams (MoE, 2008).

The science education in Ethiopia was developed based on the needs of the nation and global requirements in producing qualified educators though had not been effective as expected. This ineffectiveness of the education system enforced the government to critically revise and develop new education system which is now floored as a roadmap for discussion.

The current Ethiopian education system is structured in to kindergarten, primary education, secondary education, higher education, Technical, Vocational Education and Training (TVET) (MoE, 2010). Primary education is organized in to first cycle (grade 1-4), and second cycle (grade 5-8) school levels and secondary organized in to first cycle (grade 9-10), and second cycle or preparatory (grade 11-12,) school levels. Higher education includes colleges and universities.

The Ethiopian secondary school curriculum comprises major science subjects like physics, chemistry and biology. Biology is one of the core subjects in Ethiopian education system starting from elementary schools to universities. Biology was taught as a part of environmental science course at first cycle primary school (1-4) and as integrated science course at second cycle primary school (grade 5-6). It starts as a separate course in second cycle primary school at Grade Seven in Addis Ababa city. In first cycle secondary school (grade 7-8), students learn biology with three period per week. In secondary and preparatory schools, students' learn biology four periods per week and it covers contents that are important for students to grasp the knowledge required for their further education, for instance, in medicine, agriculture, environmental science and biotechnology. In order to achieve this end, there is a need to devise appropriate instructional approaches in line with constructivism learning theory and properly implement in schools.

Among priority areas identified for Education Sector Development Program four (ESDP–IV), the improvement of students' achievement through the enhancement of the teaching/learning process is one (MOE, 2010). Teaching learning process includes the instructional approaches and the assessment techniques used in classroom and hence, using appropriate instructional and assessment method is required.

In the past many years, the Ethiopia education system emphasized on the traditional teacher centered method of delivering education and accompanied with traditional assessment techniques that encourages memorization of facts. As a result of criticism made by educators here in Ethiopia and worldwide, the use of this method in teaching science became questionable and necessitated shifting of teaching approaches to the learner centered method. In line with this, the Ethiopian government made a change in education policy since 1994. Accordingly, the Ethiopian education and training policy launched in 1994 emphasized on the constructivist based learner centered approach that use different active learning techniques than the traditional chalk and talk mode of delivery (MoE, 2002). This policy clearly indicated that curriculum development and textbooks preparation are based on current sound pedagogical and psychological principles (TGE, 1994). The syllabi prepared for courses at different levels also gave emphasis to the learner centered approach. For example, the biology syllabi for grades 9-12 prepared by the Ministry of Education in 2009 clearly states that approaches to develop learning competencies in biology is based on constructivist theory of learning which emphasizes on active involvement of learners and construction of knowledge (MoE, 2009). It has summarized principles of learning as follows based on constructivist learning theory:

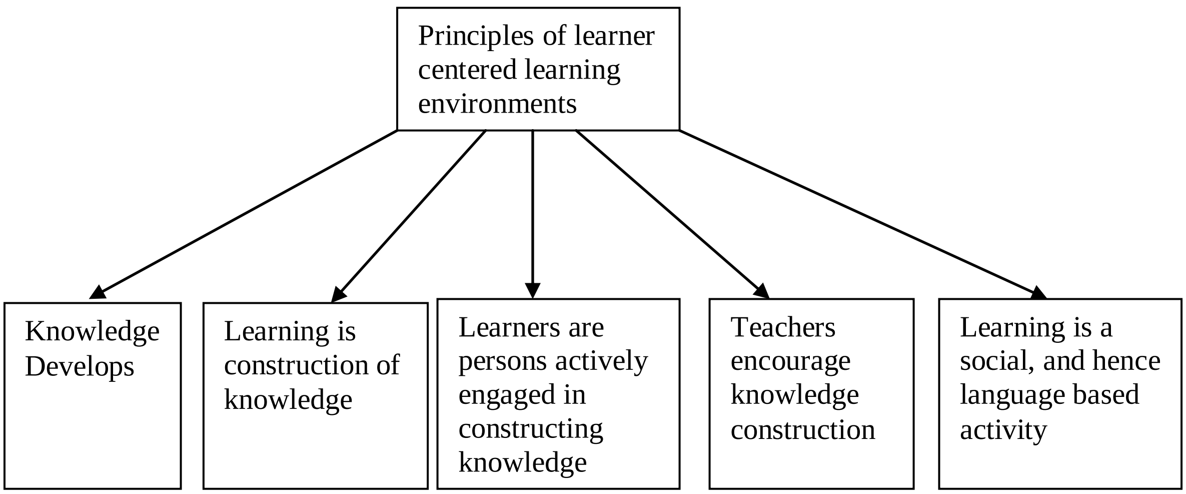

Figure 1. Biology Syllabus, Grades 9 -12, 2009: (Source: Federal Democratic Republic of Ethiopia Ministry of Education, p. 6)

The above figure explicitly shows that learning has an individual and social aspect which reflects the constructivism learning theory and the need to properly implement learner centered approach in the constructivism environment. According to this theory, learning is construction of knowledge as a result of individual interaction with task, with each other and with the teacher than passive absorption of knowledge. However, implementation of the concept of this general idea stated in the figure in the classroom is not easy. It needs appropriately designed instructional model that facilitate learners engagement, learners interaction, teachers facilitation role in knowledge construction and development. Therefore, designing suitable instructional approaches that enable students to learn in the way intended, improve their creativity and effectiveness in the society to solve different types of problems is necessary.

In addition to using appropriate instructional approaches, using educational technologies is also crucial in the 21st Century. With the expansion and shift in the way of delivering a lesson, another important activity done in Ethiopian education system in the past few years is the integration of information and communication technology (ICT) to enhance quality of education and maximize students learning. One of the technologies used in Ethiopian education system is educational broadcast through a satellite receiving device and a plasma television. It was introduced in 2004 for teaching the courses English, mathematics, physics, chemistry, biology, and civics and ethical education. However, research findings indicated that its effectiveness was doubtful. According to Latchanna and Garkebo (2012), the problems related to this are interactivity, role of the classroom teacher, language of instruction, time allocation between classroom and plasma television teachers, pace and length of broadcast, attitudes and awareness about the program. Similarly, a study conducted by Berhanu (2013) shows that students and teachers were not interested in using the plasma television in teaching learning process. Even though there was no doubt that integration of technology enhances quality of education, it was not properly implemented in Ethiopian secondary schools to attain an intended outcome. It is within this context that this study was conducted aimed at improving students' biology learning using different instructional strategies.

1.3 Statement of the Problem

It is obvious that learners are expected to achieve the expected outcomes while learning. Unfortunately, results from national learning assessment in Ethiopia indicated that most students after completing each grade cycle are unable to fulfill the minimum learning competencies stated by the Ministry of Education. The Ethiopian baseline national learning assessments of Grades 10 and 12 students conducted in April 2009 indicated that students are unable to attain the required competencies (NAE, 2010). According to this finding, the academic achievement of the students as measured by the composite mean score of the five subjects namely English, mathematics, biology, chemistry and physics was found to be less than the 50% achievement level. The minimum achievement level set by the Education and Training Policy of Ethiopia is 50% (TGE, 1994, p.18). The national composite mean score (the average of what the students scored in the five subjects) was only 36% for Grade 10 and 47.8% for Grade 12.

Looking at the mean score of biology for Grade 10, the mean scores (40.3) was below the minimum requirement (50%). However, in Grade 12, the mean score of biology was found slightly higher than the minimum requirement 50% i.e. 55.5%. The recent national learning assessment of Ethiopia also indicated that grade 10 students scored 46.96% which is still below 50% (NEAEA, 2014).

An academic achievement of students is a reflection of their level of conceptual understanding and retention of concepts. According to Omolade (2008), in order for students to have higher academic achievement, they must have deeper understanding of basic concepts of the subject. The students' conceptual understanding of science in turn depends on how their teachers teach science (Kennedy, 1998). It is also indicated that achievement in education is directly related to knowledge retention (Agaba, 2013). For learners to improve their biology achievement, they must retain knowledge acquired during teaching/learning process (Agaba, 2013).

Researchers linked regular poor academic achievement of majority students to the inability to apply effective instructional approaches by teachers while teaching (Adunola, 2011; Ahmed and Abimbola, 2011; Ganyaupfu, 2013; Gatlin; 1998; Orji and Ebele, 2006; Oloyede, 2010; Umar, 2011; Zakaria and Iksan, 2007). This implies that academic achievement of learners is a reflection of quality of teaching (Ganyaupfu, 2013). Currently, the constructivist based learner centered approaches are considered to be effective ways of teaching in improving students learning provided that it is implemented effectively.

Studies in Ethiopia show that the level of understanding and skills of teachers in applying suitable learner-centered methodology in biology classes were limited and traditional lecture methods are dominant in classrooms (Areaya, 2008; Bekele and Melesse, 2010; Berhe, 2006; Beyessa, 2014; Dufera, 2006; Teshome, 2012; UNICEF, 2010 and Yalew, 2004). One of the reasons for this is because most of the teachers were not trained in the modern teaching learning approach and even some were unable to get in to in-service training (Bekele and Melesse, 2010).

So, it is evident to partially link the low academic achievement of students in biology with inability to identify and implement suitable learner centered instructional approach in schools. It is within this context that we see students' biology achievement in Ethiopia. Biology is one of the components of education system in Ethiopian. As part of scientific inquiry, biology has special relevance to students as individuals, to the society and to the growth and development of Ethiopia at large. Biology education equips learners with the basic knowledge and skills that are essential in the study of fields such as medicines, pharmacy, nursing, agriculture, forestry and biotechnology. Moreover, many of the contemporary issues and problems such as nutrition, health, drug abuse, agriculture, pollution, rapid population growth, environmental degradation, global warming and conservation in the society are essentially biological in nature. If these problems are to be dealt with realistically, an understanding of biological knowledge is required. Therefore, teaching biological science needs instructional approaches that help students to understand biology and be able to apply their knowledge in their day to day life. There is a real need to search effective learner centered instructional approach that helps learners to learn biology better and improve their performance in the Ethiopian context.

Another important issue in science learning is students' motivation. Students' motivation towards learning science has a positive impact on their academic achievement and conceptual understanding of concepts (Cavas, 2011; Chan & Norlizah, 2017; Pintrich & Schunk, 2002). In Ethiopia, for instance, in a research conducted by Geberew and his colleagues, teachers reported that students have low motivation to learn science in secondary schools (Geberew, Tigist and J-F, 2017). Moreover, Giertz, (2016) indicated that one of the cause for teachers de-motivation in Ethiopia is a decrease in students motivation to learn.

In short, the problems are: 1) Students' low learning outcomes. 2) Students' low motivation. 3) Use of traditional teacher centered approach in schools. 4) Lack of awareness among students on how to learn?

Therefore, if the learning outcomes of students can be affected by the way education is delivered and motivation of students, there is a need to search a mechanism by which the problem pertaining to these issues could be addressed. Hence, this study focused mainly in investigating ways of improving students' biology learning and motivation in the context of Ethiopian secondary schools.

1.4 Objective of the Study

Science education is crucial in the development of the country and transformation of peoples live. Thus, there is a need to offer quality education to produce critical thinker, creative and competent individuals in the field of science. To do so, using different modern ways of delivering science education is important. Hence, the main objective of this study was to investigate how the 7E instructional model, one of the learner centered approaches, supported with metacognitive scaffolding enhances students' biology learning and their motivation.

In order to attain this objective, four groups of student were involved in the study. The groups were treatment group 1, treatment group 2, treatment group 3 and comparison group. Students in these groups were taught using 7E instructional model, 7E instructional model with metacognitive strategies, conventional instruction with metacognitive strategies and conventional instruction respectively. Based on this, specific objectives and research questions were formulated.

The specific objectives were:

1. To compare students' achievement, conceptual understanding and retention in human biology concepts between groups,
2. To examine students' motivation among groups,
3. To compare achievement, conceptual understanding and retention of human biology concepts and motivation across gender,
4. To determine misconceptions held by students in each groups,
5. To investigate extent of misconception among groups.

1.5 Research Questions

1. Is there a significant mean score difference in achievement, conceptual understanding and retention of human biology concepts between groups?
2. Is there a significant mean score difference in motivation among groups?
3. Is there a significant mean score difference in achievement, conceptual understanding and retention of human biology concepts and motivation across gender?
4. What are the misconceptions in human biology held by students in each groups?
5. How different are misconceptions in human biology among groups?

1.6 Significance of the Study

As it is discussed previously in the statement of the problem, there is a difficulty in achieving the minimum learning competencies in biology and other secondary school subjects. Scholars relate this problem with the inability to use and implement suitable instructional approaches in schools. Research on the effective instructional approaches that helps learners learn science better in Ethiopian context is undeniable. Hence, a study on the effectiveness of different instructional approaches in teaching biology to improve students' learning is very important. The findings from this study contribute to the existing body of knowledge in relation to active learning methods that actively engage learners and assessment techniques in order for teachers to organize and teach the lesson and assess students learning effectively so as to enhance their learning. This study serves as a ground for further research at different school context, and educational levels from primary to tertiary on how to improve students' biology learning. It also serves as a basis to conduct large scale studies on the effectiveness of these instructional approaches particularly the 7E instructional model with metacognitive strategies.

The findings from this study will serve as an input to policy makers, curriculum developers and teachers to teach science particularly biology in an effective way to maximize students learning and ensure quality of education that ensure sustainable development of the country.

1.7 Delimitation of Study

This study was conducted in secondary schools in Addis Ababa, Ethiopia. It is delimited to four governmental schools in the city. The content covered in this study is human biology from Grade Nine. The unit deals with food and nutrition, the digestive systems, respiratory systems, circulatory systems and cellular respiration of humans.

1.8 Limitations of the study

While conducting a research there are a number of limitations. This study was conducted in four schools with four teachers. The teachers and the schools may affect the intervention because it is difficult to control all teachers and school related variables, even though the researcher tried to select similar schools and teachers from different perspectives, gave trainings on the instructional approaches and ways of implementation and conducting classroom observations and discussions with the teachers during implementation to ensure the research protocols were adhered to. The other limitation of this study was that it was conducted in natural setting since the classes had been formed at the beginning of the semester by school administrators. This limits the extent of generalizability of the findings to different schools unless they have similar characteristics.

1.9 Definitions of Terms and Concepts

Learning – in this study learning refers to students' achievement, conceptual understanding and retention of human biology concepts.

Achievement - Student achievement is the status of human biology knowledge of students which is assessed by scores on human biology achievement test.

Conceptual understanding - Conceptual understanding reflects a student's ability to reason out their responses which is assessed by scores on human biology conceptual understanding test.

Retention – refers to maintaining acquired human biology knowledge/ concepts to use at a later time which is assessed by scores on human biology achievement and conceptual understanding test.

Misconception – refers to those conceptions in human biology which are not consistent with concepts that are currently accepted by the scientific communities which are assessed by scores on human biology conceptual understanding test.

Motivation - refers to the initiation, direction, intensity and persistence of behavior (Namasaka, Mondohand Keraro, 2013).

Metacognitive strategies - in this case refers to metacognitive strategies of planning, monitoring and evaluation of regulation of cognition.

7E Instructional model - is a learning cycle with seven phases that include elicitation, engagement, exploration, explanation, elaboration, evaluation and extension.

Metacognitive scaffolding – in this case refers to supporting students learning with metacognitive strategies of planning, monitoring and evaluation.

7E Instructional model with metacognitive strategies - is a learning cycle with seven phases that include elicitation, engagement, exploration, explanation, elaboration, evaluation and extension and metacognitive strategies of planning, monitoring and evaluation

Conventional instruction - in this case refers to the actual teaching practice in schools mainly lecture and lecture with demonstration or lecture with some times group discussion.

Chapter Two: Literature Review

Introduction

Teaching and learning are core components of educational process. Research indicated that there is a direct relationship between quality of teaching and students learning (Darling-Hammond & Youngs, 2002). Effective methods of teaching are essential to learning in teaching and learning process that actively involves learners (Ding & Sherman, 2006). The traditional teacher centered teaching and the learner centered teaching methodologies are the two most commonly mentioned methods in educational literatures. According to Sablonniere, Taylor and Sadykova (2009), the philosophical basis and underlying principle of teacher centered instructional approach is positivism and behaviorism. Behaviorism understands learning as a system of behavioral responses to physical stimuli, driven by reinforcement, practice and external motivation. Research shows that the traditional approach often promotes passive and superficial learning (Bransford, Brown and Cocking, 2000).

Due to a number of limitations of traditional teacher centered method of teaching, a new paradigm emerged with learner centered method of teaching. The philosophical basis and underlying principle of the learner centered approach to education is interpretivism and constructivism (Sablonniere, et al., 2009). They indicated that constructivism understands learning as a process of making meaning in which “learners construct their own version of reality while at the same time transform it and themselves in the process” (p.629). According to McCombs and Whisler (1997) and Richardson (2003), constructivism focuses on individual learners need and prior knowledge rather than teachers in teaching learning process. In recent year, constructivism learning theory with varieties of teaching methodologies has been investigated widely in science education.

In this chapter literatures in relation to constructivism, conceptual understanding, misconceptions, metacognition, motivation and gender issues in science education were reviewed and presented. The first sections deals with the constructivism learning theory. The second section presents the teaching strategies recommended in constructivism learning theory from which the strategy used in this research is adapted and studies related to these strategies. In the third, fourth, fifth and sixth section metacognition, conceptual understanding, misconceptions, motivation and gender are described respectively.

2.1 Constructivism Learning Theory

The theories of teaching learning process in the twenty first century dictate that there should be active involvement of learners in the construction of knowledge. This is because learning science is a complex process that needs students' active engagement on activities, curiosity, motivation and self regulation to learn. Due to its complex nature of science learning and the current inappropriate ways of delivering lessons, learners are facing difficulties in understanding most of the concepts in science. To help students understand what they learn, understanding and applying appropriate learning theory and pedagogy that advances the current environment is important. In the past many years the behaviorist learning theory and teacher centered approach were dominant in science education. The method of teaching in this theory usually was lecture method which didn't help students much in understanding science concepts other than just memorizing facts. This problem initiated scholars in the world to search new learning theories with related pedagogy. Consequently constructivism learning theory emerged.

Constructivism is a learning theory developed recently based on cognitive learning theory currently becoming more popular.

The development of present day constructivist theory is considered to originate in the work of two early 20th century contemporary epistemological theorists, Jean Piaget (1976) and Lev Vygotsky (1986). Piaget's research focused on the cognitive nature of constructivist learning in which the learner is actively involved in knowledge construction while Vygotsky's on the cultural and social context for cognitive development in constructivist learning environment.

Constructivism is not a unified theory, but rather a collection of different positions with varying emphases. In recent literature, the two branches of constructivist thought are found: radical or cognitive constructivism and social constructivism (Derry, 1996; Marshall, 1996; Phillips, 1995; von Glasersfeld, 1984).

2.1.1 Cognitive Constructivism

According to cognitive constructivism, knowledge is seen as something that individuals actively construct through a series of intellectual stages or steps based on their existing cognitive structures rather than as something passively absorbed as traditionalist say (Bruner, 1960; Piaget, 1970).

Cognitive constructivism was developed by Jean Piaget, a well-known developmental psychologist. He was concerned with how the individual constructs knowledge. Piaget's theory of cognitive development indicated that humans must construct their own knowledge instead of receiving information to understand and use (Piaget, 1953).

Through his observations of children, Piaget identified four stages of development. The first stage was *sensorimotor stage* (0-2 yrs old) which is pre-linguistic characterized by kinesthetic understandings and organizations of experience (Swan, 2005). In this stage children start to discover their surroundings at first through their own senses and physical activity and secondly through language (Piaget, 1953).

The second stage was *preoperational stage* (2 to 7 yrs old) which is characterized by egocentrism, the organization of knowledge relative to oneself (Swan, 2005). Children in his next stage of preoperational develop their own language skills but still cannot grasp the thoughts of others. Piaget stated that within this stage there is "symbolic function" where children start to differentiate pictures or symbols for diverse objects in their environment and "intuitive thought" where children ask all type of questions about the whole thing within their environment.

The third stage was *concrete operational stage* (7 to 11 yrs old) in which knowledge is organized in logical categories but still linked to concrete experience (Swan, 2005). Within this stage children start to substitute the intuitive thought with their own logical reasoning.

The fourth stage was *formal operational* stage (11 yrs old to adulthood) in which knowledge is abstracted from experience and formal reasoning can occur (Swan, 2005). In Piaget's formal operational stage children, up to adulthood, start using higher levels of thinking or abstract ideas to solve problems.

Piaget (1953) stated that children's mental structures (schemas) are constructed through the process of assimilation and accommodation, when going through four different stages of development as search for balance or "equilibration" (Swan, 2005; Wadsworth, 2004). In *assimilation*, new knowledge is incorporated into existing schemas in much the same way a new wing is added to a building. In *accommodation*, new knowledge conflicts with existing schemas which accordingly must be altered to incorporate it (Swan, 2005). Equilibration occurs when children shift from one stage to another.

The theory of equilibration, assimilation and accommodation deals with children's capability to construct their own new knowledge within their own stages and resolve conflicts (Piaget, 1953). For teachers, it is important to recognize this process within each individual student at a different pace in order to facilitate constructivist learning. Cognitive constructivism theory of Piaget emphasizes the importance of considering individual students need and pace to get knowledge and learn. Teachers need to facilitate the process in equilibration, assimilation and accommodation in the classroom.

2.1.2 Social Constructivism

Social constructivism was formed after Piaget had already described his theories involving individual or cognitive constructivism. Social constructivism, unlike cognitive constructivism, focuses on social and cultural aspects of learning. Social constructivism was developed by Lev Vygotsky, Soviet psychologist, the founder of a theory of human cultural and bio-social development commonly referred to as cultural-historical psychology. Social constructivist theory, in contrast to cognitive constructivism, maintains that knowledge is structurally and internally formulated by learners in response to interactions with their environment. Social constructivist theory maintains that because language and culture are the frameworks through which humans experience, communicate, and understand reality, cognitive structures must be explained as products of social interaction (Vygotsky, 1986).

All of Vygotsky's research and theories are collectively involved in social constructivism and language development such as, cognitive dialogue, the zone of proximal development(ZPD), social interaction, culture and inner speech (Vygotsky, 1962). One of Vygotsky's main theories is the zone of proximal development (ZPD). This part of child development controls how a child learns. According to Vygotsky (1962), ZPD is a zone at which learning occurs when a student is supported in learning a concept. According to him, cooperative learning is an integral part of creating a deeper understanding. Cooperative learning is a part of creating a social constructivist classroom. Teachers can prepare activities for students to work together with each other to construct knowledge. Teachers should recognize the diversity of the class and embrace their differences. To embrace diversity, students must interact socially and for interaction language is mandatory.

To sum up, common to these diverse views, basis for constructivism, is that the acquisition of knowledge is described as a building process in which knowledge is actively constructed by individuals or social communities. These schools of thought differ from each other mainly in the role they give to the individual and the social aspects in learning (Tynjälä, 1999). The radical or cognitive constructivist stresses individuals' knowledge construction processes and mental models, social constructivists or constructionists are more interested in social, dialogical, and collaborative processes (Tynjälä, 1999).

Constructivism is a theory of knowing and learning that aims to explain what knowledge is and how it is acquired in contrast to behaviorist tradition in learning (Duit, 1996**;** Tynjälä, 1999). Concerning knowledge, realism was the theory of knowledge in behaviorist era before constructivism (Colliver, 2002, p.49). “Realism entails the assumptions that there is something out there, not directly accessible to us, hidden from us and that our knowledge claims can accurately depict this shadowy realm- reality" (Colliver, 2002, p. 49). However, knowledge in constructivism consists simply of our claims, our constructions (Colliver, 2002). "The constructivist view is that knowledge claims are justified if we agree that they are useful in reaching our practical goals rather than verified by proving that they correspond to reality" (Colliver, 2002, p.49).

Constructivism can be broadly defined as a theory of learning or meaning making, that students make their own understandings as a result of an interaction between prior knowledge, believe and ideas and new knowledge that they come into contact (Richardson, 2003). From constructivism point of view learning is considered as a dynamic and social process that enable learners to actively construct new meaning from their experiences and prior knowledge in social setting (Driver, Asoko, Leach, Mortimer and Scott, 1994). According to constructivism principles, learners actively construct their own new understandings or knowledge because of the interaction between their prior knowledge and the newly acquired knowledge (Richardson, 1997). The belief that learners are empty headed (*tabula rasa*) passively waiting to receive readymade knowledge from teachers in behaviorist principle is not a proper description of learners from constructivism principles point of view. In the view of constructivist, students should no longer be passive receiver of knowledge given by the teachers; and the teachers should no longer be provider of knowledge (Fosnot, 1996; Tynjälä, 1999). According to Madu (2012) the constructivist view of learning argues that "students do not come to the science classroom empty but have tenaciously held ideas about how the natural world works" (p. 3). It is believed that learners actively create knowledge using their prior knowledge and experience as they interact with the environment and/or instructional topic (Richardson, 2003; Tynjälä, 1999).

Constructivism emphasizes on understanding instead of memorizing and reproducing information and it relies on social interaction and collaboration in construction of meaningful knowledge and understanding (Richardson, 1997; Tynjälä, 1999). This understanding of constructivism is regarded as a shift in instructional approach from teacher-centered to student centered method of teaching. For this, learners must actively participate in the teaching learning process through discovery, reflection and critical thinking for best achievement in learning (Santrock, 2001). Therefore, from the perspectives of constructivism learning theory, teaching is making the environment suitable for students to actively engage in scientific activities and make their own construction instead of providing information and assessing their learning to check whether they have received it or not. Hence, according to Yager (1991), teachers should encourage students to inquire, actively involved in learning process, elicit their preconceptions, and create suitable classroom environment. In line with this constructivism learning theory, different alternative learner centered approaches that allow the learners to actively engage and construct knowledge individually as well as by interacting with each other emerged.

2.2 Constructivist Teaching Strategies

The traditional teaching methods in behaviorist learning theory have different drawbacks. They did not actively engage learners in their learning and usually do not recognize learners prior conception and are unable to provide meaningful learning. In contrast to behaviorist view, constructivist methods of teaching are learner centered with different techniques and activities that provide an opportunity for student to actively engage in teaching learning process. Teaching strategies in constructivist learning theory considers students' prior knowledge at the beginning of the teaching learning process, encourage active participation of learners with guidance of the teacher during the learning process and lead to meaningful learning with deep understanding of concepts. Accordingly, the classrooms are arranged in a way that facilitates collaboration and discussions of ideas among students and teachers like, for instance, circle or semicircle arrangements of desks than in rows as traditional classroom. Literature indicated that the role of the teacher according to this theory is facilitator whereas the role of the students is to become active participants in teaching learning process (Vighnarajah, Luan, & Bakar, 2008). To this end, constructivists recommend different teaching strategies that help to implement their principles in learning (Driscoll, 1994).

The teaching methods which are recommended by constructivism learning theory proponents include cooperative learning (Lord, 2001; Tanner, Chatman & Allen, 2003); conceptual change approach (Pearsall, Skipper, & Mintzes, 1997; Venville & Treagust, 1998); concept mapping (Novak, 1990; Uzuntiryaki & Geban, 2005; Wallace & Mintzes, 1990); argumentation (Osborne, Erduran, & Simon, 2004; Zohar & Nemet, 2002); learning cycle model (Cavallo, McNeely; Marek, 2003; Lawson & Johnson, 2002). Among these methods of teaching, the learning cycle with three phases, 5phases (5E) and 7phases (7E) have become very popular in science education. In the current study, 7E learning cycle model which is based on constructivist learning theory principles was used. Therefore, in the following section, the learning cycle, the gradual development of 7E learning cycle model and studies conducted so far will be discussed.

2.2.1 Learning Cycle

Learning science in the twenty first century demands learners to be active participant in learning, critical thinkers, self-directed learners, and problem-solvers in their everyday life. There are different types of constructivist based instructional models that enables learners to develop these demands. Learning cycle is one of an inquiry based instruction recommended by constructivists. This systematic approach to instruction was proposed during the implementation of Science Curriculum Improvement Study (SCIS) project by J. Myron Atkin and Robert Karplus in 1967(Lawson, Abraham, & Renner, 1989). They first developed an instructional model/learning cycle with three phases. The first phase was preliminary exploration, the second phase was invention and the third phase was discovery (Lawson, Abraham, & Renner, 1989). Later on, according to Hanley, (1977), these phases were revised in to three phases of exploration, concept introduction, and concept application in 1977 by Karplus. Since then, the learning cycle was used as inquiry method in teaching different subjects at different field of study and educational levels; at elementary, secondary and tertiary level (Marek, Maier, and McCann, 2008). In addition to serving as method of teaching in science education, the learning cycle was also used as a model for curriculum organization in education (Marek, Laubach, & Pedersen, 2003).

According to Krajcik, Czerniak and Berger, (1999) and Carin and Bass, (2001), the first stage of the learning cycle (*exploration) was* designed to give opportunities for students to explore science concepts and construct knowledge and understand scientific ideas through different activities such as doing hands on experimental activities. The second stage of the learning cycle (*concept introduction*) was designed to give the opportunity to the teacher to explain the scientific concepts for students based on their prior knowledge so that students can understand the scientific concepts easily. The third stage of the cycle (*concept application*) was designed to gives opportunity for the teachers to engage students in to new situations to expand their understanding by focusing on the importance of the concepts and knowledge they gained in learning.

The stages and the names of the learning cycle were modified so many times and resulted in the development of additional stages such as four phases learning cycle (Barman, 1997), five phases learning cycle (Bybee & Landes, 1990) and the seven phases learning cycle (Eisenkraft, 2003). Within this modification, it is not only adding additional phases to the first one but also they differ in arrangement and activities that describe each phases. The most commonly used revised form of the learning cycle is the 5E learning cycle which was later on expanded to 7E learning cycle. The 5E instructional model also known as learning cycle was developed in the late 1980s as a component of the science for life and living curriculum created through the Biological Sciences Curriculum Study (BSCS) (Bybee & Landes, 1990). The instructional model has five phases: Engage, Explore, Explain, Elaborate and Evaluate. It falls within the theories of constructivist teaching model and promote students construction of knowledge (Bybee, Taylor, Gardner, Scotter, Powell, Westbrook and Landes, 2006).

As explained above, the Atkin-Karplus Learning Cycle developed in 1960s created through the Science Curriculum Improvement Study (SCIS) consists of three phases: Exploration, Invention and Discovery which was later on revised to Exploration, Concept Introduction, and Concept Application. The middle three elements of the BSCS model are fundamentally equivalent to the three phases of the SCIS learning cycle but the first and the fifth element included additionally (Byee et al., 2006).

Table 1 Comparison of the Phases of the SCIS and BSCS 5E Models (adopted from Byee et al., 2006, p.8)

SCIS Model	**BSCS 5E Instructional Model**
	Engagement (New Phase)
Exploration	Exploration (Adapted from SCIS)
Invention (Concept Introduction)	Explanation (Adapted from SCIS)
Discovery (Concept Application)	Elaboration (Adapted from SCIS)
	Evaluation (New Phase)

The five phases of the BSCS 5E Instructional Model can be applied at several levels in the design of curriculum materials and instructional sequences and from organizational pattern of a yearlong program, to units within the curriculum, and to sequences within lessons (Bybee et al., 2006). Bybee and his colleagues described the five phases as follows:

Phase I - Engagement: During the first phase, the teacher engages students through brief activities that focus students' attention on the phenomenon, stimulate curiosity, and reveal prior knowledge. The students mentally focus on an object, problem, situation, or event. The activities prepared in this phase help students to make connections to their past experiences and identify students' misconceptions so as to mitigate cognitive disequilibrium. This phase invite the learner's consideration, encourage their interest, spur them to unearth their prior experiences with the concepts about to be studied, and pique their interest to know more (Tanner, 2010).

Phase II- Exploration: Once the activities have engaged the students, the teacher challenges students to conduct an exploration and formulate and test predictions, make observations, record data, and collaborate with peers to develop and test alternative solutions. In this phase the role of teacher is to facilitate or coach students.

Phase III- Explanation: in this phase concepts, processes, or skills become plain, comprehensible, and clear. Students review, analyze, and interpret their observations and data. The process of explanation provides the students and the teacher with a common use of terms relative to the learning task. The key to this phase is to present concepts, processes, or skills briefly, simply, clearly, and directly and to move on to the next phase. This phase allows both instructor and students to actively participate in teaching learning process.

Phase IV- Elaboration: Once the students have an explanation and terms for their learning tasks, it is important to involve the students in further experiences that extend, or elaborate, the concepts, processes, or skills. This phase helps students to deepen their conceptual understanding, enhance their skills, and broaden their understanding of science.

Phase V- Evaluation: This is the important opportunity for students to use the skills they have acquired and evaluate their understanding. In addition, the teacher gives feedback for students on the adequacy of their explanations. However, informal evaluation can occur throughout the 5E phases but the teacher can conduct formal evaluation after the elaboration phase.

Similarly, as the three phases learning cycle extended to 5 phase learning cycle (5E), the 5 phase learning cycle also extended to 7phases learning cycle (7E) with the addition of two more phases. The next section deals with this recently developed learning cycle which is the focus of this study.

2.2.2 7E Instructional Model/Learning Cycle Model

As science grows and need more sophisticated environment for effective learning to occur, improving the way we structured our schools, curricula, instruction, instructional materials and assessment techniques in education system is important. To this end, the 5E learning cycle was extended to the 7E phases (Elicitation, Engagement, Exploration, Explanation, Elaboration, and Evaluation and Extension) and named as 7E learning cycle and instructional model (Eisenkraft, 2003) to make it more suitable than the previous one. In this newly developed learning cycle model, two more phases were added. These are elicitation phase to examine prior knowledge of learners and extension phase for application of knowledge gained in daily life or to transfer learning in a new situation (Eisenkraft, 2003). The other phases are similar with that of 5E learning cycle described above. The engage phase expanded to elicit and engage phase; elaborate and evaluate phase expand to elaborate, evaluate and extend phases.

According to Eisenkraft (2003), the objective of the change is not to make the learning cycle complex but rather to give emphasis for the need of eliciting prior knowledge of students and transferring their learning in to new situation in their day to day life which are crucial elements in learning science. When students face new information, the prior knowledge serve as a back ground information on which the new information either fit with it through the process of assimilation or reorganized changing their schema through the process of accommodation as described by Piaget (1953). Therefore, Eisenkraft argue that the *elicit* phase should be treated as separate phase rather than with in engage phase, as in 5E learning cycle, so as to give emphasis on the significance of identifying students prior knowledge in learning science and constructing scientific knowledge(Eisenkraft, 2003). Similarly, the *extend* phase is "intended to explicitly remind teachers of the importance for students to practice the transfer of learning and teachers need to make sure that knowledge is applied in a new context and is not limited to simple elaboration" (Eisenkraft, 2003, p. 59). This phase assists the transfer of knowledge to new but closely related situations. One of the major goals of science education is not only to master the content of the concepts being presented, but also to apply those concepts appropriately to new contexts and situations (Tanner, 2010). The expansion of 5E instructional model to the 7E instructional model is shown in Table 2, below.

Table 2 Expansion of 5E instructional model to 7E learning cycle and instructional model

BSCS 5E Instructional Model	**Eisenkraft 7E Instructional Model**
	Elicit (New phase)
Engagement	Engagement
Exploration	Exploration
Explanation	Explanation
Elaboration	Elaboration
Evaluation	Evaluation
	Extend (New phase)

Each phase of the instructional models has their own descriptions. The following table summarizes each phases and expansion of 5E to 7E instructional models.

Table 3 Summary of each phase of the instructional models (Adapted and modified from Bybee & Landes, 1990 & Eisenkraft, 2003)

Phase	**Instructional Models**	**Description of each phases**
Elicit		• The teacher identifies students' prior conceptions • Students express their own knowledge.
Engagement		• The teacher engages students through brief activities that focus students' attention on the phenomenon, stimulate curiosity • The teacher reveal students prior knowledge (5E)
Exploration	5E 7E	• The teacher challenges students to conduct an exploration and formulate and test predictions, make observations, record data, and collaborate with peers to develop and test alternative solutions.
Explanation		• Students present what they have explored. • Concepts, processes, or skills become comprehensible and clear.
Elaboration		• Students elaborate the concepts, processes, or skills in new context and situations. • Students deepen their conceptual understanding, enhance their skills, and broaden their understanding of science.
Evaluation		• Students use the skills they have acquired • Students evaluate their understanding.
Extend		• Students apply knowledge in their daily life, in a new context, practice transfer of learning • Students motivated to use their knowledge so as to make a new one.

The researcher wants to focus on the 7E instructional model because it gives more clear steps to grasp students' prior knowledge/conceptions that affect students learning and transfer of learning. Students' prior knowledge can help or hinder learning (Brent & Felder, 2011). Prior knowledge helps learning when activated, sufficient, appropriate and accurate otherwise hinders if the opposite happens (Brent & Felder, 2011).

The four criteria essential in constructivism learning theory are eliciting prior knowledge, creating cognitive dissonance, applying new knowledge with feedback, and reflecting on learning, aspect of metacognition (Hartle, Baviskar & Smith, 2012). Elicitation of prior knowledge is one of the important principles of constructivism learning theory and conceptual understanding which should be given a great emphasis in learning (Hartle, et al., 2012). Hence, it seems that the 7E instructional model is an appropriate approach in constructivism learning theory because it provides an opportunity to learners to eliciting prior knowledge, reflect on their own prior knowledge and transfer their learning.

Similarly, Eisenkraft argue that the last phase of 7E instructional model, extend phase, explicitly remind teachers the importance of practicing the transfer of learning. It also reminds the learners to transfer what they have learned in schools to their day to day life beyond answering questions during evaluation in schools. The use of 7E instructional model ensures that eliciting prior knowledge and opportunities for transfer of learning are not omitted (Eisenkraft 2003). Moreover, the 7E instructional model is relatively new and not researched well.

2.3 Metacognition

The term metacognition was introduced by developmental and cognitive psychologists in the 1970s (Schwarz, 2013). However, defining the term metacognition created some debate among scholars because of the variation in field of study or the viewpoints of the defining theorists. Due to this, different definitions of metacognition are available in the literature. For example, Flavell (1979), the founder of the concept, defined metacognition as one's knowledge concerning cognitive processes and products, and one's actively monitoring and regulating that cognitive process. In short, it is 'thinking about thinking'; questioning to know about what we know and what we don't know (Blakey & Spence, 1990). In another word, metacognition has been defined as the ability to monitor, evaluate /asses, and make plans for one's learning understanding (Okoro & Chukwudi, 2011). Moreover, metacognition refers to the "ability to reflect up on, understand and control one's learning" (Schraw & Dennison, 1994, p.460).

According to Schraw (1998), it is a learner's knowledge or awareness about processes of his or her cognition/thinking process and the ability to control and monitor those processes in learning. It is "An individual's awareness of where they are in the learning process, their content knowledge, personal learning strategies, and what has been done and needs to be done" (Wilson, 1999). However, even though researchers have given different emphases based on their own different theoretical point of views, they commonly agree on the definition of metacognition as the knowledge and the ability of learners to control their own cognition/thinking and learning process (Flavell, 1979; Jacobs & Paris, 1987). Hence, metacognition is considered as an engine that drives self-directed learning (Shannon, 2008). According to Hayati (2001), self-directed learners are responsible owners and managers of their own learning in teaching learning process.

Educators classified metacognition in to two distinct but interrelated subcomponents as metacognitive knowledge *or knowledge of cognition* and metacognitive regulation *or regulation of cognition (*Flavell, 1979; Schraw & Dennison, 1994; Schraw and Moshman, 1995; Schraw, 1998). The former refers to awareness of one's thinking and the later refers *to* the ability to manage one's own thinking processes.

2.3.1 Knowledge of Cognition

As indicated above, knowledge of cognition refers to awareness and reflecting on what a person knows or thinks. It is the knowledge that learners have about their cognition and the way of learning (Sperling, Howard, Staley & Dubois, 2004). According to Flavel (1979) and Schraw & Dennison (1994), knowledge of cognition includes at least three different types of metacognitive awareness: Declarative Knowledge: refers to knowledge about oneself as a learner and about what factors can influence one's performance; Procedural Knowledge: refers to knowledge about doing things, knowing about which one is useful and how to use those useful learning strategies and procedures that are best for us to accomplish the task and Conditional knowledge: refers to knowing when and why to use different useful and applicable strategies and other procedures in declarative and procedural knowledge. Knowledge of cognition develops later on and explicit in nature and hence adults can develop more knowledge about their own cognition than children and adolescents and are better able to describe it (Efklides 2008; Kuhn 2000 & McCormick, 2003).

2.3.2 Regulation of Cognition

Regulation of cognition is the second component of metacognition. It refers to directing our learning or regulating our cognition process (Schraw & Dennison, 1994). According to Schraw & Dennison (1994), regulation of cognition includes five components: planning, information management, monitoring, debugging and evaluation. However, planning, monitoring, and evaluation are the three basic essential skills in regulation of cognition (Jacobs & Paris, 1987; Schraw & Moshman, 1995; Schraw, 1998).

Regulation of cognition involves the ability to think strategically and to solve problem, plan, set goals, organize ideas, and evaluate what is known and not known. This means that learners with metacognitive awareness of regulation can regulate their own learning. "Self - regulated learning is a process that assists students in managing their thoughts, behaviors, and motions in order to successfully navigate their learning experiences" (Zumbrunn, Tadlock & Roberts, 2011, p. 4). Self-regulated learners uses different strategies to plan, monitor, and evaluate their learning activities (metacognitive strategies), as well as to control their motivation and emotion (volitional strategies) in their learning (Gonzáles, 2013). It also involves the ability to teach to others and make the thinking process visible.

Research indicated that monitoring cognitive process enhances learning (Paris & Winograd; 1990, p. 15). According to Butler and Winne (1995) those learners that regulate their own learning and activities are the most effective learners. Moreover, Schraw (1998, p. 114) states that "academic performance is improved by metacognitive regulation as learners utilize resources and existing strategies better". Furthermore, Camahalan (2006) indicated that when students get chance to self-regulate and explicitly taught metacognitive strategies, their academic achievement is more likely improved. The following section briefly describes components of regulation of cognition.

Planning

Planning is the first essential skills of regulation of cognition. It involves selecting appropriate strategies; allocate resources that include goal setting, activating background knowledge, and budgeting time in order to attain the desired outcomes in learning (Schraw, 1998). As described above, the first essential skills of regulation of cognition is planning. At the start of a learning activity, learners should be able to select strategies, set goals, and allocate time and resources. This is planning and learners should be engaged in this process because when learning is planned by someone else, like a teacher as usually occurs, it is difficult for learners to become self-directed learners because they are expecting from other (Blakey & Spence, 1990).

Monitoring

Monitoring is the second essential skill of regulation of cognition. It is “one’s on-line awareness of comprehension and task performance” (Schraw, 1998 p.115) and includes the self-testing skills essential to regulate learning. Although adults are able to monitor their learning than adolescent, even skilled adult learners may be poorly monitors under certain conditions (Pressley & Harris 2006).

Evaluation

Evaluation is the third essential skill of regulation of cognition which involves checking the process and determining if the learning outcomes are attained and the regulation processes used were effective or not (Schraw & Moshman, 1995). It is “appraising the products and regulatory processes of one’s learning,” and includes revisiting and revising one’s goals (Schraw, Crippen & Hartley, 2006). According to Lucangeli, Cornoldi, and Tellarini (1998), students having awareness of strategies of the evaluation can evaluate their goals, performance on the task, compare their performances with others and locate the error for improvement.

2.3.3 Role of Metacognition in Learning

Metacognition is an important component of teaching and learning process (Efklides 2006). As research indicated, there is a link between metacognition and students learning and performance (Muijs & Reynolds, 2001; Rahman, Jumani, Chaudry, Chisti, & Fahim, 2010). This is because, the learners' awareness about their learning and control of the way they are learning is important in meaningful learning (Azevedo, 2005; Lin, 2001).

The abilities of students to control their own learning are crucial for effective learning (Boekaerts, Pintrich, & Zeidner, 2000). Active learners control their own learning because they know and use useful and best learning strategies and are effective in their schools but passive learners do not control their own learning because they do not know or use good learning strategies and are not successful in school. Metacognition helps student to understand what they understand and adjust their learning strategies to improve their learning when they feel their understanding is incomplete (Samson, 2011). Students who have well metacognitive awareness are able to plan, monitor, and modify their cognition at different levels in their learning than who have low metacognitive awareness (Zimmerman & Martinez-Pons, 1986).

In constructivism learning environment learners are expected to be independent learners than merely dependent on the teacher to investigate and construct knowledge. Metacognition is considered as the engine that drives independent self-directed learning (Shannon, 2008). As stated by Hayati (2001), independent self-directed learners are responsible owners and managers of their own learning process. Educators suggest that "Metacognitive approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them" (Donovan & Bransford, 2005, p.10). In order to self-regulate their learning, students need to use different metacognitive strategies of planning, monitoring, and evaluating their learning (Okoro, and Chukwudi , 2011).

It is indicated that metacognitive awareness may arise at age 4-6 years (Demetriou and Efklides, 1990) and gradually develops during the primary school years as a function of age and experience (Flavell, 1988). Researchers also indicated that metacognitive abilities develop and appear to improve gradually among learners with age (Cross & Paris, 1988; Schraw & Moshman, 1995). According to Schraw and Moshman (1995) cognitive knowledge appears first, with children as young as age 6 in which they are able to reflect on the accuracy of their cognition but consolidation of these skills typically becomes evident by 8-10 years of age in metacognitive development. In metacognitive development, ability of the children to regulate cognition appears next by 10-14 years of age with dramatic improvements in monitoring and regulation in the form of planning. They indicated that monitoring and evaluation of cognition develop gradually and may remain incomplete in many adults. However, metacognition does not automatically develop in all students and therefore teachers and methods of instruction have a role in its development and acquisition of metacognitive skills than growth (Veenman, Wilhelm & Beishuizen, 2004).

Research indicated that using metacognitive strategies in learning increased learning and achievement of students (Bransford et al., 2000; Everson, & Tobias, 1998). Moreover, research findings revealed that metacognitive strategies (monitoring and control) has enabled learners to solve more complex problems and faster problem solving compared to the control group (Caraway, et al., 2003). However, most of the time, students do not use metacognitive strategies which in turn resulted in lower academic results (Bannert & Mengelkamp, 2013; Greene, Dellinger, Tüysüzoglu, & Costa, 2013; Zimmerman, 2008). Therefore, teaching about metacognitive strategies is important because it has positive consequence in enhancing learning and time management of students (Caraway, Tucker, Reinke & Hall, 2003; Cross & Paris, 1988; Dignath, Buettner & Langfeldt., 2008; Imani, Sabetimani, Qujurand & Ardestani, 2011).

In order to enhance students' academic performance, metacognition can be taught to students (Maqsud, 1997). Several researchers offer evidence that metacognition is teachable (Cross and Paris, 1988; Dignath et al., 2008; Haller Child & Walberg, 1988). According to Schoenfield (2001) teachers should teach students how to regulate their own learning processes so as to improve their academic achievement. This is because students cannot be expected to develop such metacognitive strategies by their own unless we help them by teaching specific strategies at different levels. Cross & Paris (1988) indicated that students received strategy training that included explicit attention to declarative, procedural, and conditional knowledge about reading strategies made significant gains relative to comparison students. Similarly, Dignath et al. (2008) conducted a research on the effect of training in self-regulation on learning and use of strategies among students and found that teaching combination of planning and monitoring and the combination of planning and evaluation both of which were more successful in enhancing learning.

On the other hand, researchers argue that the constructivist learner centered approache by itself can create the opportunity for students to develop awareness on metacognitive strategies (Jonassen, 2000). It promotes awareness of learners' personal thinking that lead to independent; self- regulated learning (Blakey & Spence, 1990). Learner centered approaches like cooperative learning, discussions, concept maps, graphic organizers, feedback and scaffolding can enhance students' use of metacognitive strategies (Fouché & Lamport, 2011). This is because student-centered learning, for instance, requires students to set their own goals for learning, and determine resources and activities that will help them meet those goals, which are metacognitive strategies (Jonassen, 2000). For instance, a research conducted by Feyzioğlu & Ergin (2012) and Tandel (2013), shows that 5E instructional model created opportunity for students to develop metacognitive awareness compared to traditional instruction.

Furthermore, according to Bransford et al. (2000) metacognitive strategies should be consciously integrated into curricula in all disciplines and age levels. They pointed out that this integration could improve learners learning and could help them to develop the ability to become independent learners. According to Georghiades (2004) teachers can also embed metacognitive strategy instruction within subject matter while teaching the courses.

It is reported that, one of the problems students' encountered in teaching learning process is an overall lack of awareness to their own learning process (Shannon, 2008). Most of the time students do not see learning as a process that occurs in a cycles involving engagement in the learning task, revision of previous work in learning to evaluate weakness that can be improved and planning for improvements of the weakness observed in the learning process. Hence, there is a need to teach them how to plan, monitor and assess their learning using metacognitive strategies of planning, monitoring and evaluation. This may encourage students to become self-directed and independent learners that constructivism requires. The following section deals about deferent metacognitive strategies that can be taught for students and employed while teaching a course so as to enhance their learning.

2.3.4 Metacognitive Strategies

According to Flavell, (1981) metacognitive strategies refer to the "conscious monitoring of one's cognitive strategies to achieve specific goals, for example when learners ask themselves questions about the work and then observe how well they answer these questions" (p. 273). They are strategies that enable students to actively engage in metacognitive thinking process,'thinking about their own thinking'. These strategies are actions that help learners to coordinate their own learning process so as to become an effective learner. Moreover, metacognitive strategies are strategies which allow students to plan, control and evaluate their learning (Okoro & Chukwudi , 2011). According to Bransford, et al., (2000), metacognitive strategies assist students to manage their own learning through defining learning goals and monitoring their progress in order to achieve the stated goals. This in turn enables learners to ensure that their goals and tasks are properly understood and then successfully completed and enhanced their learning (Gourgey, 1998).

Metacognitive strategies are used in the various phases of the learning process as described by Zimmerman (2002). He distinguished three phases: the forethought phase, which involves the development of planning strategies. Examples are setting goals and allocation of time. The performance phase, in which an actual learning or task performance takes place. Here the monitoring strategy comes into play; the learner repeatedly checks whether he/she understands the material, e.g. by self-questioning. The last phase is that of self-reflection, during which the learner evaluates the learning process and/or product.

There are different types of metacognitive strategies that can help learners to improve regulation of cognition. Some of them are self questioning, concept map, journaling, modeling, think aloud, metacognitive prompts, KWL chart, regulatory checklists, etc (Blakey & Spence, 1990; King, 1991**;** Schraw, 1998). As described by Kumari and Jinto **(**2014) using these strategies in teaching learning process by the teachers can help students to follow appropriate procedures in the process of learning. Some of the strategies described below.

Self-questioning: One of the strategies that can be used in developing metacognition is to encourage students to think and ask questions about themselves. Self-questioning is a metacognitive strategy in which learners ask questions frequently for themselves before, during and after learning a session or the reading a material to determine whether they understand the concept; link it with prior knowledge; and relate the main concept to other concepts (Blakey & Spence, 1990; Ratner, 1991). This strategy encourages students to assess their thinking and monitor their own cognition for self-correction for new understanding of the concepts (Ganz & Ganz (1990). As described by Tanner (2012), several examples of self-questions can be explicitly used by students in learning a biology course during class session, active-learning task, homework, assignment, quiz and exam. The following table shows examples of self-questions that can be used to promote student metacognition about learning during class session.

Table 4 Sample self-questions to promote student metacognition about learning during class session (Adapted from Tanner, 2012)

Activity	**Planning**	**Monitoring**	**Evaluating**
Class session	• What are the goals of the class session going to be? • What do I already know about this topic? • How could I best prepare for the class session? • Where should I sit and what Should I be doing (or not doing) to best support my learning during class? • What questions do I already have about this topic that I want to find out more about	• What insights am I having as I experience this class session? What confusions? • What questions are arising for me during the class session? Am I writing them down somewhere? • Do I find this interesting? Why or why not? How could I make this material personally relevant? • Can I distinguish important information from details? If not, how will I figure this out?	• What was today's class session about? • What did I hear today that is in conflict with my prior understanding? • How did the ideas of today's class session relate to previous class sessions? • What do I need to actively go and do now to get my questions answered and my confusions clarified? • What did I find most interesting about class today?

Journaling: it is a strategy in which learners keep a personal diary throughout a learning experience. According to du Toit and Kotze (2009) in journaling learners make notes of concepts that are not clear, discrepancies, mistakes and ways to correct their mistakes.

Modeling: it is a metacognitive strategy in which the teachers demonstrate the steps of performing a task by thinking aloud (Muijs & Reynolds, 2005) and students develop metacognition because student learn imitating adults Costa (1984).

Thinking aloud: it is a strategy in which students talk loudly about their thinking while doing an activity or solving a problem. It helps learners to identify their thinking skills (Blakey & Spence, 1990).

Metacognitive prompts: Questions that remind student to ask themselves about what they are thinking and doing during learning or doing a task (Sedgley, 2015). Metacognitive prompts are commonly used in order to remind students to: activate their metacognitive strategies or provide a scaffold that helped learners follow and internalize scientific processes during science learning especially for process during metacognitive regulation (Devolder, Van Braak & Tondeur, 2012). Such prompts help to engage students in metacognitive process of planning, monitoring and evaluation of their own learning involving them in regulatory activities and encourage students to explicitly express their own thinking so as to evaluate and revise their learning (Bannert, 2006; Lin & Lehman, 1999).

Metacognitive prompts can be used in the form of questions, like what do I know about this topic? or sentence starters like my difficulties in this topic are… . (Conner & Gunstone, 2004; Davis, 2003 & King, 1994). Prompts are usually presented before, during, and after learning period i.e. during planning, monitoring and evaluation. Before a lesson: Prompts during planning; why did you come today to this class/session? What is your goal/objective? What do you know about this topic? During a lesson: Prompts during monitoring; do you understand what you are doing? Are you on the right track in reaching your goal? After a lesson: Prompts during evaluation; did you understand what you learn? What does work? What does not work?

Research findings indicated that metacognitive prompts have beneficial effects on students learning (Johnson et al., 2011; Lin & Lehman, 1999). Researchers pointed out that prompts are successful at all phases of metacognitive regulation (Nückles et al., 2009), particularly when supported with metacognitive strategies training (Bannert & Reimann, 2012). In this study, the question prompts were employed in written and verbal form.

Know – Want to Know – Learned (KWL) strategy: this strategy was developed by Ogle (1986) and first suggested as reading strategy. It is a learner centered active learning strategy used to teach a course (Draper, 2002; Ogle, 2009). According to Ogle, 1986, the KWL active learning strategy consists of three stages: the first stage allows students to access and activate their prior knowledge about the topic. The second stage allows students to determine what they want to know. The third stage allows students to remember what they have learned at the end of a session or sessions. In other word, it has three columns with know (K) – want to know (W) – learned (L) (Fig. 2). Students begin by writing everything what they *Know* about a lesson on the first column(K column) and write list of questions about what they want to know about the lesson/prediction on the second column (W column) and record the new information that they have learned in the third column (L column) (Kumari & Jinto**,** 2014). Ogle (2005) pointed out that the KWL strategy help students to perceive learning as a metacognitive process. Therefore, KWL can be considered as one of the metacognitive strategies that help students to know what they already know, what they want to learn and what they did learn after learning a topic (Dixon-Krauss, 1996). According to Conner (2006) this strategy can be used for eliciting prior knowledge, setting a goal for learning, monitoring their understanding, assess their comprehension of the lesson and expanding their ideas beyond the classroom lesson.

What I Know	What I Want to Know	What I have Learned

Figure 2 KWL chart

Since then, the KWL was modified to include different activities. For instance, Weaver (1994) modified KWL in to KWLH chart, by adding H which stands for how can I learn more to encourage students to think about the possible way of expanding their knowledge and future learning.

Similarly, for this study researcher modified the KWL to include different activities suitable for implementing metacognitive strategies of planning, monitoring and evaluation. Therefore, I modified this KWL chart in to KWHAL by adding two more columns with H and A between L and W columns so as to include metacognitive strategies of planning, monitoring and evaluation. **H** column stands for **H**ow will I know/learn to give an opportunity for students to select strategies and **A** column stands for **A**m I learning well to give students an opportunity to check themselves whether they are on the right track or not. In short, the H column helps students to think of strategies and the A column helps the students to monitor their learning process. The metacognitive strategies of regulation of cognition used in this study are planning, monitoring and evaluation. The researcher used this chart as metacognitive strategies in which the first three columns (column K, W & H) for planning purpose, the fourth column (column A) for monitoring purpose and the fifth column for evaluation purpose. According to Shannon (2008), although students, even at a rudimentary level, have some basic understanding of their own knowledge and thinking, they should be encouraged to develop a sense of their own knowledge by asking questions such as, “What do I know?”, “What don’t I know?” and “What do I need to know?” These types of reflective questions can help students become more self-aware and help them to make real world connections to the information they are currently learning (Shannon, 2008). The following figure shows the chart.

Planning			**Monitoring**	**Evaluation**
What do I **know**?	What do I **Want** to learn?	**How** will I learn it?	**A**m I learning well? **A**m I on the right track?	What have I **Learnt**?

Figure 3 KWHAL Chart

In addition to KWHAL, the researcher used self regulatory check list developed by Schraw (1998) to facilitate and improve regulation of cognition. Teachers can enhance metacognition by guiding learners to evaluate the learning activities (Costa, 1984). This self evaluation of learning activities can be introduced by using checklists focusing on thinking process and can be applied independently (Blakey & Spence, 1990). The commonly used checklist in metacognition is self regulatory checklist developed by Schraw (Schraw, 1998). According to Schraw (1998) regulatory checklist help learners to implement a systematic regulatory sequence to control their performance. Self regulatory checklist helps learners to develop self regulatory characteristics to be more strategic and systemic in their learning (SESS, 2009). As it is described in Special Education Support Service (SESS, 2009) document, learners should have the checklist on their homework dairy, workbook or desk so that they can refer at any time while learning to make sure that they are on track. The following table shows some of the self regulatory checklist.

Table 5 Some of the self -regulatory check list (adapted from Schraw, 1998)

Planning	Monitoring	Evaluation
What is my goal? What kind of information and strategies do I need? How much time and resources do I need?	Do I have a clear understanding of what I am doing? Does the task make sense to me? Am I reaching my goals?	Have I reached my goal? What worked? What didn't work? Would I do things differently the next time?

In this study students used metacognitive strategies of planning, monitoring and evaluation before, during and after learning. Particularly, KWAHL, regulatory checklist and metacognitve prompts in relation to planning, monitoring and evaluation were used in this study.

2.3.5 Metacognitive Scaffolding

Students usually face difficulty in learning different subjects especially when the topic is new for them. At this time they need different types of support from their teachers, classmates and parents in order to be successful in their learning. A teacher can support his students to become competent in, for instance, problem solving skills, learning strategies skills, reading skills, study skills etc and this is part of scaffolding. According to Wood, Bruner & Ross, (1976) scaffolding can be defined as giving support to students based on their need and gradually decreasing the support as the ability of the students' increases and become competent enough. Similarly, Hartman (2001) defined scaffolding as providing assistance to students on activities that they need guidance from others. He stated that the aim of scaffolding is to make students independent, self-regulating thinkers, self-sufficient learners and less teacher-dependent.

Scaffolding can be divided in to two types; static scaffolding and dynamic scaffolding (Hill and Hannafin, 2001; Molenaar & Roda, 2008; Puntambekar & Hubscher, 2005). Similarly, Saye and Brush (2002) divided scaffolding it to hard scaffolds and soft scaffolds to mean static and dynamic scaffolding respectively. Static scaffolding is predetermined and constant over time and the same for all students (Molenaar & Roda 2008; Puntambekar & Hubscher 2005). In other words, Saye and Brush (2002) also defined Hard scaffolds as "static supports that can be anticipated and planned in advance based on typical student difficulties with a task" (p. 81). According to Hill and Hannafin (2001), static resources have stable content and include print-based textbooks as well as encyclopedias magazine and newspaper articles.

In contrast, dynamic scaffolding is to diagnose, calibrate, and provide support based on performance on the learning (Molenaar & Roda 2008; Puntambekar & Hubscher 2005). Similarly, Saye and Brush (2002) also defined soft scaffolds provide dynamic and spontaneous support based on learner responses. Dynamic resources do not have stable contend and hence, undergo regular change and include many web-based resources (Hill & Hannafin, 2001).

On the other hand, according to Hill and Hannafin (2001), there are four types of scaffolding. These are conceptual scaffolding, metacognitive scaffolding, procedural scaffolding, and strategic scaffolding. The following table describes each of the scaffolding types with examples.

Table 6 Resource-based learning environments scaffolding components (adapted from Hill and Hannafin, 2001)

Scaffolding Mechanism	**Function**	**Examples**
Conceptual Scaffolding	Mechanism designed to assist with defining things to consider.	. Creating an outline of a paper before you start to write or examining a map of a location to determine best ways to reach your destination (either in a paper or a physical place).
Metacognitive Scaffolding	Assist with establishing what is known and how to think.	• Providing learners with structured "reflection reminders," which may come in the form of daily journal entries. • Enabling scaffolded inquiry so that as learners are engaging the process, they are assisted in ways that make the most sense for them.
Procedural Scaffolding	Assist with how to use a resource.	• Providing and encouraging the use of help functions in productivity tools to assist the learner with trouble-shooting and problem-solving. • Creating Web site maps so the learner can get a sense of the scope of the site, as well as indicators of how varied elements in the site are linked together.
Strategic Scaffolding	Alternative ways to do a task.	• Arranging for an expert consultant to demonstrate how to perform a task so learners can observe and ask questions while learning a new technique. • Creating "question pools" where learners can pose questions for others to provide responses, enabling multiple perspectives on a problem.

Metacognitive scaffolding is defined as a way of guiding students to know what they are thinking about and assisting students to know how to solve problems (Xie & Bradshaw, 2008). According to Brown (1987) in Metacognitive scaffolding, the three activities are planning scaffolds, monitoring scaffolds and evaluating scaffolds. This type of scaffolding, according to, Hannafin et al. (1999) enhances metacognitive thinking and metacognitive strategies of planning, monitoring, and evaluating. In other words, metacognitive scaffolding helps learners to reflect on what they know, how they are learning and what they have learned at the end of the session.

In metacognitive scaffolding, the guidance may be in various forms, such as expert modeling, expert advice, prompts, learner guides, and tools that assist them in organizing and accessing their knowledge (Way & Rowe, 2008).

Studies have investigated the effects of metacognitive scaffolding on learning. For instance, a research conducted by Ge and Land (2003) shows that metacognitive scaffolding enhances problem-solving processes and use of metacognitive strategies. According to this study students who were instructed with metacognitive question prompts performed significantly better than those who did not in problem-solving processes. Moreover, studies reveal that metacognitive scaffolding has a positive effect on students' content learning and knowledge construction and metacognitive processes as well (Bulu & Pedersen, 2010).

The current study focused on metacognitive scaffolding in which students were give supports to use metacognitive strategies of planning, monitoring and evaluation with training. The metacognitive scaffolding used in this study was to enhance ability of the regulation of cognition of students during learning through metacognitive strategies training on planning, monitoring and evaluation and hence to improve their motivation, achievement, conceptual understanding and retention of concepts in biology combining with 7E instructional model.

7E instructional model has seven phases (section 2.2.2). The first phase of the 7E instructional model is (Elicit). For this phase students need to be aware of what they know. Hence, they need to think of what is there in mind. The third (explore), fourth (Explain) phases students need to be aware of want to know and how to know. Hence they need to plan ahead with objective, strategies of exploring and presentation, time and resources. This is metacognitive strategies of planning which can be used during forethought phase as described by Zimmerman (2002). For this purpose students can use the first three columns of KWHAL chart and the first column of self regulatory checklist, self questioning and other strategies listed above. In the second, fifth, and seventh phases, the teacher engages students by providing activities and keeps attention and stimulates curiosity, clear confusions and extends learning beyond the classroom respectively. During all these phases, students are expected to manage their progress. They have to monitor what and how they are doing. This is metacognitive strategies of monitoring which can be used during performance phase as described by Zimmerman (2002). For this purpose students can use fourth column of KWHAL chart, second column of self regulatory checklist, metacognitive prompts and other strategies. The teacher can also use metacognitive prompts as a reminder of students to monitor their activity. The sixth phase (evaluation) expects students to assess their learning. This requires metacognitive strategies of evaluation which can be used during self reflection phase as described by Zimmerman (2002). For this they can use the last column of KWHAL chart, self regulatory checklist, self questioning and other strategies.

2.4 Studies Related to Learning Cycle and Metacognitive Strategies

Following the beginning of the implementation of the three phase learning cycle developed in Science Curriculum Improvement Study (SCIS), several studies have been conducted to evaluate the effectiveness of the constructivist based learning cycle and recommended by many scholars as effective way of teaching for meaningful learning (Lawson, 2001; Levitt, 2002; Ray & Beardsley, 2008; Wilder & Shuttleworth, 2005). Research on the impact of using learning cycle has been conducted in a variety of disciplines and teaching contexts from elementary school through colleges. The studies focused on the effectiveness of learning cycle alone and with combination of other instructional method like conceptual change approaches, metacognitive strategies, concept map, technology etc comparing with traditional approaches (Ajaja, 2013; Artun and Coştu, 2012; Doğru and Tekkaya, 2008; Kaynar, Tekkaya & Cakıroğlu, 2009; Lee, 2003; Nuhoglu & Yalcin, 2006; Odom and Kelly; 2001; Sadi & Çakiroğlu, 2010). Many of them documented improvement in students' conceptual understanding, achievement, scientific reasoning, as well as more positive attitudes toward science among students.

Most of the studies conducted on the effectiveness of learning cycle in biology gave great emphasis on conceptual understanding (Balci, Cakiroglu, & Tekkaya, 2006; Yılmaz, et al. 2011; Odom & Kelly, 200) and achievement of students in biology (Appamaraka, Suksringarm, & Singseewo, 2009; Cakiroglu, 2006; Dogru-Atay & Tekkaya, 2008; Sadi & Cakiroglu, 2010). Moreover, a research conducted to see the effect of learning cycle on retention in biology concepts found positive results (Blank, 2000)**.** For instance, learning cycle instruction promoted high school students understanding in diffusion and osmosis (Marek, Cowan, & Cavallo, 1994; Odom and Kelly, 2001). According to these finding, students taught with learning cycle had better understanding about the concept of diffusion and osmosis than those taught with expository instruction. Similarly, researchers investigated the effect of the learning cycle on students' achievement in genetics and cell concepts (Doğru & Tekkaya, 2008; Kaynar, Tekkaya, & Cakıroğlu, 2009). The results of the study shows that the experimental groups instructed with the learning cycle better achieved in genetics and cell concept results than the controlled group instructed with traditional approach.

Particularly, studies conducted on the effectiveness of 5E learning cycle show that students' achievement, retention and conceptual understanding improved and alternative conceptions reduced after the instruction of 5E instructional model (Ajaja, 2013; Artun & Coştu, 2012; Lee, 2003; Lord, 1999; Nuhoglu & Yalcin, 2006; Sadi & Çakiroğlu, 2010). A study conducted by Ajaja, (2013) found that students taught with 5E learning cycle scored the highest marks and retained more of the biological knowledge than those taught with concept mapping, cooperative learning and lecture methods respectively. Similarly, study results revealed that teaching activities based on the constructivist 5E model are effective means for conceptual understanding and reduction of misconceptions (Artun & Coştu, 2012). Moreover, a study conducted by Sadi and Çakiroğlu, (2010) show that 5E learning cycle instruction increased students' achievement in biology more than the traditional instruction did. Furthermore, researches have been conducted to see the effect of the combination of learning cycle with other strategies. For instance, a research conducted by Blank, (2000) on effectiveness of the three phase (SCIS) learning cycle model combined with metacognitive cycle found that there was no significant difference between the two groups in content knowledge in ecology but metacognitive learning cycle groups did better ecology understandings.

After the development of the 7E instructional model, many studies have been conducted to see its effectiveness in learning science in different fields. The results of these studies revealed that 7E instructional model significantly improved students' critical thinking skills, conceptual understanding, retaining acquired knowledge, and promoting self-regulation, achievement (Gök, 2014; Mecit, 2006; Polyiem, Nuangchalerm & Wongchantra, 2011). According to Shaheen, and Kayani (2015) the 7E instructional model was more effective than the traditional instructional in terms of students' biology achievements. Moreover, a research conducted by Adesoji & Idika (2015) in chemistry field revealed that 7E instructional model is effective in improving students' achievement.

Though, 7E learning cycle was proofed to be effective, few researches were conducted by combining 7E learning cycle with other strategies. For instance, a research conducted by Warliani, Muslim and Setiawan (2016) on effects of 7E learning cycle model using technology based constructivist teaching shows that students in experimental group performed better in understanding than control group instructed with 7E learning cycle model alone. Similarly, a research conducted by Bulbul (2010) shows the effectiveness of 7E learning cycle with computer animation on students understanding and achievement. Students in this group performed better in understanding of concepts in osmosis and diffusion. Parallel to this result Kunduz & Secken, (2013) in chemistry found that experimental groups taught with 7E learning cycle with computer assisted teaching material performed better in achievement than control group.

A research conducted by Yerdelen-Damar & Eryilmaz (2016) on the effectiveness of metacognitive 7E learning cycle on the students' epistemological understandings revealed that students with in experimental group performed better. According to this study, metacognitive activities like the prompted small and whole group discussions, journal writings as homework, error analyses, and concept mapping were used with 7E learning cycle. They found that the group assigned with metacognitive 7E learning cycle performed better than those taught with teacher-centered instruction. Another study conducted by Sornsakda, Suksringarm & Singseewo (2009) on the effect of using 7E instructional model with three metacognitive techniques of intelligibility, plausibility and wide – applicability found that the experimental groups performed better in learning achievement, integrated science process skills and critical thinking than control group.

In the current study, however, metacognitive strategies of planning, monitoring and evaluation were used with 7E instructional model to see how these approaches help students' biology learning in the Ethiopian context. My study builds on what is reported in the literature by including metacognitive strategies into the 7E instructional model. Using metacognitive strategies of planning, monitoring and evaluation with 7E instructional model, however, makes this study somewhat different from the studies conducted so far and it will have its own knowledge contribution to the literature.

Therefore, the main purpose of this study was to investigate the effectiveness of 7E instructional model supported with metacognitive strategies on Ethiopians 9th grade students' motivation, achievement and conceptual understanding of biology concepts.

2.5 Conceptual Understanding

The concept of gaining knowledge and understanding of science should be seen separately. Gaining knowledge about science may not necessarily be understanding science. Wiggins & McTighe (1998), associate the term knowing with facts, memorization, and superficial knowledge, whereas the term understanding signifies a more complex, multidimensional integration of information into a learner's own conceptual framework.

Conceptual understanding has become a focus of wide range of current research in science education (Alkhawaldeh, 2007; Bilal & Erol, 2012; Marasigan & Espinosa, 2013). Many of them attempted to address students' conceptual understanding of science concepts from different perspectives such as learning, teaching and assessment techniques. In relation to learning, researchers found that students have major problem in understanding major concepts and hold misconceptions or alternative conceptions in science concepts (Bahar, Johnstone & Hansell, 1999; Tekkaya, Ozkan & Sungur, 2001).

It is clear that students do not come to classroom with an empty mind in view of constructivism. They come with some knowledge about the concept which may be constructed from their daily life experience before they come to the formal classroom instruction (Teichert & Stacy, 2002). This prior knowledge held by students may or may not be similar with the formal concept that is agreed upon by scientist community. So, students' prior knowledge might be able to cause some difficulties in students' learning process affecting their conceptual understanding about science concepts.

Taking the prior knowledge of learners in to account, conceptual change within conceptual change theory has become the term denoting learning science from constructivist perspectives (Lin, 2004; Tanner & Allen, 2005). Conceptual change is define as "a learning process in which an existing conception (idea or belief or knowledge about how the world works) held by a student is shifted and restructured, often away from an alternative or misconception and toward the dominant conception held by experts in a field" (Tanner and Allen, 2005, p. 113).

According to Posner et al. (1982) conceptual change is defined in relation to assimilation and accommodation. Assimilation, a weak knowledge structuring or conceptual capture occurs when students use existing concepts to deal with new phenomena whereas accommodation, a radical knowledge structuring, occurs when students lack sufficient existing knowledge to grasp new phenomena and replace or reorganize their central concepts (Duit & Treagust, 2003; Posner et al., 1982).

As stated by Posner et al. (1982), there are four conditions for conceptual change to occur. These are dissatisfaction with existing conceptions, intelligibility; plausibility and fruitfulness of new conception. Dissatisfaction with existing conceptions occur when students first encountered difficulties with an existing conception to consider a new one due to anomaly which creates cognitive conflict that prepare students for accommodation. The intelligibility of new conception is when students know the meaning of new conception, create a logical representation and see that it is internally consistent existing conception. The new conception is plausible for students when they bring together a new conception with preconception without any difficulties. The new conception is fruitful for students when it has a potential to open up and lead new insights and discoveries. This type of learning process helps students to have deep understanding of science concepts (Jonassen, Strobel & Gottdenker, 2005).

With regard to the problem of how to teach for conceptual understanding, research findings point out that the traditional instructional approach encourages memorization and recalling of facts which is gaining knowledge than conceptual understanding (Zakaria & Iksan, 2007). Similarly, Dhaaka (2012) reported that this approach encourages students to memorize the content and reproduce the same to pass the examination without understanding the concept of the subject. Researchers indicated that students' academic achievement cannot be determined by acquiring knowledge to pass examination but rather by acquiring deep meaningful understanding of the materials presented to the students (Sakiyo & Waziri, 2015).

In teaching toward understanding, an explicit confrontation between pre-knowledge and new knowledge is the critical element, as stated in theory of conceptual change (Posner, George, Strike, Hewson & Gertzog, 1982; Tanner & Allen; 2005). Thus, in teaching toward understanding of major concepts in biology and achieving conceptual understanding for students, it is first necessary to understand students' prior knowledge and identify misconceptions or alternative conceptions. This needs effective implementation of suitable learner centered approaches that enables to extract prior knowledge of learners and treat misconceptions and leads to conceptual understanding. Different learner centered methods are recommended to facilitate effective learning with understanding. For example, the 5E and 7E instructional approaches are useful to extract students' prior knowledge and misconceptions and to teach for conceptual understandings (Bybee, et al., 2006; Eisenkraft, 2003). The following section deals with misconceptions and related literatures.

2.5.1 Misconceptions

As indicated above, students come into classroom with their own prior knowledge which may not be consistent with ideas accepted by scientific community. These students prior knowledge have been given different names by scholars at different times. Among the different names, some of them are misconceptions (Lawson & Thompson, 1988; Nakhleh, 1992; Treagust, 1988; Schmidt, 1997), alternative conceptions (Taber, 2001), alternative views (Odom & Barrow, 1995), alternative frameworks (Gonzalez, 1997; Taber, 2001) and preconceptions (Novak, 1977). In this study, the most commonly used name misconception was used.

Misconceptions can be held by all students at all levels of education. There are different sources of misconception. According to Duit & Treagust, (1995) and Harrison & Treagust (1996) the possible sources of misconceptions include text books; teachers; culture and language; mass media; daily usage of concepts; personal real-life experiences and lack of understandings from previous school courses. Moreover, innate structures of the brain (Duit, 1991) and traditional instruction (Kindfiled, 1991) were also reported as source of misconceptions. Concerning sources of misconceptions, there are different studies conducted in science education (Chattopadhyay, 2012; Chu, Treagust, & Chandrasegaran, 2009; Dikmenli, 2010; Pesman & Eryilmaz, 2010; Sesli & Kara, 2012; Williams et al., 2012).

Students learning can be affected by their prior knowledge, experience and the social context in which learning occurs (Grayson, Anderson & Crossley, 2001; von Glasersfeld, 1992). Since the students have previously perceived concepts in their mind, students may have difficulties in understanding the new concepts (Schmidt, Baumgartner, & Eybe, 2003). While teaching, considering these misconceptions and planning instructions according to these conceptions becomes very important to ensure meaningful learning. This is because misconceptions are obstacles for meaningful learning, they are persuasive, stable, and resistant to change especially through traditional instructional strategies and remain even after formal science instruction (Guzzetti, 2000, Stavy, 1991; Wandersee, Mintzes, Novak, 1994). For meaningful learning to occur, students need to link new knowledge to previously perceived relevant concepts; otherwise, rote learning occurs (Ausubel, 1968). This integration of previously perceived concepts and new concepts during introduction of the concept and entire lesson enable learners to understand the subject matter (Muijs & Reynolds, 2005).

2.5.2 Misconceptions in Biology

Similarly, students understanding and misconceptions concerning biology concept have been the focus of researchers in the past many years (for instance, Coley & Tanner, 2012; Lin, 2004; Tanner & Allen, 2005; Vitharana, 2015). The studies were conducted on different topics in biology. For example, Lewis & Wood-Robinson (2000) and Krüger, Fleige, & Riemeie (2006) conducted a research on cell division; Odom (1995) and Odom & Kelly (2001) on diffusion and osmosis; Balcı, Çakıroğlu, & Tekkaya (2006) and Griffard & Wandersee, (2001); Haslam & Treagust (1987) and Mikkila, (2001) on photosynthesis and respiration in plants; Doğru & Tekkaya, (2008) and Tsui & Treagust (2004) on genetics and Mauricio & Pinto (2008) on cell metabolism focusing on students understanding and misconceptions. Moreover, Caravita & Falchetti, (2005) conducted a research on skeletal system; Sungur, Tekkaya & Geban, (2001) on circulatory system; Alparslan, Tekkaya & Geban, (2003); Sanders, 1993) on respiratory system and Teixeira, (2000) on the digestive system. They found that students hold different types of misconceptions concerning these concepts in biology. Research findings on students' understanding of biology concepts showed that there were misconceptions at different grade levels and difficult to change these misconceptions by traditional teaching methods (Marek et al., 1994; Odom & Barrow, 1995; Odom & Kelly, 2001; Christianson & Fisher, 1999).

2.5.3 Identifying Misconceptions

Students' understanding of scientific concepts is key component of any school science curriculum. Science learning with conceptual understanding could not be possible with shifting only the method of instruction from teacher centered to student centered approaches but rather the assessment technique too. Therefore, the shift away from a focus on facts towards conceptual understanding requires the shift of assessment techniques from recalling of facts to conceptual understanding (Richmond, Merritt, Urban-Lurain & Parker, 2010). In order to facilitate students' understanding of scientific concepts, appropriate assessment tools have to be used by teachers (Duit & Treagust 2003). In literature, many studies have been conducted to develop different assessment tools to assess students understanding and identify students' misconceptions in science education.

In traditional classroom, teachers are unable to identify misconceptions because students are not encouraged to reflect on their thinking, assessment techniques (multiple-choice and short answer) do not allow students to express their thinking and destructors were constructed based on teachers decision rather than students thinking (Wandersee, Fisher, & Moody, 2000). The most commonly used traditional multiple-choice test items (MCQs) evaluates only content knowledge without considering the reasoning behind students' choices of responses that indicates their deep understanding of concepts. These types of multiple choice test items are unable to identify the reasons behind the answers of the students (Palmer, 1998). Therefore, identification of misconceptions requires different methodologies than those traditional assessment technique that are used in traditional classrooms such as multiple-choice, short answer and matching assessment techniques (Wandersee et al., 2000).

Different types of methodologies that have been used in science education for the identification of students' misconceptions includes: concept maps (Hazel & Prosser, 1994; Kinchin, 2000), interviews (Stewart et al., 1990), drawings (Dikmenli, 2010; Smith, 1991), open-ended questions (Atilboz, 2004), two tier diagnostic tests (Mann & Treagust, 1998; Odom & Barrow, 1995; Sesli & Kara, 2012; Treagust, 1988; Wang, 2004) and three-tier diagnostic tests (Arslan, Cigdemoglu & Moseley, 2012). Though it has some limitations, science teachers preferred to use multiple choice tests because they can be easily applied with in short period and help to assess large number of students unlike interview, concept map and open ended questions. As an improvement to traditionally used multiple choice test, two-tier and three tier multiple choice tests were developed to assess the reason behind the answer to the first choice (Arslan et al., 2012; Tan, Goh, Chia, & Treagust, 2002; Treagust, 1995).

Multiple choice test items that require students to justify their choice with reason was proposed by Tamir (1971). Treagust (1995) described this approach as two tiers multiple choice test (TTMCT) items that diagnose students' conceptual understanding and misconceptions in science education research.

The first tier involves a content response and the second tiers reasoning response. The questions also aim to identify misconceptions held by students as many of the distracters are based on such misconceptions. He described the item format of the two-tier multiple choice tests as the first tier consisting of a content question with two, three, or four choices and the second tier with four possible reasons for the first part with three of them alternative reasons and one desired reason. The second tier can also include a blank that students can write a reason for the first tier when they cannot see their reasons among the alternatives of the second tier (Griffard & Wandersee, 2001).

Since then, it has been used to assess understanding and misconceptions (Dhindsa, & Treagust, 2009). Currently, two-tier multiple choice tests become popular instruments among science educators and many researchers from different fields of science preferred to use two-tier multiple choice tests instead of traditional multiple choice test items to measure students' understanding and identify misconceptions (Chu, Treagust, & Chandrasegaran, 2009; Odom & Barrow, 1995; Wang, 2004). Two tiers multiple choice test is useful for classroom teachers to understand students understanding and identify misconceptions by administering at the beginning and at the end of specific topic (Treagust, 2006). However, students still have a chance to guess the correct answer in two tier diagnostic test that may lead to over estimation of students understanding (Pesman & Eryilmaz, 2010). To minimize this problem a three tier multiple choice test that asks students on third tier for the certainty of response has been proposed (Hasan, Bagayoko, & Kelley, 1999; Pesman & Eryilmaz, 2010).

A wide range of two-tier multiple choice instruments have been developed and used to determine students understanding of the concepts in several science disciplines. Examples of two – tiers diagnostic instruments developed since 1980's and used to investigate topics in biology include: instruments on photosynthesis and respiration (Haslam & Treagust, 1987), photosynthesis (Griffard & Wandersee, 2001), breathing and respiration (Mann and

Treagust,1998), diffusion and osmosis (Odom & Barrow,1995), internal transport in plants and human circulatory system (Wang, 2004). In addition, open ended questions and interviews are recommended by educators to assess conceptual understanding. According to Cohen and Manion (1989), interview allows assessing students' understandings and justification for answers in-depth. Similarly, this study used the two tiers multiple choice test and interview questions in order to assess students understanding and misconceptions of biology concepts.

2.6 Motivation

In any curriculum students are expected to understand scientific concepts and phenomena. In addition to the misconceptions held by students and instructional method used, learning can be affected by different factors. The two major groups of factors are cognitive factors and affective factors. Factors that are considered as cognitive include reasoning ability, information processing and academic achievement (Lawson, 2004; Lawson, Banks, & Logvin, 2006). The factors that are considered as affective include attitude, self-efficacy and motivation (Osborne, Simon & Collins, 2003; Uzuntiryaki & Capa Aydin, 2008). Affective issues are considered as catalyst to learning science for understanding to occur (Perrier & Nsengiyumva, 2003). In science education, the affective factor that has been given a great emphasis was motivation than the other factors (Osborne, et al., 2003). The term motivation has been defined in different ways from different perspectives. From psychological perspectives, according to Glynn, Brickman, Armstrong, and Taasoobshirazi (2011), motivation is defined as "an internal state that arouses, directs, and sustains students' behavior" (p. 1160). They extended this definition of motivation to learning science perspectives and defined as "internal state that arouses, directs, and sustains science-learning behavior" (p.1160).

Motivation is the internal energy that stimulates a person to keep on engagement on an activity and consist of intrinsic and extrinsic motivation, self-determination, self -efficacy, personal relevance, and anxiety (Chow & Yong, 2013; Stewart, Bachman, & Johnson, 2010). It is these components that influence students' intrinsic motivation to learn science (Koballa & Glynn, 2007).

Intrinsic motivation is mental satisfaction which is achieved by others' praise, while, extrinsic motivation is an incentive activated by external factors such as good marks and getting reward (Mahadi & Jafari, 2012). It is the eagerness and interest to do and take part in some certain activities because an individual feels that they are attractive and pleasant (Mahadi & Jafari, 2012). In comparison, intrinsic motivation is motivation of students to engage in an activity for their own sake whereas extrinsic motivation of students to engage in an activity as a means to an end (Pintrich & Schunk, 2002). Those students who are intrinsically motivated do the task because they enjoy with work whereas those students who are extrinsically motivated do the task because of the outcome such as teacher praise and reward. Research on motivation focused on extrinsic motivation like grades, praises or appreciation (Stipek, 1996) and intrinsic motivation like an innate interest, joy and pleasure that comes from within (Guay, Chanal, Ratelle, Marsh, Larose, & Boivin, 2010). Intrinsic motivation is more long lasting and sustainable as compared to extrinsic motivation (Guay, et al., 2010). It is this type of motivation that helps students to take on the accountability of acquiring knowledge in all their life (Ainley, 2004). When students are intrinsically motivated, they know the way and means how to master the content of the course in science learning and develop the skills required to learn the content (Cavallo, Rozman, Blinkenstaff, & Walker, 2003). They also tend to develop high regard for learning course information without the use of external rewards or reinforcement unlike those extrinsically motivated who depend on rewards and desirable results for their motivation (Lei, 2010). Studies indicated that students are intrinsically motivated when they are engaged in science activities (Wigfield, Eccles, & Rodriguez, 1998) like doing and discovering which in turn enhances meaningful science learning (Carin & Bass, 2001).

Generally, research findings indicted that motivation is one of the most important aspects of learning in science education (Pintrich, Marx, and Boyle, 1993; Palmer, 2003)). A research conducted by Chan and Norlizah (2017) revealed that students' motivation towards science learning has a significant correlation with students' science achievement. Moreover, Athman and Monroe (2004) and Betül Sevinç et al. (2011) indicated that there is a link between motivation and academic achievement of students in science. The more they are motivated to learn science, the more they achieve in their science learning (Glynn et al., 2009 & Betül, Haluk & Netzat, 2011). Hence, students' motivation to learn science plays a crucial role in enhancing their construction of conceptual understanding (Cavas, 2011) and achievement (Pintrich & Schunk, 2002).

According to Tuan, Chin and Shieh (2005), factors that influence students' motivation towards science learning include science learning values, self-efficacy, active learning strategies, achievement goals, and learning environment. Similarly, Williams & Williams, (2011) indicated that student, teacher, content, method/process, and environment are important components that influence student motivation to learn science.

In relation to the impact of the method of teaching used on students' motivation to learn science, different researches have been conducted so far. Research indicated that students' motivation and cognitive gain can be affected by the instructional approaches teachers use in the classroom (Mills, 1991).

Teaching methods that actively participate learners would likely lead to higher motivation and meaningful learning than those teaching methods where learners remain passive in classroom (Shihusa and Keraro, 2009). For example, the finding of the research conducted by Tuan, Chin, Tsai & Shieh (2005) revealed that students instructed with inquiry instruction were significantly motivated than those instructed with traditional teaching method. Another research conducted by Shihusa and Keraro (2009) revealed that students taught using advance organizers had a higher level of motivation than those taught using traditional teaching methods. Similarly, Tosun & Taşkesenligil, (2012) indicated that teaching students with problem based learning method had positive effect on motivation. Moreover, according to Keraro, Wachanga and Orora (2007) cooperative concept mapping teaching approach significantly enhanced secondary school students' motivation to learn. Furthermore, studies indicated that the learning cycle instruction has positive effect on students' affective aspects like motivation to learn science (Kim, 2005; Turk & Calik 2008). In the current study, the constructivist based 7E instructional model with metacognitive strategies was investigated in relation to motivation.

2.7 Gender Issues in Science Education

Science education was one of the areas in which gender difference was most strongly pronounced in the past. In the last decades, gender difference in science education investigated very well and reported that there was a gender difference (Alparslan, Tekkaya, & Geban, 2003; Cavallo et al., 2004; Young & Fraser, 1994). Studies in relation to gender were focused on psychological (motivation), societal, schooling, and achievement in science learning (Kahle & Meece, 2004; Fuselier & Jackson, 2010) and reported that there was a gender gap.

In most studies it has been reported that there was a significant difference between male and females in achievement favoring males (Lee & Burkam, 1996). A research conducted by Amedu (2015) on the topics microorganisms using jigsaw method shows that males performed significantly better than females. Similarly, Young and Fraser (1994), reported that there was a significant gender differences in biology achievement in favor of boys.

However, other studies point out female students performed better than male students (Anderman & Young, 1994; Britner, 2008; Britner & Pajares, 2006). A research conducted by Filgona and Sababa (2017) on learning with mastery learning strategy revealed that female students performed better than their male counterparts. Soyibo (1999) revealed that females performed significantly better on a test in biological labeling. Alparslan et al., (2003) also found that a significant difference between girls‟ and boys‟ performance in favor of the girls on understanding of respiration (Alparslan at al., 2003).

On the other hand, studies revealed that there was no significant difference between males and females with respect to science achievement (Cakiroglu, 2006; Hupper et al., 2002; Shaheen and Kayani, 2015; Sungur and Tekkaya, 2003; Thompson & Soyibo, 2002; Ugwu & Soyibo, 2004). For instance, Sungur and Tekkaya (2003), reported that there was no difference between males and females in achievement and attitude toward biology. Similarly, according to Shaheen and Kayani (2015), there was no significant difference in the mean scores of boys and girls with respect to students' achievement. Ugwu and Soyibo (2004) also reported no significant gender difference in performance on nutrition and plant reproduction concepts.

Similarly, concerning motivation, studies reported that there was gender differences in science education boys performing better than females (Meece, Glienke, & Burg, 2006; Jacobs & Bleeker, 2004; Shihusa and Keraro, 2009). For instance, Shihusa and Keraro (2009) found that male students had a significantly higher level of motivation than females after teaching using advance organizers. Moreover, gender difference was found in components of motivation such as, for instance, in intrinsic and extrinsic motivation, self-determination, self-efficacy, test anxiety and goal-orientations (Britner, 2008; Glynn, Taasoobshirazi, & Brickman, 2009; Britner & Pajares, 2006).

In contrast, females were significantly more motivated than males in learning science (Cavas, 2011; Chan & Norlizah, 2017). They reported that female students have higher motivation in learning science than male students.

On the other hand studies also reported that there is no difference between male students and females students in science motivation (Akbaş & Kan, 2007; Albert, 2010; Mubeen, Saeed, & Arif, 2013; Ongowo & Hungi, 2014).

Studies reported that teachers and parental influence have contributed for such gender difference in science learning (Adamuti-Trache & Andres, 2008; Jacobs & Bleeker, 2004; Jones, 1991). In addition to teachers and parental influence, the method of teaching implemented in a classroom may contribute for gender differences in science education. For instance, , active learning strategies used in classroom is one of the factors that influence students' motivation towards science learning (Tuan, Chin and Shieh, 2005). This study was designed to investigate gender issues in relation to learning biology and motivation.

2.8 Conceptual Framework

This conceptual framework shows the theoretical perspectives of the study and the relationship between independent and dependent variables while students learn human biology. The guiding theories for this study are constructivism, motivation and metacognition. The constructivist based 7E instructional model and components of regulation of cognition of metacognition were considered in this study.

As shown in the figure, the independent variables of this study were 7E instructional model (7EIM), 7E instructional model with metacognitive strategies (7EIMMS) and conventional instruction with metacognitive strategies (CIMS). Theoretical basis of 7EIM is constructivism learning theory and metacognitive strategies (MS) are from regulation of cognition in metacognition. In addition gender was considered as independent variables. The dependent variables of this study were achievement, conceptual understanding, retention of human biology concepts and motivation of students to learn biology. The effect of each independent variable on each dependent variable was investigated and the extents of their effects on the dependent variables were compared.

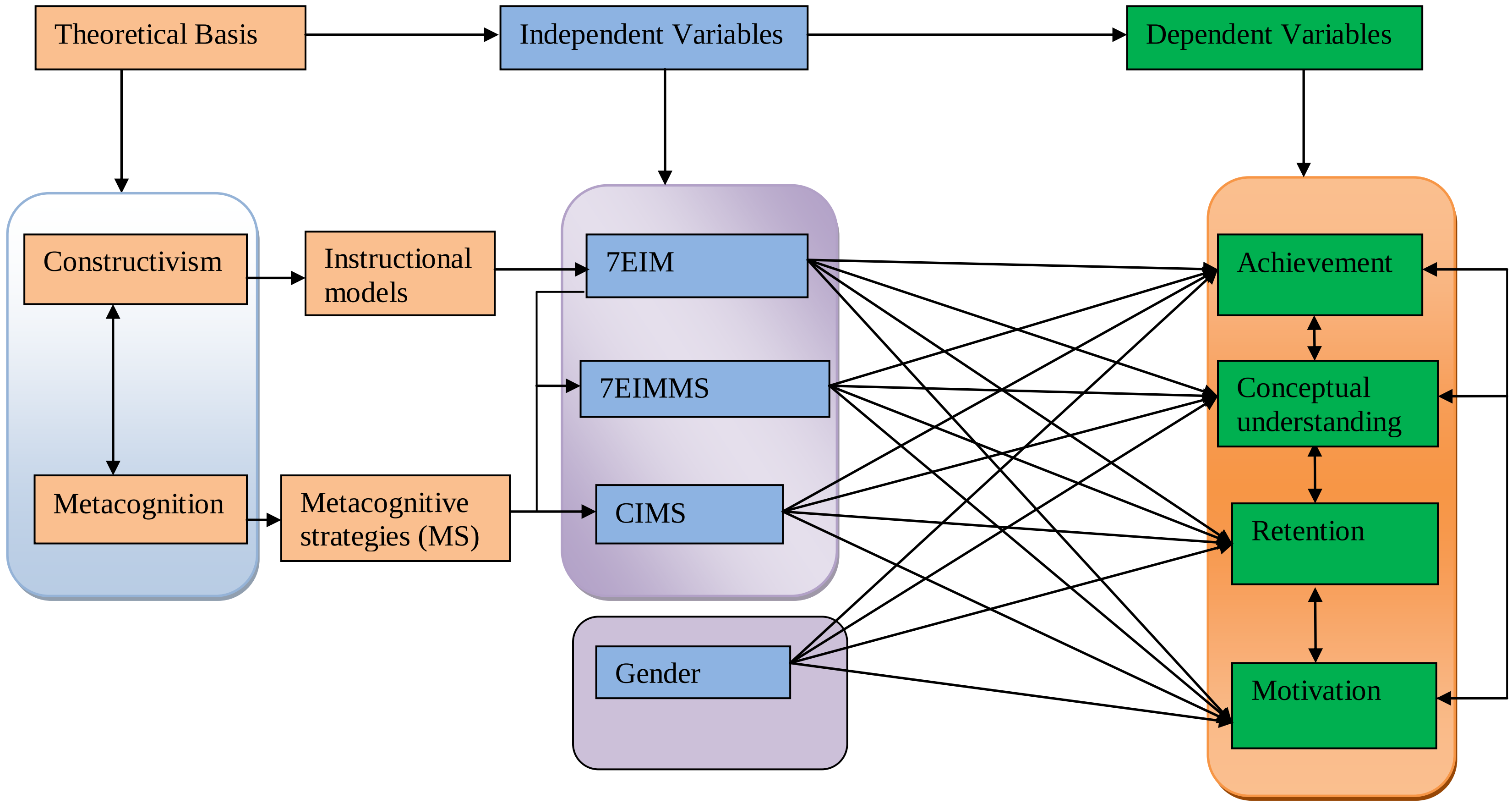

Figure 4. Conceptual Framework

Chapter Three: Research Methodology

Introduction

This section is devoted to explain the research methodology of the study. Here, the research method, research design, population and sampling technique, variables, instruments used to collect data, procedure, treatments, data analysis methods, and ethical issues are presented in some details.

3.1 Research Method

For this study, the mixed method research was used. Literature indicated that in educational research there are three types of research approaches namely quantitative, qualitative and mixed research methods. Creswell (1994) has given a very concise definition of quantitative and qualitative research. He defined quantitative research as a type of research explaining phenomena by collecting numerical data that are analyzed using mathematically based methods (in particular statistics). Qualitative research, on the other hand, is concerned with qualitative phenomenon, i.e., phenomena relating to or involving quality or kind. Qualitative approach to research generates results either in non-quantitative form or in the form which are not subjected to rigorous quantitative analysis (Kothari, 2004). Mixed methods research combine quantitative and qualitative research methods in different ways, with each approach adding something to the understanding of the phenomenon.

The underlying philosophy and world view of the mixed methods research is described as being pragmatist (Ary, Jacobs & Sorenson, 2010). Pragmatism focuses on "what works" to answer the research question and the pragmatic mixed method research is considered as the "third paradigm" or the "third wave" in research (Ary, et al., 2010). Scholars point out that mixed method research can take advantage of the combined strengths of qualitative and quantitative approaches and can use the strengths of one method to overcome the weaknesses of another (Ary, et al., 2010). It can provide stronger evidence for a conclusion through corroboration of findings (Ary, et al., 2010).

One of the purposes of this study was to investigate students' biology learning especially in terms of conceptual understanding. Assessing students' conceptual understanding through only quantitative method is not enough because they may score by chance. Therefore, in addition to measuring students' conceptual understanding through quantitative method it is useful to apply qualitative method so as to find detail information on students' in-depth understanding. In this study, the findings from qualitative data help to support or contend the findings of the quantitative data so as to have strong evidence.

For qualitative part, I mainly focus on students understanding of human biology and misconceptions. As it is known the commonly used traditional multiple choice test can assess students learning but it can't help to assess how much they understood the concepts. As a solution for this, a two tier multiple choice test has been developed in the past. But, still there is a problem with this because it is a multiple choice test in which students can select answer possibly without understanding. Therefore, supporting the quantitative data obtained from the two tiers multiple choice tests with qualitative data obtained from semi-structured interview was necessary to have strong evidence for conclusion through triangulation. Moreover, qualitative data about the actual classroom practice, students and teachers' perception towards the intervention were collected through classroom observation and interviews.

3.1 Research Design

The research design according to Ary, et al. (2010), is the researcher's plan of how to proceed to gain an understanding of some group or some phenomenon in its context. It is a logical plan for getting from here to there i.e. from initial research questions to conclusions (Yin, 2003).

For this study the concurrent embedded mixed research design was used in which the qualitative research is embedded in the quantitative research (Creswell & Plano Clark, 2011). QUAN and qual represents quantitative and qualitative data respectively.

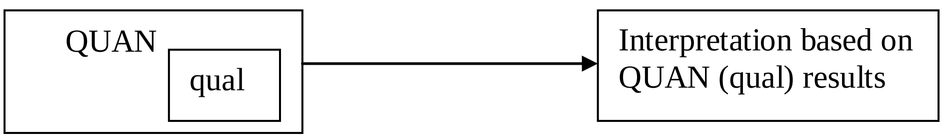

Figure 5 Embedded Mixed Research Design (adapted and modified from Creswell and Plano Clark, 2011, p. 70)

According to Creswell (2009), concurrent embedded approach has a primary method(quantitative) that guides the study and a secondary method (qualitative) that provides a supporting role in the procedures or vice versa. In short, the secondary method is embedded, or nested, within the predominant method. In this mixed research design, the researcher is able to collect the two types of data simultaneously (before, during and after) intervention and it provides a study with the advantages of both quantitative and qualitative data (Ary, et al., 2010; Creswell, 2009).

In educational research, it is difficult to conduct true experiment for the reason that variables cannot be controlled fully and randomization is not easy. As a result of this, quasi experiment emerged as an alternative in experimental research. In this study, the non equivalent pretest, multiple treatments, post test control group quasi experimental research design (Creswell, 2009; Shadish, Cook & Campbell, 2002) was used. The design has one comparison (CG) group and three experimental groups (TG) with pretest, post test and delayed post test. Accordingly, Group 1 was with treatment of 7E instructional model (X_1), Group 2 was with treatment of 7E instructional model supported with metacognitive strategies (X_2), Group 3 was conventional method with metacognitive strategies(X_3) and Group 4 was with conventional methods. Because of this, the research design for this study can be presented as follows:

Groups	Pre test	Treatment	Post test	Delayed post test
Treatment Group1(TG1)	O_1	X_1	O_2	O_3
Treatment Group2(TG2)	O_1	X_2	O_2	O_3
Treatment Group3(TG3)	O_1	X_3	O_2	O_3
Comparison Group (CG)	O_1		O_2	O_3

Similarly, for qualitative part an instrumental case study was used to provide an in-depth examination of conceptual understanding of students in support to the quantitative data (Ary, et al., 2010, Creswell, 2009). According to Creswell (2009), in the instrumental case study, the researcher focuses on an issue or concern and then selects one bounded case to illustrate this issue. In this study, the researcher focuses on conceptual understanding of human biology concepts and grade nine students learning of this topic.

The nonequivalent control group quasi experimental research design with pretest and posttest has been described as "one of the most commonly used quasi-experimental designs in educational research" (Cohen, Manion & Marrison, 2007). This is because students in schools were organized in to groups as classes at the beginning of each academic year by school administrators and was not possible to assign the students randomly into groups as in true experiment (Best & Kahn, 2006). However, the groups *are considered to share similar characteristics.* Wiseman (1999) stated that when the assignment of subjects to treatment groups is done without the application of randomization procedures, the design is described as a quasi-experimental design.

In a similar vein, Campbell and Stanley (1963) stated that when a researcher lacks the full control over the scheduling of experimental stimuli which makes a true experiment possible, collectively, such situations can be regarded as quasi-experimental designs. Nonequivalent groups specifically mean that participant characteristics may not be balanced equally among the control and experimental group and hence participants' experiences during the study may differ (Heiman, 1999). Due to this, it is preferable to use the nonequivalent control group quasi experimental research design for this study. This is because biology students in the schools were not randomly assigned to treatment due to intact sections and class schedule formed by the schools and inability to control variables fully in the schools.

Although randomization of subjects to treatment was not applicable in quasi-experiment research design because of the aforementioned reasons, schools and intact classes were randomly assigned as treatment and comparison groups. The treatment groups were instructed using 7E instructional model (7EIM) alone, 7E instructional model supported with metacognitive strategies (7EIMMS) and conventional instruction with metacognitive strategies (CIMS). The comparison group was instructed using conventional instruction (CI).

All the four groups were instructed by different biology teachers who have similar experience in teaching grade 9 biology courses. Before the beginning of the implementation of the intervention the teachers were informed about the purpose of the study and trained about 7E IM (treatment group 1), 7EIMMS (treatment group 2) and CIMS (treatment group 3). Similarly, the students in TG 2 and TG 3 were trained about metacognitive strategies.

At the beginning of the study, human biology achievement test, human biology conceptual understanding test, motivation questionnaire were administered to students in all groups as a pretest (O1) in order to check whether the groups were equal in motivation, understanding and achievement in human biology concepts. Moreover, metacognitive awareness questionnaire was administered before training to check students' awareness about metacognitive strategies.

After 10 weeks implementation period of the treatment, these instruments were administered again as posttest (O_2) and 6 weeks later, human biology achievement test and human biology conceptual understanding test were administered as a delayed post test (O_3). Furthermore, metacognitive awareness questionnaire was used to check whether the metacognitive strategies training have brought improvement on the students' awareness or not.

Besides to these tests and questionnaires, semi-structured interviews were conducted with twenty four students (eighteen of them from three treatment groups - six students from each) and six of them from comparison groups. The study was conducted over 10 weeks. There were four periods, 45-minute each per week for each group.

3.2 Population and Sampling Technique

The study was conducted in Addis Ababa, Ethiopia, on secondary education particularly on first cycle secondary schools (Grade Nine). Hence, the population of this study was grade 9 students in government secondary schools.

Secondary education is an important sub-sector of an educational system for several factors. It provides the middle level work force for the economy and other sectors. It serves as a feeder for the higher levels of education. Production of high quality professional in different fields from higher education depends on the quality of secondary education. This level of education, therefore, needs to equip learners with necessary skills and scientific knowledge that serve as a basis for higher education. Moreover, the researcher, have exposure to the problems that exist in secondary schools biology teaching because of his engagement in teaching secondary school biology, training and supervising secondary schools biology teachers.

The reason for the selection of Grade Nine is that secondary education starts from Grade Nine. As already mentioned in the statement of the problem, achievement in biology for Grade Ten is low and not that much good for Grade Twelve. So it is better to work at the start of secondary education to improve students' achievement and prepare them well for higher education. It is believed that the experience obtained from this grade will help the learners to learn better in the next consecutive grades.

Four particular schools were selected using purposive sampling for the intervention. Those schools that have relatively similar condition in terms of school facilities (laboratory with microscope, library with references materials), teachers' qualification and experience, school effectiveness (those ranked 1st - 2rd by sub-city education bureau) were selected. This is because, although in non equivalent quasi experimental research design difference between groups naturally exists, according to Cohen et al. (2007), the researcher should have to select similar groups as much as possible. The aim of having four schools is to avoid contamination of information during intervention and data collection. Then, the four schools were randomly assigned as treatment and comparison group.

From each of the four schools, one biology teacher and one section of Grade Nine students were involved. First, relatively well qualified and experienced biology teachers in teaching grade 9 biology were selected purposely for each school. Teachers involved in this study taught grade 9 biology for more than 10 years. Moreover, they are currently attending summer program for their master degree in biology. Second, among the sections that the selected teacher was teaching, one section was selected randomly from each school. The assignment of sections in to comparison and treatment group was based on the already made assignment of schools.

Based on this, the study involved 164 ninth grade students (64 boys and 100 girls) in the selected government secondary schools. The age of students range from 14 to 19 and the mean age of students was 15.51. Moreover, in order to triangulate the data, 24 students were selected using purposive sampling (based on their conceptual understanding scores) for semi structured interviews after the intervention.

The intervention covered five topics of human biology under unit three of 9th grade text book. The unit includes contents like food and nutrition, the digestive systems, respiratory systems, cellular respiration and circulatory systems. In the syllabus it is indicated that the unit needs 37 periods to be completed. Hence, the intervention took about 10 weeks in the first semester (4 periods per week, 45 minute each). The reason for the selection of this unit is that, as already mentioned in the background, contents within this unit are reported as difficult concepts for students to learn and hence, needs suitable instructional approaches to enhance students learning.

3.3 Variables

According to Leech, Barrett and Morgan (2005), variables are characteristic of the participants or situation for a given study that has different values in that study. *Variables* are the conditions or characteristics that the experimenter manipulates, controls, or observes (Best & Kahn, 2006). There are three types of variables: independent variables (active or attribute), dependent variables, and extraneous variables. The *independent* variables are the conditions or characteristic that the experimenter manipulates or controls in his or her attempt to ascertain their relationship to observed phenomena whereas the *dependent* variables are the conditions or characteristics that appear, disappear, or change as the experimenter introduces, removes, or changes independent variables(Best & Kahn, 2006). Accordingly, there were six variables in this study. These are two independent variables and four dependent variables.

3.3.1 Independent

The independent variables of this study were instructional method and gender. One of the independent variables of this study, the teaching method, has four levels which are 7EIM alone, 7EIMMS, CIMS and CI. Likewise, gender has two levels which are male and female.

3.3.2 Dependent

The dependent variables of this study were the human biology achievement, human biology conceptual understanding, retention of human biology concepts and motivation.

3.4 Data Gathering Instruments

In order to answer the research questions of this study, data were gathered using different data gathering tools. The data gathering tools of this research were human biology achievement and conceptual understanding test (prepared by the researcher), science motivation questionnaire

–II (SMQ-II) and metacognitive awareness inventory test (MAIT) (adapted from literature), semi-structured interviews and classroom observation.

The conceptual understanding and achievement tests were used three times as pre-test before intervention, post-test and delayed post test after intervention. Questionnaire were used two times as pre-test before intervention and post-test after intervention; interview was conducted once at the end; classroom observation was made throughout the intervention. The characteristics and development process of these instruments are described in detail below.

Human Biology Achievement Test (HBAT)

The human biology achievement tests were developed by the researcher. The development of the tests was based on the objectives of human biology unit stated in 9^{th} grade syllabus, questions in the biology textbooks and those in the Ethiopia general secondary education certificate examination (EGSECE) prepared for grade 10 students. Questions prepared for Ethiopia general secondary education certificate examination (EGSECE) in the years 2003 - 2008 E.C were reviewed and those questions that came from grade 9 human biology unit were considered in preparing the tests. Moreover, while preparing the multiple choice test items a table of specification was used base on Blooms taxonomy. Originally, 40 multiple choice test items were developed and after item analysis was conducted, five of them were rejected and a total of 35 multiple choice items with four distracters were prepared (appendix 1). The final 35 multiple choice test items were administered to all four groups to assess students' achievement on human biology concept before and after the intervention and 6 weeks later after the intervention was completed to assess retention of concepts.

Human Biology Conceptual Understanding Test (HBCUT)

Students' conceptual understanding about human biology concepts was measured by the use of human biology conceptual understanding test (HBCUT). HBCUT was a two tier multiple choice test. As described in literature, this two tiers multiple choice test (TTMCT) contains content response (first tier) with two to four choices and a set of four to five possible multiple choice reasoning responses and one additional blank space (second tiers) that diagnose students' conceptual understanding and help to identify misconceptions held by students in science. Some of the items (item 6, 7, 8, 9, and 10) that focus on breathing and gas exchange were used from Professor David Treagust (1998) from two-tier breathing, gas exchange and respiration diagnostic instrument with permission. The rest 13 items were prepared by the researcher. The following section describes the development process of human biology conceptual understanding test.

Development Process of HBCUT

To develop HBCUT, the two tiers multiple choice test development procedure described by Haslam and Treagust (1987) and Treagust (1988, 1995) was used. The procedure includes three phases and 10 steps in which the first phase with four steps, the second phase with 3 steps and the third phase with 3 steps. The three phases with each step are presented in table below (Table 7).

Table 7 The three phases and 10 steps.

Phases	Title	Steps	
I	Defining the Content	1	Identify propositional knowledge statements.
		2	Develop a concept map.
		3	Relate propositional knowledge to the concept map.
		4	Content validation
II	Obtaining Alternative Conceptions	5	Review literature related
		6	Conduct interview
		7	Conduct multiple choice content items with free response
III	Developing the Instrument	8	Develop two-tier items
		9	Design a specific grid.
		10	Refine test

The flowchart of human biology conceptual understanding test development process is shown bellow.

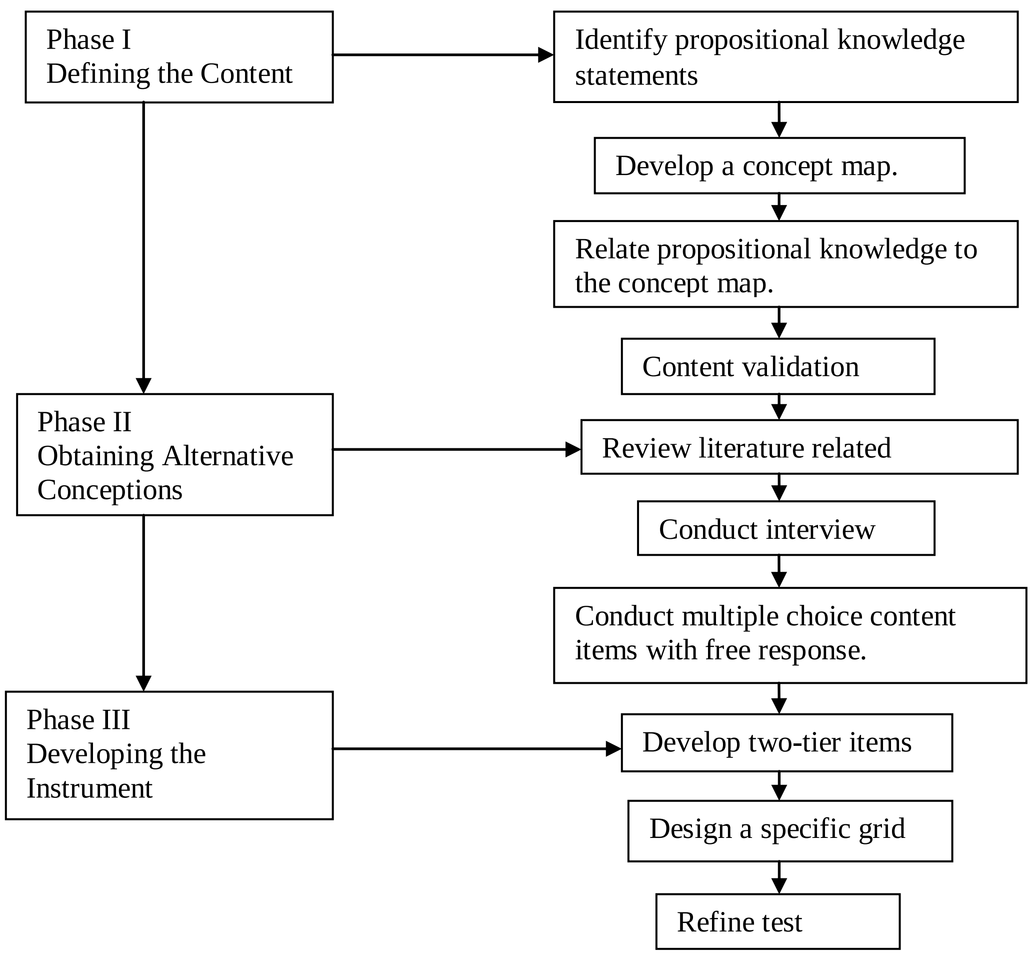

Figure 6 The Flow Chart of HBCUT Development

Phase 1: Define the Content

This phase with first four steps was used to define the margins for the students' understanding of human biology. The first step in phase I is the identification of propositional knowledge statements from the text book and syllabus by examining each sub topics in human biology unit which includes food and nutrition, digestive system, breathing system, cellular respiration and circulatory system. The objectives and core concepts of the content were identified from what is written under this unit in grade 9 text book and syllabus. The list of propositional knowledge statements were identified from human biology unit categorized under the following five target concepts. The target concepts are food and nutrition, the digestive system, the respiratory system, cellular respiration and the circulatory system. For the propositional knowledge statements identified for the target concepts, see appendix (appendix -2)

After identification of propositional knowledge statements, the second step in phase I is the development of concept map. A concept map for human biology was developed based on the content of grade 9 text book and syllabus. The contents under the unit human biology are wide. Because of this it was difficult to put all concepts in to one concept map. Hence, the researcher developed three concept maps. The first one includes the target concept of food and nutrition, the digestive system and cellular respiration (Fig. 7). The second and the third concept map were the breathing/respiratory system (Fig. 8) and circulatory system (Fig.9).

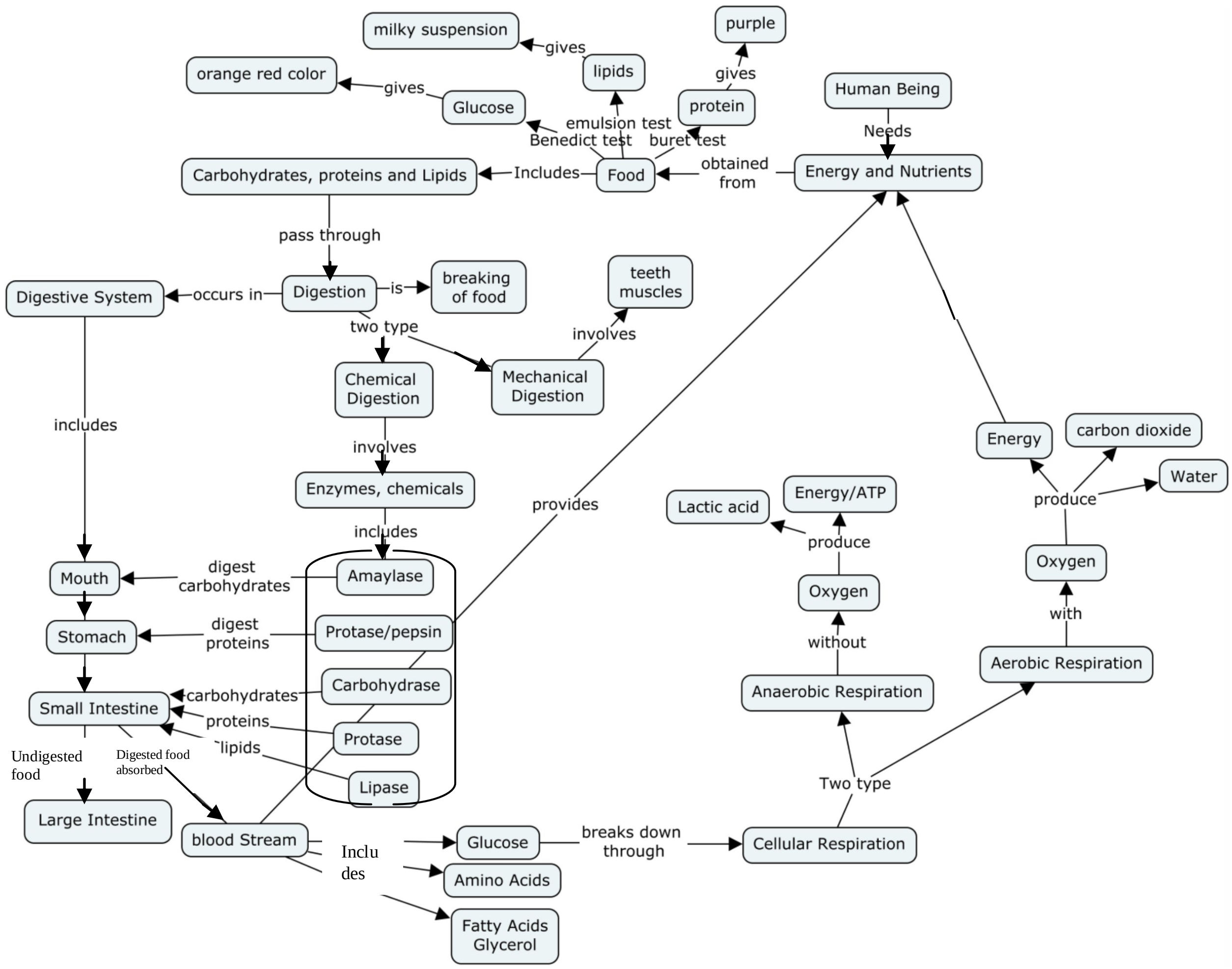

Figure 7 Concept map for food and nutrition, the digestive system and cellular respiration

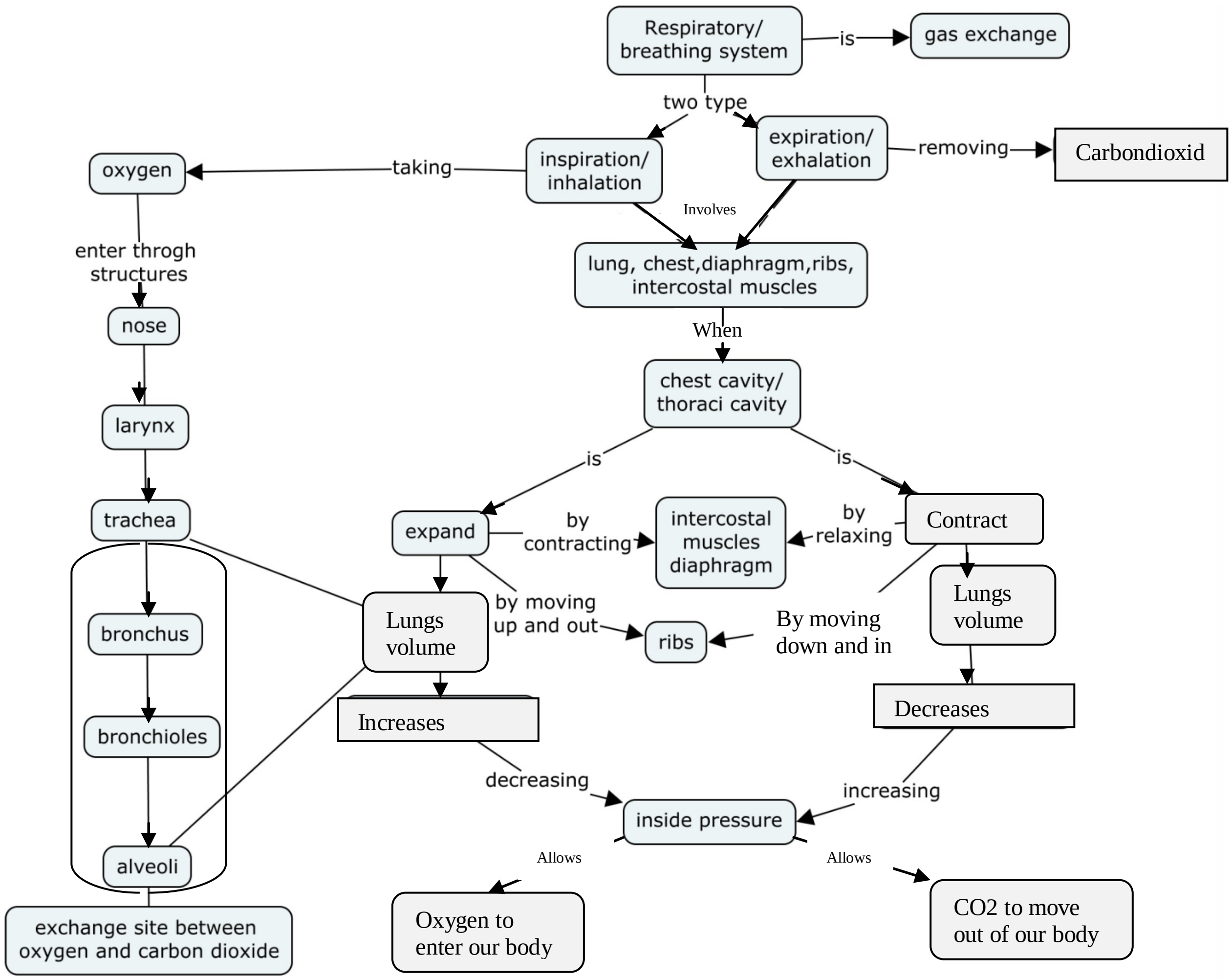

Figure 8 Concept map for respiratory system

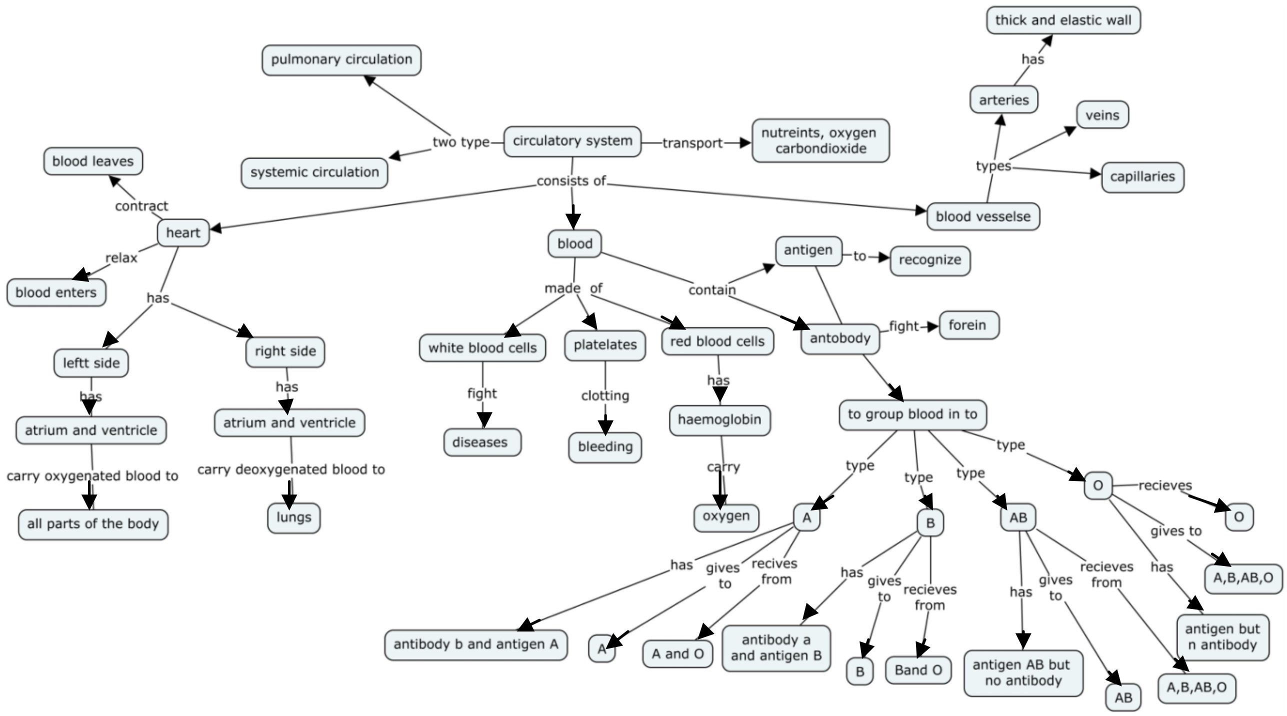

Figure 9 Concept map for circulatory system

The third step in phase I is relating the identified propositional knowledge with the concept maps developed. The fourth step is to validate the propositional statements and concept map with validity checking mechanisms. To do this, the identified propositional statements and concept maps were given to two experienced secondary school biology teachers for validation (forth step). The comments obtained from the teachers are considered to improve the propositional knowledge and the concept map.

Phase 2: Identifying Misconceptions

Phase II is to identify students misconceptions/alternative conceptions from different resources. The alternative conceptions were obtained from students' response during interview and multiple choice open ended questions and literature review.

The fifth step in phase II is to examine related literature that discuss about misconceptions. Therefore, the following literatures were consulted. Some of the literatures discussed misconceptions on cell division (Krüger et al., 2006; Lewis & Wood-Robinson, 2000). Other researchers focused on misconceptions in photosynthesis and respiration in plants (Balcı et al., 2006; Griffard & Wandersee, 2001; Haslam & Treagust, 1987; Mikkila, 2001). There are also literatures on genetics (Doğru & Tekkaya, 2008; Tsui & Treagust, 2004) and on cell metabolism (Mauricio & Pinto, 2008) focusing on students understanding and misconceptions. The findings of the studies to identify misconceptions of plant transport and human circulation (Wang, 2004), human body systems (Aydin & Balim, 2009), skeletal system (Caravita & Falchetti, 2005; Teixeira, 2000), circulatory system (Alkhawaldeh, 2007; Sungur, Tekkaya & Geban, 2001) and respiratory system (Alparslan, Tekkaya & Geban, 2003) are also among literatures that were consulted for this study.

The sixth step is about identifying misconceptions through interview. Students' misconceptions were identified using semi structured interview questions about human biology. Interviews were conducted with a total of 15 grade 9 students each interview lasting 15 to 25 minutes to examine students' understanding of human biology concepts. The interviews were audio recorded and transcribed and used to prepare list of misconceptions.

The seventh step in this phase is another way of identifying alternative conceptions through multiple choice open-ended responses for students to respond freely. Each item was followed by a blank space for the student to write the reason why they selected the content choice. So, I developed 15 multiple choices with open-ended response and administered to 45 grade 9 students. The responses obtained from open-ended response part were examined to collect misconceptions of human biology. Misconceptions identified from students' responses to each multiple choice open-ended questions and interviews and literatures were used to develop the instrument.

Phase 3: Develop the Instruments

The eighth step is about constructing the items. Based on the data obtained from phase I and II, the first version of the two tiers multiple choice test items were developed. Misconceptions collected from multiple choice tests with free responses and interviews were used to develop the two tier diagnostic instruments in relation to the propositional knowledge statements identified and concept map developed.

As described above, the final instrument of two tier multiple choice test item consisted of two parts: the first part assess the students' knowledge about the topics such as food and nutrition, digestive system breathing system, cellular respiration and circulatory system and the second part consisted of the reasons for the responses of the first part. The first tier consisted of one correct answer and one to four other alternative distracters. The second tier consisted of one accepted reason and two to four other alternative reasons with one blank space to write reasons that are not included in the alternatives distracters.

The ninth step is about developing specification gird. The purpose of developing specification gird was to make sure that the items fairly covered all propositional knowledge statements identified from the human biology unit. The following table shows the specification gird that consisted of content area and propositional statement that they refer to.

Table 8 Specification grid

Topic	Sub- topic areas	Items	Propositional statements
Human biology	Food and nutrition	2	3, 6, 8
	Digestive system	3	4, 5, 6, 7, 8, 9, 14, 15
	Breathing system	5	4, 5, 6, 7, 8, 9, 10, 11, 12, 16
	Cellular respiration	3	3, 4, 5, 6, 7
	Circulatory system	5	2, 3, 5, 6, 10, 11, 12, 13, 14, 15, 21, 24

The tenth step is about refining the instrument. After the development of items, each item was revised again based on comments from experts in biology and the students' responses about accuracy of distracter, correctness of the answers, clarity of the questions, consistency with the grade level and addressing the concepts in the topics. The final version of the two tiers multiple choice test item for assessing human biology concept consisted of 18 items (Appendix 3).

There are several studies on how to analyze two tiers multiple choice items. They analyzed differently. For instance, Chandrasegaran, Treagust, and Mocerino (2007) consider the two-tier test item as correct answer if both content and reason parts were correctly answered. According to Tarakci, Hatipoglu, Tekkaya and Ozden (1999), if students give correct answer in two tiers evaluated as complete understanding, if students give correct answers in the first tier and wrong in the second tiers evaluated as partial understanding with specific misconceptions and if students give wrong answer in both tier evaluated as complete misunderstanding of concepts. Moreover, according to Ozkan and Selcuk (2015), if students scored both tiers correct (T-T) considered as sound understanding, if first tier correct and second tier incorrect (T-F) as specific misconception, if first tier incorrect and second tier correct (F-T) as Partial understanding) and if both tiers incorrect (F-F) as No understanding. Based on Tarakci Hatipoglu, Tekkaya and Ozden (1999) and Ozkan and Selcuk (2015) classification of students understanding, the table below was used to analyze the data obtained from the HBCUT. Misconceptions are considered significant and common if it is hold at least by 10% of the total sample of students (Chandrasegaran et al., 2007; Haslam & Treagust, 1987).

Table 9 Classification of understanding of students

Combination answers		
First tier	**Second tier**	**Classification**
Correct	Correct	Sound understanding
Correct	Incorrect	Misconceptions
Incorrect	Correct	Partial understanding
Incorrect	Incorrect	No understanding

Science Motivation Questionnaire –II (SMQ-II)

Science motivation questionnaire –II (SMQ-II), developed by Glynn, et al., (2011), was used to assess students' motivation to learn biology. The item originally consists of 25 items in 5 scales such as intrinsic motivation, self determination, self efficacy, career motivation and grade motivation. Students respond to questions using the scale never (0), rarely (1), sometimes (2) often (3) and always (4) and the score ranges from 0-20 (Glynn, et al., 2011). In this study career motivation was not considered because it was felt that it is not appropriate for secondary school students. Similarly, Bryan, Glynn, Kittleson (2011), used only the first three components intrinsic motivation, self determination, self efficacy to assess secondary students' motivation to learn biology. Hence, the items for this study were 20 items (Appendix 4).

Metacognitive Awareness Inventory Test (MAIT)

Metacognitive awareness inventory test (MAIT) for regulation of cognition adapted from (Schraw & Dennison, 1994) was used to assess student's metacognitive awareness. The MAIT developed by these scholars consists of 52 items of which 17 items are for knowledge of cognition and 35 items are for regulation of cognition. Of the 35 items for regulation of cognition, the three essential skills, planning, monitoring, and evaluation, (Jacobs and Paris, 1987) consists of 20 items. These 20 MAIT items were used for this study because of the emphasis given to the three skills (appendix 5).

Semi-Structured Interviews

It is obvious that collecting data from different sources increases the credibility and validity of the results of the study (Cohen & Manion, 1989). Therefore, in addition to biology conceptual understanding test, semi-structured interviews were conducted to assess students understanding of human biology concepts and the benefit they gained from the intervention. For this purpose, 6 individuals from each group (total of 24 individuals) were selected based on their score on human biology conceptual understanding test i.e. 2 students from the top, 2 from middle and 2 from bottom of the scores. There were 10 interview questions from all sub topics in human biology unit (Appendix 6). Interview with each student lasted from 15-25 minutes and was audio recorded and transcribed.

Classroom Observations

Moreover, classroom observations were conducted to evaluate the practice of teaching learning process and proper implementation of the intervention as it was intended. For this purpose there was one classroom observation per week for ten weeks and data were collected manually. For evaluation of proper implementation of the intervention, observation check list, prepared by the researcher based on the seven phases in 7E instructional model and metacognitive strategies was used. An observation checklist consisting of 29 items with Yes, No and Partially scale was prepared by the researcher and used during observation to evaluate the extent of the implementation (Appendix 7). Before actual implementation of the intervention, the researcher conducted a classroom observation so that students become familiar with the process. Furthermore, there were a discussion with the teachers and students about the intervention and its benefit at the end.

3.4.1 Validity of Instruments

Validity can be defined as the extent to which an instrument measured what it claimed to measure (Ary, et al., 2010). Validity also indicates the degree of accuracy of study conclusions (Polit & Beck, 2004).

Of various aspects of validity, content and face validity are commonly employed. Content validity is the extent to which a measuring instrument provides adequate coverage of the topic under study (Kothari, 2004). To demonstrate this form of validity the instrument must show that it fairly and comprehensively covers the domain or items that it purports to cover (Cohen et al., 2007).

Content validity usually depends on the judgment of experts in the field (Kothari, 2004; Kimberlin and Winterstein, 2008). It can be determined by using a panel of persons who shall judge how well the measuring instrument meets the standards (Kothari, 2004). Setting up a panel of experts /users and getting them to comment on your instrument while you are developing it is a good way of doing it (Muijs, 2004). Accordingly, content and face validity of instruments were checked using experts opinions from biology education, psychology and curriculum and instruction. Data collecting instruments such as human biology achievement and conceptual understanding test were given to experts from biology. A PhD candidate in biology education and biology teachers from secondary schools reviewed the test items to check the consistency between what is in the text book (objectives, concepts) and items, clarity and mistakes in the answer key. Finally, corrections were made by considering the feedbacks and recommendations obtained from the experts.

Similarly, science motivation questionnaire (SMQ) and metacognitive awareness inventory test (MAIT) were translated to Amharic by language experts and given to experts from psychology and language for validation. The instruments were reviewed according to the comments obtained. Furthermore, according to Cohen et al. (2007), validity might be also improved through careful sampling, appropriate instrumentation and appropriate statistical treatments of the data.

The materials prepared on 7E instructional model that contain brief description on the model, each phases of the model with specific examples of biology lesson plans and metacognitive strategies, mainly on regulation of cognition (planning, monitoring and evaluation) were given to experts from related fields like curriculum and instruction, subject area (biology) and language for review and validation (face and content validity). Comments obtained from these experts incorporated to prepare the materials.

After doing all this, a pilot study was conducted for item analysis of instruments and reliability checking. The following section deals with the process of pilot testing, item analysis and reliability checking.

3.4.2 Pilot Study

To see the practicability of the models, difficulty and discrimination level of test items and reliability of instruments, pilot test were conducted at selected school in Addis Ababa.

Piloting the model

First, orientation on 7EIMMS was given to teachers and students. The orientation was given by the researcher for two consecutive periods each 45 min in school. Second, the 7EIM alone, 7EIMMS and CIMS were implemented in actual classroom for one week while teaching Grade Nine biology topic. During the pilot study data were collected though classroom observations note and discussion with participants (the teachers and some selected students). Useful feedbacks were obtained in relation to the time to implement the 7 phases with in 45 minute, use of the metacognitive strategies in addition to the instructional methods. Feedback obtained from observation and participants was considered and revision was made on methods for implementation. For instance, feedbacks on if the topic needs more investigation, extending the explore phase to the next period, relating the metacognitive strategies with the 7E phases and activities used during engage phase were obtained.

Piloting the instruments

The final versions of data collection instruments such as human biology achievement test (HBAT), human biology conceptual understanding test (HBCUT), science motivation questionnaire (SMQ) and metacognitive awareness inventory test (MAIT) were pilot tested to check reliability. The instruments were administered to 114 grade 9 students during the second semester after they studied the content. Using the results obtained from the pilot test, first item analysis for biology achievement and conceptual understanding test using parameters such as difficulty index and discrimination index were conducted. Second, internal consistency reliability of instruments was estimated using Cronbach's coefficient alpha for scales (MAIT) and (SMQ) and Kuder-Rechardson coefficient alpha for testes (achievement and conceptual understanding). The following sections describe the item analysis and reliability.

3.4.3 Item Analysis

Item analysis is an investigation of test items to determine how the items are appropriate in terms of difficulty (P) and discrimination (D). This means that checking whether items are not too difficult or too easy and how the test effectively differentiates students that scored higher and lower on tests. The test results were investigated using item difficulty and discrimination index of items.

Item difficulty index expresses how difficult the item is and the value ranges from 0.0 to 1.0 in which the higher the scores, the easy the items and the lower the scores, the difficult the items (Boopathiraj and Chellamani, 2013; Miller, Linn and Gronlund, 2009). In other word the higher the score means that high number of students selected a correct answer and the smaller the score means a small number students selected the correct answers.

According to Miller, Linn and Gronlund (2009), the recommended p-value for item difficulty ranges from 30 - 70% or 0.3 – 0.7 that means items having p-values below 0.3 and above 0.7 are considered difficult and easy items respectively.

Table 10 Difficulty index of items according to p value

p value	Interpretation
> 0.7	too easy
0.3 - 0.7	Average
< 0.3	too difficult

Item discrimination describes how well the item discriminates between low scorer and high scorer students and the D-value ranges from -1 to +1. Items having D-value closer to +1 discriminates better and items having D-value closer to 0 discriminates less. According to Ebel and Frisbie (1986), items with discrimination index values (D) range 0.20 - 0.29 needs to be checked and the items with discrimination value index values (D) below 0.20 should be discarded or reviewed in depth. The table below shows the value and interpretation.

Table 11 Discrimination power of the answers according to their D value

D	Quality	Recommendations
> 0.39	Excellent	Retain
0.30 - 0.39	Good	Possibilities for improvement
0.20 - 0.29	Mediocre	Need to check/review
0.00 - 0.20	Poor	Discard or review in depth
< -0.01	Worst	Definitely discard

Based on the above description, item difficulty and discrimination of items in the current study were analyzed as follows.

The mean difficulty level of the human biology achievement test (HBAT) was 0.34 which shows that it was average that means items are moderately difficult for students. The item difficulty of HBAT ranges from 0.15 to 0.53. Out of 40 items, most of the items were in an acceptable difficulty range, some of them revised but 5 of them (item 4, 9, 12, 28 and 37) appeared to be very difficult items to students and hence dropped.

The mean discrimination index of the human biology achievement test (HBAT) was .34 which shows that it was good test for students. The discrimination index of HBAT ranges from 0.0 to 0.58. Out of 40 items, 35 of the items discriminated fairly well between high and low achiever students but 7 of them appeared to be poor items in discriminating the students because they have low discrimination index , i.e. < 0.2. Two of the items were reviewed and 5 of them, items 4, 9, 12, 28 and 37 were dropped.

Table 12 Item difficulty (P) and discrimination index (D) for Human biology achievement test

Test item type	Difficulty indices (p)	No. of items	Discrimination indices (D	No. of items
HBAT	(0.4 < p < 0.6)	8	(0.4 < D < 0.6)	13
	(0.3 < p < 0.4)	15	(0.3 < D < 0.4)	9
	(0.2 < P < 0.3)	12	(0.2 < D < 0.3)	11
	(P< 0.2)	5	(D < 0.2)	7
	Mean = 0.34	Total = 40	Mean = 0.34	Total = 40

Therefore, the final version of HBAT which consisted of 35 items (appendix 1) was administered to all treatment and comparison groups as a pre-test, post-test and delayed post test.

Similarly, in the human biology conceptual understanding test (HBCUT), the mean difficulty level was .40 which shows that it was average that means items are moderately difficult students. The item difficulty of HBCUT ranges from 0.29 to 0.52. Out of 20 items, 19 of the items were in an acceptable difficulty range but 1 of them (item 2) appeared to be very difficult items to students and hence dropped.

The mean discrimination index of the human biology conceptual understanding test (HBCUT) was .49 which shows that it was excellent test for students. The discrimination index of HBCUT ranges from 0.03 to 0.75. Out of 20 items, 17 of them discriminated fairly well between high and low achiever students but 3 of them were average items in discriminating the students because they have low discrimination index < 0.3. One of the items were reviewed and 2 of them (item 2 and 4) were dropped.

Table 13 Item Difficulty (P) and Discrimination Indexes (D) of HBCUT

Test item type	Difficulty indices (p)	No. of items	Discrimination indices (D	No. of items
HBCUT	(0.5 < p < 0.6)	3	(0.6 < D < 0.8)	6
	(0.4 < p < 0.5)	5	(0.4 < D < 0.6)	6
	(0.3< P < 0.4)	11	(0.3 < D < 0.4)	5
	(p<0.3)	1	(D < 0.3)	3
	Mean = 0.40	Total = 20	Mean = 0.49	Total = 20

Therefore, the final version of HBCUT consisted of 18 items (appendix 3) and was administered to all treatment and comparison groups as a pre-test, post-test and delayed post test.

3.4.4 Reliability of Instruments

According to Leech, et al. (2005), reliability is used to indicate the extent to which the different items, measures, or assessments are consistent with one another and the extent to which each measure is free from measurement error. Reliability indicates how consistently a test measures whatever it does measure (Ary, et al., 2010).

Reliability estimates are used to evaluate (1) the stability of measures administered at different times to the same individuals or using the same standard (test–retest reliability) or (2) the equivalence of sets of items/instruments from the same test (internal consistency) or of different observers scoring a behavior or event using the same instrument (inter-rater reliability) (Kimberlin and Winterstein, 2008).

One of the commonly used ways of calculating internal consistency reliability is *coefficient alpha* (Muijs, 2004). The most widely used method for estimating internal consistency reliability are Cronbach’s coefficient alpha for scales and Kuder-Rechardson coefficient alpha for testes (Ary, et al., 2010). Hence, for this study, I used Cronbach’s coefficient alpha for scales (MAIT) and (SMQ) and Kuder-Rechardson coefficient alpha for testes (achievement and conceptual understanding) as checking mechanism of reliability of instruments after pilot testing.

During calculation of HBAT scores, correct responses were coded as 1 and incorrect responses were coded as 0, hence, the maximum score was 35 and the minimum was 0. Similarly, to calculate HBCUT scores, correct responses for both tiers (first and second tier) were coded as 1 and incorrect responses in any one of the two tiers were coded as 0, hence, the maximum score was 18 and the minimum was 0.

Reliability of HBAT and HBCUT tests were investigated by calculating an internal consistency measure of Kuder-Richardson 20. The reliability coefficient of HBAT and HBCUT was found to be 0.73, and 0.70, respectively. Similarly, reliability coefficient of science motivation questionnaire (SMQ) and metacognitive awareness questionnaire (MAIT) was calculated by SPSS program to get Cronbach's coefficient alpha. It was found to be 0.82 and 0.83 respectively. The values of all instruments are within acceptable ranges. Therefore, the test items were considered as reliable and valid instrument to be conducted in the current study. The following table presents Cronbach's coefficient alpha value and KR-20 Values of HBAT HBCUT

Table 14 Cronbach alpha and Kuder Richardson reliability coefficient value of instruments

Instrument type	N of items	Cronbach alpha	Kuder Richardson-20 (KR-20)
HBAT	35		0.73
HBCUT	18		0.70
SMQ	24	0.82	
MST	20	0.83	

After instruments passed all these process and necessary revisions made, the final forms of the tests and questionnaires were administered as pretest, post test and delayed post test to determine their achievement, conceptual understanding, retention of human biology concepts, motivation and metacognitive awareness before and after intervention.

3.4.5 Intervention Procedure

First, four schools, four teachers and four sections (one teacher and one section from each school), were selected and assigned as treatment and comparison group randomly. In this study there were three treatment groups and one comparison group. One of the sections in the selected schools was assigned with 7EIM and the second section was assigned with 7EIMMS, and the third section was assigned with CIMS randomly. These were considered as experimental groups in three schools. The forth section in the remaining school which was considered as comparison group was assigned with CI.

Second, training was conducted for teachers and students in treatment groups. At the beginning of the intervention, I gave brief information about the purpose of the study, the ways of the implementation of the intervention, the activities to be carried out during the intervention, and the time schedule. The training on 7EIM was given to the teacher from the treatment group which was assigned with 7EIM. Similarly, training on 7EIMMS strategies were given to the teacher from the second treatment group which was assigned with 7EIMMS. Then, training on MS was given to students from the second and third treatment groups which were assigned with 7EIMMS and CIMS. The training was given by the researcher and lasted for 6 days, 45 minute per day. The first day, two 45 minutes, was for explanation on the materials and the rest days were for practice in actual classroom.

The training consisted of brief description of the 7EIM, its developments and each phase within the model. The training also consisted on how teachers can prepare a daily lesson plan using the model with practical examples.

The other part of the training was about MS. Before the start of the training, a metacognitive awareness inventory test on regulation of cognition was administered as a diagnostic assessment. The training in this case was focused on what metacognition is, how we can use MS of planning, monitoring and evaluation during teaching and learning. The purpose of this training was to support or scaffold students to develop metacognitive skills so as to become self directed and independent learners. At the beginning of the training I provided training manuals for participants and described the aim of the study and the training and provided a general presentation about metacognition and MS. Definition of metacognition, regulation of cognitions, planning, monitoring and evaluation were presented and discussed with the participants. The discussion on planning was focused on setting goals, activating their prior knowledge, selecting a strategy (e.g. concept map, taking notes, self questioning, discussing with others, practicing things over and over), allocating time and resources before starting the work. Similarly the discussion on monitoring was focused on how students get aware of the process of learning and tasks. It focused on questions like ‘how am I doing?’; ‘Do I understand what I am learning?’; ‘Am I in the right direction for achieving the task objective?’ These can be used both during learning, studying and doing activities in classroom as well as outside classroom. The discussion on evaluation was focused on making careful judgments about the effectiveness of their learning which includes checking whether they achieved their goal or not and their own strengths and weakness while learning and doing activities.

During training KWHAL chart and Regulatory check list were used for making the training practical. KWHAL refers to: **K** = What do I **k**now? **W** = **W**hat do I want to know? **H** = **H**ow will I know it? **A** = **A**m I learning well/on the right tack/achieving my goal? **L** = What have I **L**earnt?. Self Regulatory checklist were also used which help to check whether they are on track or not (see the detail description under literature review).

These two materials were given to all students in the treatment group, taped on their desk, wall and exercise book. Students were given a topic to practice planning, monitoring and evaluation using the KWHAL chart. Finally, students were given some assignments to do on metacognitive strategies of planning, monitoring and evaluation using KWHAL chart and bring back the next session so as to practice before the intervention. The following table shows KWHAL chart and self regulatory check list used during training and intervention as well.

KWHAL – "Thinking about my Thinking" Student Worksheet

Name: ____________________ Date: ___________________Topic/lesson: _____________________

Planning			**Monitoring**	**Evaluation**
What do I **know**?	What do I **Want** to learn?	**How** will I learn it?	**A**m I learning?	What have I **Learnt**?

Figure 10 KWHAL Chart

Table 15 Some of the self-regulatory check list

Planning	Monitoring	Evaluation
What is my goal? What kind of information and strategies do I need? How much time and resources do I need?	Do I have a clear understanding of what I am doing? Does the task make sense to me? Am I reaching my goals?	Have I reached my goal? What worked? What didn't work? Would I do things differently the next time?

Third, pretest about the content (human biology achievement test and human biology conceptual understanding test) and science motivation questionnaire were given to the four sections taught by the four teachers.

After completing these activities, implementation of intervention was started. During the intervention, normal class schedule were used in the school because most of the schools did not want alteration of their normal school timetables. The following is an example of how the intervention was implemented in one of the treatment group which was assigned with 7EIMMS using the topic inhalation and exhalation in human biology unit.

The 7EIM was used while designing the lesson plans on human biology unit taking MS in to consideration. The lesson plan was prepared based on the phases of the 7E instructional model which are elicit, engage, explore, explain, elaborate, evaluate and extend (appendix 8).

In the first phase, students were asked questions to elicit their prior knowledge. The teacher used metacognitive prompts like 'why did you come today to this class/session?'; 'What is your goal/objective?'; 'What do you know about this topic?' This is to remind students about using MS while learning in classroom. The KWHAL chart was given to students ahead of the section to come with their own plan. The teacher reminded the students to use the first, second and third column of the KWHAL chart and first column of self regulatory check list as part of planning in MS. Then, the instruction was started with brainstorming students' prior knowledge about how air moves in to and out of our body and what happens to the structure of respiratory system like a lung, intercostals muscles and diaphragm while we breathe in and out, the composition of inhaled and exhaled air and the importance of breathing for humans. For that purpose the teacher asked the students to discuss what they know about these inquiry questions.

During the second step, engagement phase, the teacher showed a model of the breathing system made by one of the groups from locally available materials such as plastic bottle, balloon, pen and hollow stick and ordered the students in each group to see what they came with. This helped the teacher to get the attention of the students.

During the third step, explore phase, students referred the brief note written on their text book, read about the movement of the air in to and out of the lung, the volume of the lung, pressure in the lung, the shape of the diaphragm, the movement of the ribs and place where gas exchange occurs in lung and discussed in a group. For this purpose, the teacher formed a group and informed about what they are going to do with the model while reading and discussing. Then they investigated how the air moves in to the lung and out of the lung by blowing air in to the model and opening the pore to release the air out of the balloon so as to observe what happens to the volume of the lung, the shape of diaphragm. They compared this phenomenon by breathing in and out by themselves. The teacher used metacognitive prompts like Do you understand what you are doing? Are you on the right track in reaching your goal stated earlier? This is to remind students about using MS while learning in classroom especially in relation of monitoring their learning process. The teacher kept reminding students to refer to column 4 of KWHAL and second column of self regulatory check list. These prompts were used until phase five. The teacher served as a facilitator and guidance while students are exploring about the days lesson.

During the fourth step, explanation phase, the teacher asked the group representatives of each group to explain about the model in relation to breathing in and out and encouraged students to explain in detail and other members of the group to add their own opinion. The role of the teacher was to facilitate the learning process by observing and listening to students' presentation and corrected and added his own idea to make concepts clear and make students to understand the concepts. Teacher answered and clarified the questions asked in the previous phases and connected explanations with students daily life.

During the fifth step, elaboration phase, teacher provided students an activity for further investigations to elaborate the concepts gained during the previous phases. For this purpose the teacher gave an activity for students to explore about the volume of the air that we can take in and out each time at normal condition and the difference between tidal volume and vital capacity.

During the six step, evaluation phase, the teacher encouraged students to assess their understandings of concepts from previous phases. To do this, the teacher asked three questions in classroom and provided two questions as homework for students. The teacher checked their answers and then gave feedback for them. The teacher used metacognitive prompts like 'did you understand what you learn?'; 'What does work?'; 'What does not work?' This is to remind students about using MS while learning in classroom especially in relation to evaluation. He reminded the students to refer column5 of KWHAL chart and the third column of self regulatory check list.

During seventh step, extension phase, students were involved in different activities in order to practice the transfer of their learning in new situation. To this end, the teacher provided an activity to explore about the use of inhaled air in our body and exhaled air in the environment. This one helps students to transfer their learning in to energy production (cellular respiration) in our body and photosynthesis in plants. Finally, he told the topic for the next section and to come with their own first, second and third column filled KWHAL chart.

The group assigned with 7EIM alone, TG 1, followed the same procedure with TG 2 except they did not get training and didn't use MS. The treatment group assigned with CIMS used the method that the teachers always used in actual classroom but the teacher and students trained to use MS. In comparison group the teacher used the method of teaching that he always used while teaching biology.

While implementing the intervention, the researcher conducted a meeting with teachers at the beginning of each week to discuss on how to prepare the lesson plan and how to implement the activities of the intervention in the treatment groups to minimize variation in practice. At the end of the interventions post test (HBAT, HBCUT, SMQ and MAIT) were administered for all students in the four groups. After six weeks delayed post test (HBAT and HBCUT) were administered for all groups. Moreover, classroom observation during implementation of the intervention and interview after intervention were conducted. The following table summarizes the intervention.

Table 16 summary of intervention procedure

To	Group	Pre test	Training	Trainees	Intervention/Treatment	Post test	Delayed post test
Human biology	Comparison group	Yes	No	No	No	Yes	Yes
	Treatment Group 1	Yes	Yes (7EIM)	Teacher	7E IM(X_1)	Yes	Yes
	Treatment Group 2	Yes	Yes(7EIMMS)	Teacher and Students	7EIMMS (X_2)	Yes	Yes
	Treatment group 3	Yes	Yes (MS)	Teacher and Students	MS(X_3)	Yes	Yes

3.4.6 Analysis Methods

Data collected from such different sources were analyzed quantitatively using appropriate statistical data analysis methods and qualitatively. In analyzing the data Statistical Package for Social Sciences (SPSS) version 20 software was used. Since, the data were normally distributed parametric test - multivariate analysis of variance (MANOVA), ANOVA, independent t-test and pearson correlation were used. Concerning the qualitative data obtained from semi-structured interviews transcription and categorization under themes were made. Students' responses to interview questions were compared among the four groups. Similarly, data obtained from conceptual understanding test were also categorized, analyzed and compared among the four groups in relation to sound understanding, partial understanding and misconceptions.

3.4.7 Ethical Issue

This study did not intend to cause any possible harm to the participants (neither teachers nor students**).** Therefore, in relation to ethical issues, at first the proposal was approved by the Department of Science and Mathematics Education. Then, having official letter from the

Department, permission was asked from Addis Ababa city Education Bureau and Sub-city education office by explaining the objective of the study which is purely academic (appendix 9). After taking the permission, the researcher requested the acceptance of the school administration by explaining the aim of the study. After this, the participants were informed on the rationale for the study and were guaranteed that any data collected from or about the participants held is confidential and the names of participants will never be used in any publication. Students were not asked to write their name rather a code was used. The study was also conducted based on the consent of the school director, teachers and students. For this purpose, a consent letter was prepared and signed by all participants (appendix 9). The study was conducted in their regular school environment and neither the activities nor the instruments covered a potential danger for the students.

Moreover, the teachers were informed about the purpose of observing their lessons. Generally, teachers were informed that the aim of this study is not to investigate their knowledge rather it is to provide evidence as to whether the implementation of the intervention was carried out as planned.

Furthermore, honesty, confidentiality, anonymity were taken in to consideration while conducting research. There were regular reports about the process of the research to advisers, files on the computer were protected with password and documents will be locked in a locker. Access of information was only with the advisors and personally identifiable information will be protected. Access of information was only with the advisors and personally identifiable information was protected.

Chapter 4: Result and Discussion

Introduction

This chapter presents the results, data analysis and discussions. The main purpose of this study was to investigate the effects of 7E instructional model with metacognitive scaffolding on students learning biology and motivation. Therefore, the chapter first presents the results of both quantitative and qualitative data analysis and second discussions of the findings on students' human biology achievement, conceptual understanding, retention of concepts, misconceptions and motivation across groups and gender in relation to related literatures.

4.1 Results

In this section, the results of data analysis are presented. The quantitative data were analyzed statistically using SPSS version 20 software and the qualitative data were manually transcribed, coded and categorized in to themes. The statistical analysis of quantitative data included checking the assumptions for selected statistical analysis techniques and pretest, posttest and delayed posttest scores analysis using one way analysis of variance (ANOVA) and multivariate analysis of variance (MANOVA). The pretest and post test scores were human biology achievement test (HBAT), human biology conceptual understanding test (HBCUT) and science motivation questionnaire (SMQ) whereas the delayed post test scores were HBAT and HBCUT. Moreover, metacognitive awareness inventory test was also analyzed under this section. The analysis results are presented, described and interpreted as shown below.

4.1.1 Results of Pretest Scores Analysis

In this study, there were four groups: TG 1, TG 2, TG 3 and CG. A week before the implementation of the intervention, a MAIT was administered to all groups to see their status of metacognitive awareness. Then, training was given to TG 2 and TG 3 on MS of planning, monitoring and evaluation. After assumptions for normality was checked One Way ANOVA was run to check their status of metacognitive awareness.

The descriptive statistics result (Table 17) revealed that the mean scores of Pre-MAIT for TG 1, TG 2, TG 3 and CG were slightly different. The descriptive statistics of Pre-MAIT tests scores of the groups were summarized in table below.

Table 17 The descriptive statistics of pre-MAIT scores of the groups

Variables	**Groups**											
	Treatment Group 1			**Treatment group 2**			**Treatment group 3**			**Comparison group**		
	N	M	SD	N	M	SD	N	M	SD	N	M	SD
Pre-MAIT	41	3.73	.52	38	3.77	.44	43	3.75	.49	41	3.78	.49

After the analysis of the descriptive statistics, one way ANOVA was conducted to check whether there is significant difference between groups on their Pre-MAIT tests. Result from one way ANOVA revealed that there was no significant mean difference between the groups in Pre-MAIT F (3, 163) = .08, p = .97), for the groups (Table 18). In summary, there is no statistically significant difference among groups in metacognitive awareness before the training. So, the groups were assumed to be the same with their metacognitive awareness of planning, monitoring and evaluation. Below is the ANOVA result of pre-MAIT scores.

Table 18 ANOVA result comparing groups in terms of pre- MAIT scores

Variable		**Sum of Squares**	**Df**	**Mean Square**	**F**	***p***
Pre- MAIT	Between Groups	.06	3	.02	.08	.97
	Within Groups	37.57	160	.24		
	Total	37.63	163			

After completing the training on metacognitive strategies for TG 2 and TG 3 and before the implementation of the intervention begins, HBAT, HBCUT and SMQ were administered to all groups as a pretest. The purpose of administering the pretests were to compare whether or not students in three treatment groups and comparison group were different from each other in their knowledge, understanding on concepts in human biology and motivation before the implementation the intervention.

Therefore, ANOVA were executed to see whether there was a significant mean difference between them in biology achievement, conceptual understanding and motivation. Before performing the analysis of pre-test scores, assumptions of ANOVA such as normality and homogeneity of variance were checked. For normally distributed scores, the skewness and kurtosis values were described by different scholars. According to George & Mallery, (2003) the skewness and kurtosis value should be within the range of -2 and +2 to be normally distributed. The following table (Table 19) shows the skewness and kurtosis of the pretest data and it was in an acceptable range in both cases. This means the data were approximately normally distributed. The other assumptions of ANOVA, the homogeneity of variance, was checked from the Levene test which was not significant for all dependent variables, pre- human biology achievement test (Pre- HBAT), pre -human biology conceptual understanding test (Pre- HBCUT) and pre-science motivation questionnaire (Pre- SMQ) (Table 19). This means that the variance of scores on each variable for the population of the groups is equal. So, the assumptions for ANOVA were not violated.

Table 19 Skewness, kurtosis and Levene test of homogeneity of variances

				Levene Test of Homogeneity of Variances	
Dependent variables	**N**	**Skewness**	**Kurtosis**	***F***	***P***
Pre- HBAT	164	-.01	-.74	1.98	.12
Pre- HBCUT	164	.29	-.22	2.48	.06
Pre- SMQ	164	-.45	.13	1.99	.12

After checking the assumption for ANOVA, descriptive statistics of the pre test scores were determined whose results of pre-HBAT, pre-HBCUT and pre-SMQ tests scores of the groups were summarized below (Table 20). The descriptive statistics result revealed that the mean score of pre-HBAT, pre-HBCUT and pre-SMQ for TG 2 were higher than the other groups and lower for TG1 and TG3 respectively.

Table 20 The descriptive statistics of pre-HBAT, pre-HBCUT and pre-SMQ tests scores of the groups

Variables	**Groups**											
	Treatment Group 1			**Treatment group 2**			**Treatment group 3**			**Comparison group**		
	N	M	SD	N	M	SD	N	M	SD	N	M	SD
Pre-HBAT	41	23.90	10.55	38	26.31	9.30	43	25.25	9.49	42	26.19	8.01
Pre-HBCUT	41	12.47	7.74	38	13.16	5.39	43	10.34	5.63	42	10.72	6.18
Pre-SMQ	41	2.82	.41	38	2.86	.50	43	2.64	.58	42	2.71	.51

After performing descriptive statistics, ANOVA was conducted to check whether there is statistically significant difference between groups on their pre-HBAT, pre-HBCUT and pre-SMQ tests. Result from the ANOVA analysis (Table 21) revealed that there was no statistically significant mean difference between the groups in pre-HBAT $F(3, 163) = .57$, $p = .63$), pre-HBCUT $F(3, 163) = 1.88$, $p = .14$) and pre-SMQ tests $F(3, 163) = 1.64$, $p = .18$). This means that the groups were assumed to be the same in their achievement, understanding and motivation before the implementation of the intervention. So, the change observed after intervention could not be attributed to treatment groups difference before the implementation of the intervention. The ANOVA result is shown in the table below (Table 21).

Table 21 ANOVA result comparing groups in terms of pre-HBAT, pre-HBCUT and pre-SMQ scores

Variables		**Sum of Squares**	**Df**	**Mean Square**	**F**	***p***
Pre-HBAT	Between Groups	150.88	3	50.29	.57	.63
	Within Groups	14069.16	160	87.93		
	Total	14220.04	163			
Pre-HBCUT	Between Groups	224.51	3	74.84	1.88	.14
	Within Groups	6367.71	160	39.80		
	Total	6592.22	163			
Pre-SMQ	Between Groups	1.27	3	.42	1.64	.18
	Within Groups	41.21	160	.258		
	Total	42.48	163			

After completing the implementation of the intervention data were collected through post - HBAT, post- HBCUT, post -SMQ and delayed post- HBAT and delayed post- HBCUT. Before the statistical analysis of these data was made, assumptions for statistical analysis techniques were checked. The following sections deals with assumptions for statistical analysis techniques.

4.1.2 Evaluation of Assumptions

For different statistical analysis techniques, there are different statistical assumptions that need to be fulfilled. For the analysis of the assumptions, the data measured through post-HBAT, post- HBCUT, post- SMQ and delayed post- HBAT and delayed post- HBCUT in relation to groups and gender were considered. Therefore, for analysis of these data, multivariate analysis of variance (MANOVA) was used because of the presence of more than two dependent variables. Hence, under this section, assumptions of MANOVA for these variables were checked. Assumptions of MANOVA include sample size and independence of observation, normality, outliers, linearity, homogeneity of variance-covariance matrices, and multicollinearity and singularity assumptions.

Sample size and independence of observation

For this study, the sample size was enough to conduct the analysis for each variable and students completed the post test and delayed post test individually to assure independence of observation assumption. So, the assumptions were not violated.

Normality

The other assumption is that the data should be normally distributed to run a MANOVA. The normal distribution of the data can be checked by looking at skewness and kurtosis value. If the skewness and kurtosis values are around zero, the data are expected to be normally distributed. As stated above, according to George & Mallery (2003) the skewness and kurtosis value should be within the range of -2 and +2 for a data to be normally or approximately normally distributed. In this study, as presented in the table below (Table 22), the skewness and kurtosis values were between -1.5 and +1.5. Therefore, the data were approximately normally distributed and hence normality assumption was not violated to run parametric test.

Table 22 Skewness and kurtosis

Variables	N	Skewness	Kurtosis
Post-HBAT	164	.63	.14
Post-HBCUT	164	.46	.44
Post-SMQ	164	-.79	1.10
Del-Post-HBAT	164	.92	1.38
Del-Post-HBCUT	164	.28	-.61

Outliers

Another assumption was that there should be no outliers in the data to run MANOVA. Outliers were checked by examining Mahalanobis distances as described by Pallant (2007, 2005). He reported the critical value for three and two dependent variables to be 16.27 and 13.82

respectively. For this study, the three post testes (HBAT, HBCUT and SMQ) and the two delayed Post testes (del-HBAT and HBCUT) were taken as three and two dependent variables respectively. Therefore, the Mahalanobis distance for post test data of this study was 15.94. This is nearly below the critical value for three dependent variables which is 16.27. So, there was no outlier for post test data. Whereas, the Mahalanobis distances for delayed post test data of this study was 14.95 (Table 23). This is slightly higher than the critical value for two dependent variables which is 13.82 but only one scores exceed the critical value and are not too high as it was seen from Extreme Values box. Therefore, there was no need to remove any outlier value from the data. So, the assumption of outlier was not violated. The table below shows the Mahalanobis distance values of post test and delayed post test scores.

Table 23 Mahalanobis distances for post test and delayed post scores

Variables		**N**	**Min**	**Max**	**Mean**	**SD**
Post tests	Mahal. Distance	164	.08	15.94	2.98	2.48
Delayed Post tests	Mahal. Distance	164	.03	14.95	1.99	2.17

Linearity

The linearity assumption was checked by producing scatter plots between each pair of the dependent variables for each group. This study consisted of two groups. The first group is with three treatment group and comparison group and the second group is gender with male and female. There are four dependent variables (achievement, understanding and motivation) measured through post test and (retention of concepts) measured through delayed post tests. Therefore, scatter plots were generated for each pair of the dependent variables and revealed that there was no violation of this assumption.

Homogeneity of Variance-Covariance Matrices

In order to check the Homogeneity of variance-covariance matrices, Box‘s Test of Equality of Covariance Matrices was generated. From Table 24, it can be seen that there was no violation of homogeneity of variance-covariance matrices with Box‘s M significant values of post test and delayed post test $p > 0.001$ (Pallant, 2005). The table below shows the Box‘s Test of Equality of Covariance Matrices.

Table 24 Box's Test of Equality of Covariance Matrices of post test and delayed post test

Variables	Box's Test of Equality of Covariance Matrices[a]				
	Box's M	**F**	**df1**	**df2**	**Sig.**
Post test	56.79	1.26	42	28911.56	.12
Delayed Post test	36.20	1.65	21	55589.07	.03

Moreover, Levene‘s Test was also investigated to examine the homogeneity of variances between groups. As Table 25 shows, there was no violation of homogeneity of variance assumption for all variables $p > 0.05$. The table below shows the Levene test for the variables.

Table 25 Levene's Test of Equality of Error Variances of post test and delayed post test

Variables	Levene's Test of Equality of Error Variances[a]			
	F	**df1**	**df2**	***P***
Post-HBAT	1.37	7	156	.22
Post-HBCUT	.47	7	156	.86
Post-SMQ	1.19	7	156	.31
Del-Post-HBAT	2.11	7	156	.05
Del-Post-HBCUT	1.96	7	156	.06

Multicollinearity and Singularity

According to Pallant (2005) MANOVA works best when the dependent variables are moderately correlated. To check this assumptions correlation were computed for all dependent variables, Post-HBAT, Post-HBCUT, Post-SMQ dependent variables, and there was no a strong relationship between them (r < .8) (Pallant, 2001). Similarly, there was no strong correlation among delayed post- HBAT and delayed post-HBCUT dependent variables. Therefore, there were no violations of assumptions to conduct MANOVA.

Table 26 Pearson of correlation dependent variables

	Post-HBAT	Post-HBCUT	Post-SMQ	Del-post-HBAT	Del-post-HBCUT
Post-HBAT	1				
Post-HBCUT	.45**	1			
Post-SMQ	.32**	.32**	1		
Del-post-HBAT	-	-	-	1	
Del-post-HBCUT	-	-	-	.56**	1

In summary there was no violation of assumptions to run multivariate analysis of variance (MANOVA). Hence, MANOVA was run and the results for post test and delayed post test scores are presented.

4.1.3 Results of Post Test Scores Analysis

The following section presents the descriptive statistics of Post-HBAT, post-HBCUT and post-SMQ test scores in relation to groups and gender. As it can be seen from the table below (Table 27), the mean scores of the TG 1, TG 2, TG 3 and CG on post-HBAT, post-HBCUT and post-SMQ tests were different. The mean score for TG 2 (60.98) is higher than the other groups in post HBAT. The mean score for this group (44.44) is also higher than the other groups in post HBCUT. Likewise, the mean score for TG 2 (3.02) is slightly higher than the other groups in post SMQ. The mean score for the CG is lower than the others in all the three variables.

Table 27 Descriptive statistics for post-HBAT, post-HBCUT and post-SMQ tests scores across groups

Variables	**Groups**											
	Treatment Group 1			**Treatment group 2**			**Treatment group 3**			**Comparison group**		
	N	M	SD	N	M	SD	N	M	SD	N	M	SD
Post-HBAT	41	51.92	15.79	38	60.98	14.31	43	42.46	8.92	42	40.68	11.71
Post-HBCUT	41	37.94	10.16	38	44.44	8.57	43	31.91	8.14	42	30.69	8.52
Post-SMQ	41	2.99	.59	38	3.02	.517	43	2.57	.65	42	2.55	.74

In addition to groups, descriptive statistic of post test scores across gender also computed. As it can be seen from the table below (Table 28), the mean post-HBAT score of female students (57.14) were higher than male students in TG 1(43.75) but male students scored slightly higher than female students in TG 2 (63.03), TG 3 (43.39) and CG (45.36). Similarly, the mean post-HBCUT score of female students (40.67) were higher than male students (33.68) in TG 1 but score of male students (33.68) in TG 3 were higher than female students (30.86) whereas score of male students were almost similar with female students in TG 2(44.79 and 44.19) and CG (30.90 and 30.56) respectively. In the same manner, the mean post-SMQ score of female students (3.08) was higher than male students (2.83) in TG 1 and the same with male students (3.02) in TG 2. However, the mean score of male students (2.66 & 2.65) was slightly higher than female students (2.52) in TG 3 and CG (2.48). Table 28 shows descriptive statistics of post scores across gender.

Table 28 Descriptive statistics for post-HBAT, post-HBCUT and post-SMQ tests scores across gender

Variables		**Groups**											
		Treatment Group 1			**Treatment group 2**			**Treatment group 3**			**Comparison group**		
		N	M	SD	N	M	SD	N	M	SD	N	M	SD
Post-HBAT	M	16	43.75	13.39	16	63.03	12.97	16	43.39	8.03	16	45.36	11.94
	F	25	57.14	15.19	22	59.48	15.34	27	41.91	9.51	26	37.80	10.82
Post-HBUT	M	16	33.68	10.03	16	44.79	7.72	16	33.68	10.44	16	30.90	8.83
	F	25	40.67	9.45	22	44.19	9.31	27	30.86	6.41	26	30.56	8.50
Pos-SMQ	M	16	2.83	.58	16	3.02	.49	16	2.66	.516	16	2.65	.48
	F	25	3.08	.59	22	3.02	.55	27	2.52	.72	26	2.48	.87

As described above, the result of the descriptive statistics revealed that there was a mean score difference between groups and male and female students in relation to post test scores of HBAT, HBCUT and SMQ tests. To assess if there were statistically significant post- tests mean score differences between the four groups and gender and if there was an interaction between treatment groups and gender, MANOVA was conducted. The MANOVA results revealed that there was a statistically significant difference between the four groups on post test mean scores: F (9, 374) = 9.89, p = 0.00; Wilks' Lambda =.60; η^2 = .16 (Table 29). The eta squared (η^2) value is much larger than typical value based on the (Cohen, 1988). This eta squared (η^2) value indicated that 16 % of multivariate variance of post test mean scores was associated with the intervention. This means that the difference between the groups accounted for by the intervention. However, the MANOVA result revealed that there was no statistically significant mean difference between male and female students on post test mean scores: F (3, 154) = .13[b], p = .94; Wilks' Lambda = .99; η^2 = .00. Moreover, the MANOVA result revealed that there was a statistically significant interaction effect between treatment groups and gender: *F* (9, 374) = 2.22, *p* = 0.02; Wilk's λ = .88; η^2 = .04. The eta squared (η^2) value of interaction effect is medium or typical based on the (Cohen, 1988). This implies that 4% of the multivariate variance of post test mean scores was associated with the interaction between intervention and gender. This means that the difference between the groups accounted for by the interaction between treatment group and gender. The following table is the MANOVA result.

Table 29 MANOVA Result – multivariate test

	Wilks' Lambda	F	Df	Error df	*p*	η^2
Treatment groups	.60	9.89	9.00	374.95	.00	.16
Gender	.99	.13[b]	3.00	154.00	.94	.00
Gender * Treatment groups	.88	2.22	9.00	374.95	.02	.04

Tests of Between-Subjects Effects result (Table 30) confirmed that there was a significant mean difference between groups in post-HBAT (p = .00), Eta- Squared .28; post-HBCUT (p = .00), Eta-Squared .27 and post-SMQ tests scores (p = .00), Eta-Squared .10. The eta squared (η^2) values are .28, .27 and .10 respectively for post-HBAT, post-HBCUT and post-SMQ indicating that 28 %, 27 % and 10 % of multivariate variance of dependent variables was associated with treatment. The eta squared (η^2) values are much larger than typical value for post-HBAT and post-HBCUT and large or larger than typical for post-SMQ based on the (Cohen, 1988). This implies that the difference between groups in dependent variable was attributed to the intervention.

Similarly, no significant difference was found between males and females on each dependent variable p= .92, .57 and .89 respectively. Interaction effects between gender and treatment for each variables were.09 p = .00, .04 p = .08, .02 p = .44 respectively. Below is table 30 that shows the above results.

Table 30 Tests of Between-Subjects Effects

Independent variables	Dependent variables	Type III Sum of Squares	Df	F	*p*	η^2
Treatment group	Post-HBAT	9441.24	3	20.40	.00	.28
	Post-HBCUT	4384.67	3	18.93	.00	.27
	Post-SMQ	6.60	3	5.444	.00	.10
Gender	Post-HBAT	1.55	1	.01	.92	.00
	Post-HBCUT	25.28	1	.33	.57	.00
	Post-SMQ	.01	1	.02	.89	.00
Gender * Treatment group	Post-HBAT	2452.99	3	5.30	.00	.09
	Post-HBCUT	535.73	3	2.31	.08	.04
	Post-SMQ	1.09	3	.90	.44	.02

Although the Tests of Between-Subjects Effects result showed that there was a statistically significant mean score difference between treatment groups in all dependent variables, it did not show which group differs from the other one. Therefore, in order to see which group is different from the others, post hoc multiple comparisons were conducted. In this case, according to Tabachnick and Fidell (2007, p. 270) Bonferroni type adjustment should be made in order to ensure a lower Type 1 error on multiple comparisons. Accordingly, to make the adjustment, it is to divide already set alpha by the number of dependent variables of the study. In this study alpha was set to be 0.05. As a result, when we divided 0.05 by 3 (dependent variables), it gives 0.02 which is an adjusted alpha for the multiple comparisons. The three dependent variables for this analysis are achievement, conceptual understanding and motivation.

The post hoc multiple comparison result revealed that there was statistically significant mean difference between each pair of the group (*p* = .01) except between TG 3 and CG (*p*= .91) in HBAT mean scores. Students in TG 2 performed better than TG 1, TG 3 and CG with mean gain of 9.06, 18.52 and 20.30 respectively. Similarly, students in TG 1 performed better than TG 3 and CG with mean gain of 9.46 and 11.24 respectively in HBAT mean scores.

In the same way, post hoc multiple comparison result revealed that there was statistically significant mean difference between each pair of the groups (*p* = .01) except between TG 3 and CG (*p*= .92) in HBCUT mean scores. Students in TG 2 performed better than TG 1, TG 3 and CG with mean gain of 6.05, 12.53 and 13.76 respectively. Similarly, students in TG 1 performed better than TG 3 and CG with mean gain of 6.03 and 7.25 respectively in HBCUT mean scores. The 7EIMMS helped students to score significantly higher mean scores in both post HBAT and post-HBCUT indicating its effectiveness over the other methods in enhancing achievement and conceptual understanding followed by 7EIM.

Although there was a mean difference between TG 3 and CG in both post HBAT and post-HBCUT, it was not statistically significant. This implies that the use of MS with CI has no effect on student's achievement and conceptual understanding but it has meaningful effect when it is with 7EIM.

In relation to post-SMQ, the post hoc multiple comparison result revealed that there was a statistically significant mean difference between pairs of groups (*p* = .01) except between TG 1 and TG 2 (*p* = .98) and between TG 3 and CG (*p*= .98). Students in TG 1 and 2 have higher mean score than TG 3 and CG with mean gain of .41, .44, and .45, .47 respectively in post-SMQ. However, though there was a difference in mean score between pairs of groups (TG 1 and 2) and

(TG 3 and CG) in post-SMQ, it was not statistically significant. This implies that MS has no significant effect on students' motivation but the 7E instructional model. The table below shows post hoc multiple comparison result.

Table 31 post hoc multiple comparison test result

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	*P*
Post-HBAT	TG 1	TG 2	-9.06*	2.80	.01
		TG 3	9.46*	2.71	.00
		CG	11.24*	2.73	.00
	TG 2	TG 3	18.52*	2.77	.00
		CG	20.30*	2.78	.00
	TG 3	CG	1.78	2.70	.91
Post-HBUT	TG 1	TG 2	-6.50*	1.98	.01
		TG 3	6.03*	1.92	.01
		CG	7.25*	1.93	.00
	TG 2	TG 3	12.53*	1.96	.00
		CG	13.76*	1.97	.00
	TG 3	CG	1.22	1.91	.92
Post-SMQ	TG 1	TG 2	-.03	.14	.98
		TG 3	.41*	.14	.01
		CG	.44*	.14	.01
	TG 2	TG 3	.45*	.14	.01
		CG	.47*	.14	.01
	TG 3	CG	.03	.14	.98

In summary, 7EIMMS significantly better than the others instructional approaches in improving students' achievement and conceptual understanding of concepts in biology followed by 7EIM alone. However, it was not better in enhancing students' motivation than 7EIM alone.

4.1.4 Analysis of HBCUT Items and Misconceptions

In addition to descriptive statistics and significant result of MANOVA, percentage of students' response to post-HBCUT and misconceptions identified from students' response provided evidences of the difference between the groups after the treatment supporting the effectiveness of the intervention on conceptual understanding. At first the percentage of students' response and then the percentage of students' misconceptions for each item were calculated and analyzed.

First, students correct response to only first tiers (content), only the second tier (reason) and both two tiers (content and reason) of the treatment and the comparison groups post-HBCUT were calculated. In relation to students response to only first tiers, only the second tiers, both two tiers of the treatment and the comparison groups of post-HBCUT, the mean percentages of those students who answered only first tiers were 27.42, 25.02, 31.52 and 30.87 for TG 1, TG 2, TG 3 and CG respectively. TG 3 had the highest percentage in answering the only first tier followed by CG. TG 2 was with the lowest percentage in answering only the first tier. The highest percentage of only first tier correct answers were recorded from item 10 for TG 1(50.22%), item 16 for TG 2 (50%), and item 13 for TG 3 (58.13%) and item 17 for CG (54.76%). Similarly, the lowest percentages of only first tier correct answers were recorded from item 2 and 4 for TG 1(7.32%), item 2 for TG 2(5.26%), item 18 for TG 3 (9.31%) and item 1 for CG (24.28%).

The mean percentages of those students who correctly answered only the second tier were 11.70, 11.62, 12.14 and 15.07 for TG 1, TG 2, TG 3 and CG respectively. All the groups are relatively similar in answering only the second tier. The mean percentages of those students who answered both two tiers were 37.21, 44.06, 31.26 and 30.47 for TG 1, TG 2, TG 3 and CG respectively. TG 2 has the highest percentage in answering both tiers followed by TG 1.

When the percentage of the combination of both correct first and second tiers answers examined, the highest percentages of correct combination of the two tier answers were recorded from item 11 for TG 1 (70.32%), TG 2 (74.24%) and CG (59.44%) and from item 6 and 17 for TG 3 (46.89%). The next highest percentage was recorded from item 8 for TG 2 (66.33%) and item 9 for TG 1 (57.58%). The lowest percentage of correct combination of the two tiers was recorded from item 18 for TG 1 (19.1%), item 7 for TG 2 (26.1%), item 1 and 2 for TG 3 (18.99%) and item 7 for CG (18.96%). The following table summarizes the students' response to each item with respect to tiers.

Table 32 percentage of the response of students on post-HBCUT scores

	Only First Tier Correct				**Only Second Tier Correct**				**Both Tier Correct**			
No	**EG1**	**EG2**	**EG3**	**C**	**EG1**	**EG2**	**EG3**	**C**	**EG1**	**EG2**	**EG3**	**C**
1	21.96	23.68	23.26	14.28	29.27	26.32	23.26	33.33	28.86	26.85	18.99	30.86
2	7.32	5.26	25.58	19.04	14.64	10.52	9.31	21.42	26.42	40.01	18.99	26.1
3	36.59	7.89	18.6	19.04	12.2	7.89	6.98	4.76	21.54	29.49	28.29	23.72
4	7.32	7.89	25.59	16.66	19.51	13.16	11.63	16.67	33.73	40.01	28.29	26.1
5	39.03	36.84	41.88	29.56	9.76	13.16	18.6	9.53	28.86	40.01	35.26	26.1
6	29.27	23.68	23.17	38.1	12.2	15.59	6.98	11.9	50.81	42.64	46.89	42.77
7	19.51	36.64	32.53	26.18	14.63	13.16	11.63	14.29	21.54	26.1	21.31	18.96
8	36.58	23.68	32.56	23.8	12.2	5.26	11.63	9.3	28.86	66.33	28.29	30.86
9	39.03	34.22	48.84	50.01	7.14	7.89	20.93	14.29	57.58	55.8	25.96	40.39
10	50.22	42.11	41.86	45.24	7.32	7.89	9.3	9.52	50.81	40.01	35.26	28.48
11	9.76	7.89	18.61	28.57	4.88	5.26	9.31	7.14	70.32	74.22	35.26	59.44
12	17.08	18.42	25.58	33.33	4.88	15.78	16.28	26.19	31.29	50.54	30.61	23.72
13	41.47	42.11	58.13	54.76	2.44	0	2.33	4.76	31.29	55.8	25.96	33.25
14	24.4	28.95	44.18	28.56	9.76	13.16	11.63	7.14	54.76	42.64	30.61	30.86
15	31.72	7.89	39.54	21.42	9.76	23.68	9.13	19.05	36.17	53.17	39.92	26.1
16	26.84	50	30.23	26.18	12.2	5.26	9.31	16.66	28.86	32.12	39.92	23.72
17	40.9	40.11	27.91	54.76	17.07	23.68	16.28	14.29	45.93	45.28	46.89	28.48
18	14.64	13.15	9.31	26.18	26.83	10.53	13.96	30.95	19.1	32.12	25.96	28.48
Mean	**27.42**	**25.02**	**31.52**	**30.87**	**12.59**	**12.12**	**12.14**	**15.07**	**37.21**	**44.06**	**31.26**	**30.47**

Second, based on the above response of students (Table 32), the percentage of students responses were categorized in to sound understanding, partial understanding, misconceptions and no understanding (Table 33). As indicated in the methodology part (p. 94), development process of HBCUT, the categories of students response in to sound understanding (SU) - those students who answered both two tiers correctly; partial understanding (PU) - those students who answered only the second tier correctly; misconception (MC) - those students who answered only first tiers correctly, and no understanding (NU) - those students who answered both tiers incorrect were used for each items. When the percentage of students' responses in to sound understanding, partial understanding, misconceptions and no understanding examined, the mean percentage of students' response in the table below (Table 33) showed that 37.21, 44.06, 31.26 and 30.47 of the students for TG 1, TG 2, TG 3, and CG have sound understanding on the concepts in human biology. Comparatively, highest percentage of students in TG 2 understood the concepts in biology followed by students in TG 1. On the other hand, 12.59, 12.12, 12.14 and 15.07 mean percentages of students' response showed that they have partially understood the concepts while 27.42, 25.02, 31.52 and 30.87% for TG 1, TG 2, TG 3, and CG respectively showed that they have misconceptions about concepts in human biology. Moreover, 23.54, 19.30, 25.08 and 23.47 mean percentages of students' response for TG 1, TG 2, TG 3, and CG respectively showed that they have no understanding of the concepts. Comparatively, highest mean percentage of misconceptions found from TG 3 and CG (31.52 and 30.87) respectively. The relatively highest percentage of sound understanding (44.06) and lower percentage of misconception held (25.13) among students in TG2 ensures the effectiveness of 7E instructional model with metacognitive strategies than the others in conceptual understanding and minimizing misconceptions followed by TG 1 (27.65) with 7E instructional model alone in sound understanding.

The percentage of students response in TG 2 was higher than the others followed by students in TG 1 in relation to sound understanding and lower in relation to misconceptions and no understanding indicating that 7Einstructional model with metacognitive strategies was relatively superior to the other instructional methods and 7E instruction model alone is also relatively superior to the two instructional method (conventional alone and with metacognitive strategies) in helping students understand the concept. This can be taken as evidence that support the MANOVA result. The following table summarizes the percentage of students' response for each item under each category.

Table 33 percentages of the response of students on post-HBCUT scores per categories

	Treatment Group1				Treatment Group 2				Treatment Group 3				Comparison Group			
Item	**SU**	**PU**	**MC**	**NU**	**SU**	**PU**	**MC**	**NU**	**SU**	**PU**	**MC**	**NU**	**SU**	**PU**	**MC**	**NU**
1	28.86	29.27	21.96	19.91	26.85	26.32	23.68	23.15	18.99	23.26	23.26	34.49	30.86	33.33	14.28	21.53
2	26.42	14.64	7.32	51.62	40.01	10.52	5.26	44.21	18.99	9.31	25.58	46.12	26.1	21.42	19.04	33.44
3	21.54	12.2	36.59	29.67	29.49	7.89	7.89	54.73	28.29	6.98	18.6	46.13	23.72	4.76	19.04	52.48
4	33.73	19.51	7.32	39.44	40.01	13.16	7.89	38.94	28.29	11.63	25.59	34.49	26.1	16.67	16.66	40.57
5	28.86	9.76	39.03	22.35	40.01	13.16	36.84	9.99	35.26	18.6	41.88	4.26	26.1	9.53	29.56	34.81
6	50.81	12.2	29.27	7.72	42.64	15.59	23.68	18.09	46.89	6.98	23.17	22.96	42.77	11.9	38.1	7.23
7	21.54	14.63	19.51	44.32	26.1	13.16	36.64	24.1	21.31	11.63	32.53	34.53	18.96	14.29	26.18	40.57
8	28.86	12.2	36.58	22.36	66.33	5.26	23.68	4.73	28.29	11.63	32.56	27.52	30.86	9.3	23.18	33.66
9	57.58	2.44	39.00	0.98	55.8	7.89	34.22	2.09	25.96	20.93	48.84	4.27	40.39	9.29	50.01	0.69
10	50.81	0	50.22	1.02	40.01	7.89	42.11	9.99	35.26	9.3	41.86	13.58	28.48	9.52	45.24	16.76
11	70.32	4.88	9.76	15.04	74.22	5.26	7.89	12.63	35.26	9.31	18.61	36.82	59.44	7.14	28.57	4.85
12	31.29	4.88	17.08	46.75	50.54	15.78	18.42	15.26	30.61	16.28	25.58	27.53	23.72	26.19	33.33	16.76
13	31.29	2.44	41.47	24.8	55.8	0	42.1	2.1	25.96	2.33	58.13	13.58	33.25	4.76	54.76	7.23
14	54.76	9.76	24.4	11.08	42.64	13.16	28.95	15.25	30.61	11.63	44.18	13.58	30.86	7.14	28.56	33.44
15	36.17	9.76	31.72	22.35	53.17	23.68	7.89	15.26	39.92	9.13	39.54	11.41	26.1	19.05	21.42	33.43
16	28.86	12.2	26.84	32.1	32.12	5.26	50	12.62	39.92	9.31	30.23	20.54	23.72	16.66	26.18	33.44
17	45.93	13.07	40.9	0.01	45.28	14.68	40.11	.07	46.89	16.28	27.91	8.92	28.48	14.29	54.76	2.47
18	19.1	26.83	14.64	39.43	32.12	10.53	13.15	44.2	25.96	13.96	9.31	50.77	28.48	30.95	26.18	14.39
Mean	**37.21**	**11.70**	**27.42**	**23.54**	**44.06**	**11.62**	**25.02**	**19.30**	**31.26**	**12.14**	**31.52**	**25.08**	**30.47**	**15.07**	**30.87**	**23.47**

When each item was examined in relation to sound understanding, in 12 of the items (67%) TG 2 performed better in understanding of the concept than TG 1. Similarly, TG 2 performed better in understanding of the concept in 15 of the items (83%) than TG 3 and in 16 of the items (89%) than CG. TG 1 better performed in understanding of 10 of the items (56%) than TG 3 and 11 of the items (61%) than CG.

Highest percentage of sound understanding was recorded from item 11 with percentage 70.32, 74.22 and 59.44 for TG 1, TG 2 and CG respectively whereas from item 6 and 17 with percentage of 46.89 each for TG 3. In other words, item 11 was the easiest item for the three groups (TG 1, TG 2 and CG) whereas item 6 and 17 were easiest item for TG 3. On the other hand the lowest percentages of sound understanding were recorded from item 18 for TG 1(19.1), item 7 for TG 2 (26.1), item 1 and 2 for TG 3 (18.99) and item 7 for CG (18.96). In other words, these items were relatively the difficult items for these groups. The following line graph (Fig.11) shows the percentage of sound understanding for each item. As it can be seen from the line graph below, students in TG 2 performed better in most of the items followed by students from TG 1.

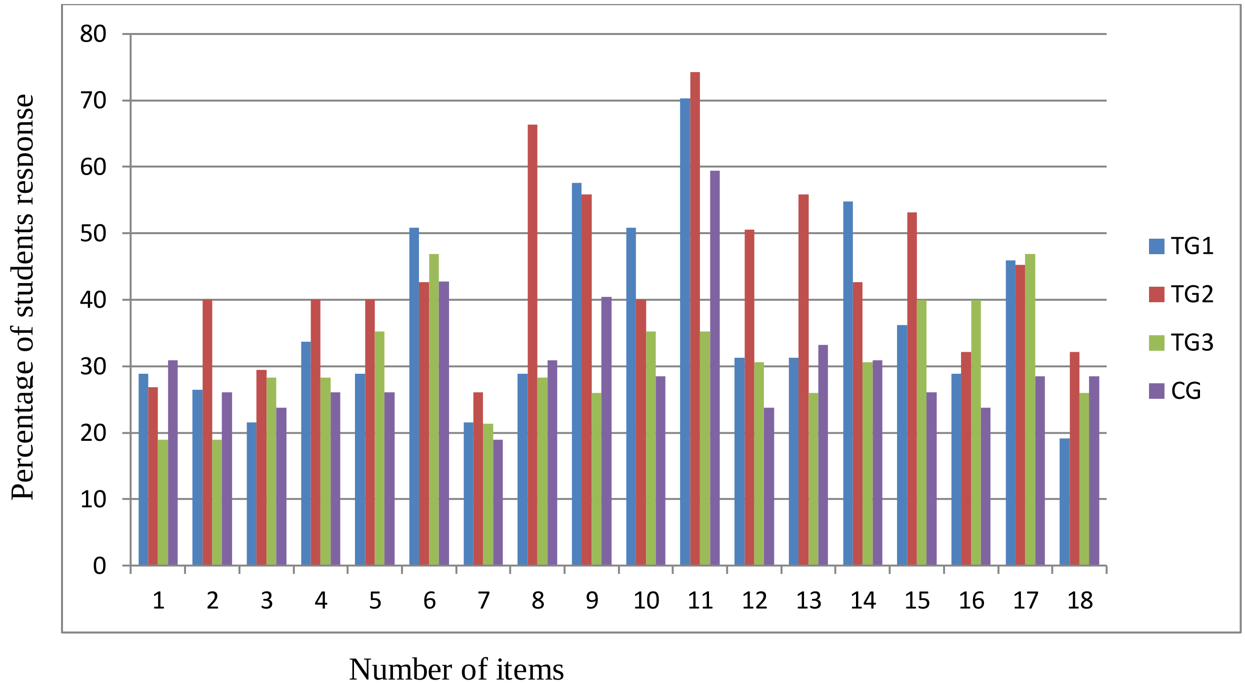

Figure 11 Bar graph of percentage of sound understanding for each item

In relation to misconceptions, students in TG 2 hold less percentage of misconceptions in 11 of the items (61%) than the TG 1 and in 12 of items (67%) than TG 3 and in 13 of items (72%) than CG. Students in TG 1 hold less percentage of misconceptions in 12 of the items (67%) than TG 3 and in 11 of the items (61%) than CG.

Highest percentage of misconception recorded from item 10 with percentage of 50.22 for TG 1 and from item 16 with percentage of 50 for TG 2 and from item 13 for TG 3 and CG with percentage of 58.13 and 54.76 respectively. The following line graph (Fig. 12) shows the percentage of misconception for each item. As it can be seen from the line graph below, students in TG 2 performed better most of the items in minimizing misconceptions.

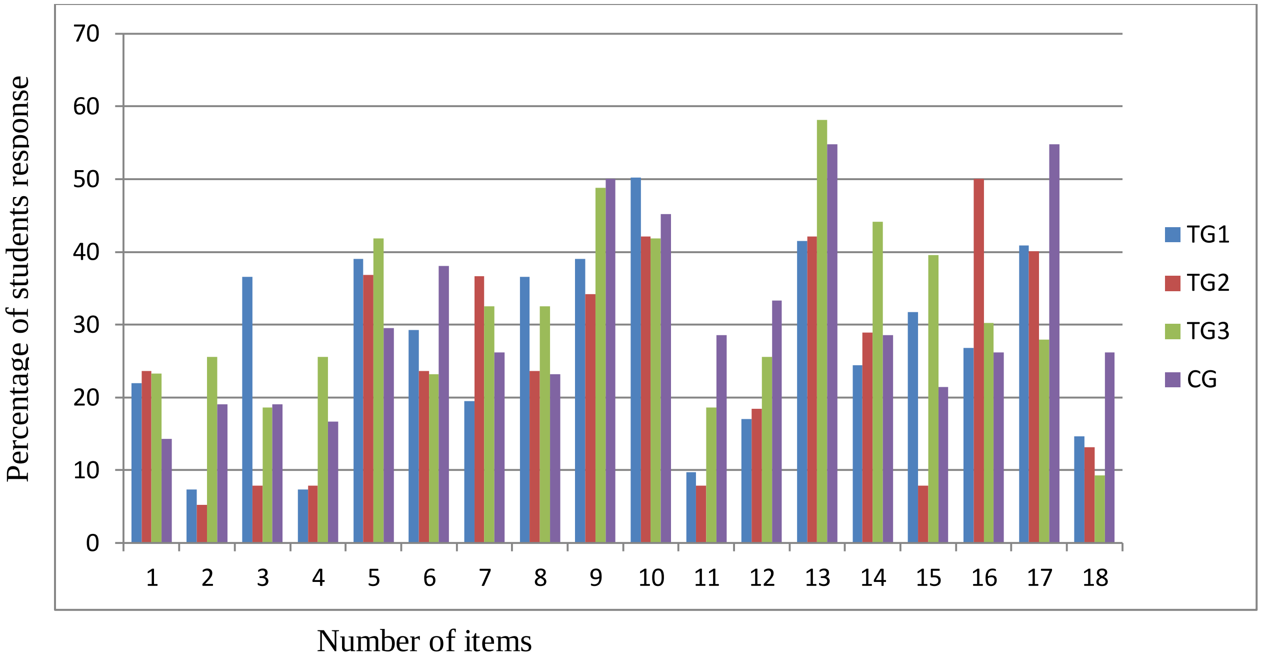

Figure 12 Bar graph of percentage of misconceptions of each item

The analysis and identification of misconception using percentage of students' response to each item are presented as follows with examples of items. The analysis was based on the categories of concepts in human biology in to food and nutrition; the digestive system; the respiratory system, cellular respiration and the circulatory system. For identification of misconceptions, responses of students to all items were analyzed but those items on which relatively considerable differences between treatment and comparison groups observed were taken as an example to show the analysis and identification of misconceptions. Therefore, items 2, 4, 8, 9, 12, 14, 15 from HBCUT were presented as an example in the analysis and identification of misconceptions. See appendix for the rest items (appendix 11).

For the first category, food and nutrition, item 1 and 2 were prepared to examine students' conceptual understanding about concepts in food and nutrition. Three misconceptions were identified from these two items.

According to the percentage of correct fist tier and incorrect reason choice, it was found that considerable percentage of students had misconceptions about the purpose of converting food in to lipid and result of glucose test with Benedict solution. For this study, those correct first tier and incorrect second tier reason responses above 10% were taken as major misconception (Haslam & Treagust, 1987). Based on this, one misconception was identified from item 1 in that students considered the conversion of excess food to lipid is because of lipid serve as major source of energy when there is lack of oxygen in our body while the correct reason is because it is the most important source and effective storage of energy for our body.

Item 2 was taken as an example to show the analysis and identification of misconceptions. When we look at item 2, the result showed that only 26.42%, 40.01%, 18.99 % and 26.1% from TG 1, TG 2, TG 3 and CG respectively have understood the reason for colour change in glucose test using Benedicts solution while relatively higher percentage of students in TG 3 (25%) and CG (19%) have misconceptions compared to students in TG 1(7%) and TG 2 (5%). Comparatively higher percentage of the students understood the concept from TG 2 (40%). Considering correct first tier and incorrect second tier, students' responses with percentage of 13.95 from TG 3 and 11.93 from CG were taken as two misconceptions from item 2. Students in comparison group considered the change in colour during testing the presence of glucose with Benedict's solution is due to reduction of monosaccharide to disaccharides in the reaction and it is because when water boils it changes its colour**.** However, no major misconceptions were identified from TG 1 and TG 2. This implies that 7E instructional model alone and with metacognitive strategies was effective in reducing misconception. Responses of students for item 2 were analyzed as shown in the table below (Table 34).

Table 34 percentage of students' response to item no. 2

Item			TG1	TG2	TG3	CG
2	A grade 9 student conducted an experiment in biology laboratory. First she put a sample of glucose powder and water in to a test tube. Then she added a few drops of Benedict's solution in to the test tube and placed it in boiling water. What was the most probable colour she observed within the test tube?					
	A	Blue	29.27	26.56	42.14	29.66
	B	Purple	30.73	23.84	11.62	27.28
	C	Black	7.32	5.26	2.33	7.14
	D	Orangey-red*	33.74	45.27	44.47	47.5
	The reason for my answer is:					
	1	Copper(II) in the Benedict's solution is reduced to copper(I)*	26.42	40.01	18.99	26.1
	2	Copper(I) in the Benedict's solution is oxidized to copper(II)	2.44	5.26	2.33	7.14
	3	Monosaccharide is reduced in the reaction to disaccharides	0	0	9.3	**11.93**
	4	When water boils it changes its colour	4.88	0	**13.95**	2.38
	5	Other reason:	0	0	0	0

NB. Percentages under reasons are those only with correct first choice
* indicates correct combination of response

For the second category, the digestive system, item 3, 4 and 5 were used to examine students' conceptual understanding of concepts in the digestive system. According to the percentages of correct fist tier choice and incorrect reason choice, considerable percentage of students had misconceptions about the absorption of food in small intestine, mechanical digestion and enzymes. Six misconceptions were identified from these three items. One misconception from item 3, two from item 4 and three from item 5.

Result from item 3 showed that small percentage of students understood the concept behind absorption of food in the small intestine. One misconception identified with regards to absorption of food in small intestine is that students considered absorption of food from small intestine in to blood stream is because of the process of peristalsis to move substance through villi. They confused with the movement of food through the digestive track. The correct conception is that absorption occurs in small intestine because digestion is completed in small intestine and contains structure called villi that increase surface area for diffusion to occur rapidly in to the blood stream.

Result from item 5 showed that, compared to item 3, relatively higher percentages of students have understood the concept of enzymes and have misconceptions as well. The three misconceptions identified were students considered that enzymes take part in the reaction, affected by the reaction they catalyze and broken down in to amino acids after they catalyze a reaction because they are proteins**.** The correct conception is that enzymes do not take part in the reaction and not affected by the reaction they catalyze at the end. Hence, they are used over and over again to catalyze a reaction in human body.

Item 4 was taken as an example from this category to show the analysis. When we look at item 4, the result showed that only 33.73 %, 40.01%, 28.29% and 26.1% from TG 1, TG 2, TG 3 and CG respectively have understood the concept of mechanical digestion while 7%, 8%, 26% and 17% from TG 1, TG 2, TG 3 and CG respectively have misconceptions. Quite higher percentage of students in TG 2 understood the concept (40.01%) followed by TG 1 (33.73%). On the other hand, lower percentages of misconceptions held in TG 1 (7%) and TG 2 (8%) while higher percentage of misconception held in TG 3. Moreover, two misconceptions with response percentage of 11.63 and 11.93 from TG 3 and CG were identified from this item. This implies that 7E instructional model alone and with metacognitive strategies were effective in reducing misconceptions. One of the misconceptions identified was that students considered that mechanical digestion releases enzymes from glands and it involves enzymes action for food digestion**.** Responses of students for item 4 were analyzed as shown in table below (Table 35).

Table 35 Percentage of students' responses to item no. 4

Item			TG1	TG2	TG3	CG
4	Mechanical digestion breaks down large food substance in to smaller and soluble molecules?					
	A	True	58.15	52.05	48.8	54.67
	B	False*	41.05	47.9	51.76	45.2
	The reason for my answer is:					
	1	It releases enzymes from glands and breaks food substance in to small and soluble molecules.	2.44	0	11.63	0
	2	It breaks down food in to smaller pieces and increases the surface area for enzyme action*	33.73	40.01	28.29	26.1
	3	It breaks down food substance in to small and soluble molecules through hydrolysis reaction.	2.44		2.33	4.76
	4	It changes large and insoluble molecules to smaller and soluble one through the action of enzymes.	2.44	7.89	**11.63**	**11.93**
	5	Other reason:	0	0	0	2.38

For the third category, respiratory system, item 6, 7, 8, 9 and 10 were used to examine students' conceptual understanding of concepts in human respiratory system. According to the percentage of correct fist tier choice and incorrect reason choice, considerable percentage of students had misconceptions about movement of air in and out, the lungs and related structures and the relation between breathing and respiration. Thirteen misconceptions were identified from these five items. Three from item 6, two from item 7, two from item 8, three from item 9 and three from item 10.

Result from item 6, showed that relatively higher percentage of students from all groups have understood the role of oxygen and its presence within the air that we breathe in and out during inhalation and exhalation and have misconceptions as well. From this item, three misconceptions were identified that indicates no oxygen exist in exhaled air because it is used for different purpose in our body. The first one was students considered all the oxygen that we breathe in is absorbed and it is all used in the process of respiration. The second misconception was all of the oxygen we inhale absorbed because we need it and only carbon dioxide is remove because it poisonous to us. The third one was students considered that unabsorbed oxygen is stored in the alveoli for later use and it is not exhaled. The correct conception is that not all of the oxygen inhaled is absorbed and so there is some left in the lungs that will be breathed out with the carbon dioxide and other gases during exhalation.

Results from item 7, showed that smaller percentage of students have understood the concept of lungs phenomena while some percentages of students have misconceptions in all groups. Two misconceptions were identified from this item. The first misconception was that students considered the lungs as two balloons in a cavity that expand to let air into them and get smaller to push air out of them. The second misconception was that students consider the lungs are composed of lots of little sacks and the air entering them makes them expand. The correct conception is that the lungs are made up of a lot of tiny sacks and the lungs expand and contract as the thoracic (chest) cavity changes its volume, not as a result of the presence of two balloons like structures and movement of air in to and out of the lungs.

The results from item 10 showed that most of students in treatment groups have understood the concept of the role of diaphragm, chest cavity and intercostals muscles on lung volume except CG. However, misconceptions were also found in all groups. There are three misconception identified from this item. The first misconception was students considered the carbon dioxide produced during exercise make the lung to expand more. The second misconception was that students assumed the air we breathe in during exercise causes the lungs to expand as the air needs more space than normal breath and this pushes out the diaphragm and ribs and so we get an increase in thoracic (chest) cavity size. The third misconception was students conceived the extra oxygen moving into the lungs makes them bigger and as we use oxygen the volume decreases. The correct conception is that it is the contraction and relaxation of diaphragm and intercostals muscles that leads to an increase and decrease in the volume of the thoracic (chest) cavity which in turn changes the volume of the lungs rather than exercise and excess oxygen.

Item 8 and 9 was taken as an example for the analysis of misconceptions in this category. When we look at item 8, the result showed that only 28.86%, 66.33%, 28.29% and 30.86% from TG1, TG2, TG3 and CG respectively have understood the concept of the difference between breathing and respiration while 36%, 24%, 33% and 23% from TG1, TG2, TG3 and CG respectively have misconceptions. Higher percentage of students in TG 2 (66.33%) understood the concept whereas relatively higher percentage of students in TG 1 (36%) and TG 3 (33) held misconceptions. Two misconceptions were identified. One of the misconceptions identified was with response percentage of 14.6(TG1), 16.28 (TG3) and 11.9 (CG). Students considered that breathing is getting oxygen into the body and carbon dioxide out; while respiration is the process involved in moving these gases around the body in the blood. The second misconception identified was with response percentage of 14.63(TG1), 10.53 (TG2), 11.63 (TG3). Students considered breathing as the process of getting oxygen into the lungs from the atmosphere (inhaling) and carbon dioxide out of the body (exhaling) while respiration as the process of getting oxygen from the lungs to the body and carbon dioxide from the body into the lungs. Responses of students for item 8 were analyzed as shown in Table 36.

Table 36 Percentage of students' responses to item no. 8

Item			TG1	TG2	EG3	CG
8	Breathing is the same as respiration.					
	A	True	34.07	10.53	39.49	45.84
	B	False*	65.48	90.01	60.42	54.46
	The reason for my answer is:					
	1	Both of these processes involve getting oxygen into the body and carbon dioxide out of the body so they are the same.	4.88	5.26	4.66	2.38
	2	Breathing is getting oxygen into the body and carbon dioxide out; while respiration is the process involved in moving these gases around the body in the blood.	**14.63**	2.63	**16.28**	**11.9**
	3	Breathing is the process of getting oxygen into the lungs from the atmosphere (inhaling) and carbon dioxide out of the body (exhaling). Respiration is the process of getting oxygen from the lungs to the body and carbon dioxide from the body into the lungs.	**14.63**	**10.53**	**11.63**	7.14
	4	Breathing is the process of getting oxygen from the atmosphere into the cells and carbon dioxide out of the cells and into the atmosphere. Respiration is the process in which the cells produce energy and carbon dioxide*	28.86	66.33	28.29	30.86
	5	Breathing occurs in the lungs while respiration occurs elsewhere in the body but not in or near the lungs. Apart from where they occur they are the same thing.		5.26		2.38
	6	Other reason:	2.44			

The second item taken from this category is item 9. When we look at item 9, the result showed that 57.58 %, 55.8 %, 25.96% and 40.39% from TG1, TG2, TG3 and CG respectively have understood the concept of the nature of volume of the lung when we breathe in while still students have misconceptions while 38%, 34%, 49% and 50% from TG1, TG2, TG3 and CG respectively have misconceptions. Higher percentage of students in TG 1(57.58 %) understood the concepts followed by TG 2 (55.8) whereas higher percentage of students in TG 3(49) and CG (50%) held misconceptions. From this item, three misconceptions were identified. One of the misconceptions identified was with response percentage of 12.2 (TG1), 13.16 (TG2), 11.63 (TG3) and 19.05 (CG). Students considered that the air moving into the lungs forces them to expand to let the air in and as the air moves out the lungs decrease in volume because there is less air to fill them. The second misconception identified was with response percentage of 12.2 (TG1), 10.53 (TG2), 27.91(TG3) and 16.67 (CG). The students considered the lungs change in volume and this causes the thoracic cavity to change in volume to accommodate the lungs new volume. The third misconception identified was with response percentage of 14.63 (TG1), and 10.53 (TG2) and 14.29 from CG. The students considered that the lungs actively expand and contract so as to breathe in and out respectively. The correct conception is that the surface tension between the thoracic (chest) cavity, the pleura and the lungs causes the thoracic cavity to increases in volume (size) which in turn increases the volume of the lungs. Responses of students for item 9 were analyzed as shown in Table 37.

Table 37 Percentage of students' responses to item no. 9

Item			**TG1**	**TG2**	**TG3**	**CG**
9	When we breathe in, the lungs expand in volume because the thorasic (chest) cavity expands.					
	A	True*	96.12	89.06	74.8	90.44
	B	False	4.34	11.16	25.54	9.52
	The reason for my answer is:					
	1	Air moving into the lungs forces them to expand to let the air in and as the air moves out the lungs decrease in volume because there is less air to fill them.	**12.2**	**13.16**	**11.63**	**19.05**
	2	Because of surface tension between the thorasic (chest) cavity, the pleura and the lungs, as the thorasic cavity increases in volume (size) the lungs increase in volume as well*	57.58	55.5	25.96	40.09
	3	The lungs change in volume and this causes the thorasic cavity to change in volume to accommodate the lungs' new volume.	**12.2**	**10.53**	**27.91**	**16.67**
	4	The lungs actively expand so we can breathe in (inhale) and they contract so we can breathe out (exhale).	**14.63**	**10.53**	9.3	**14.29**
	5	Other reason:				

For the fourth category, cellular respiration, items 11, 12 and 13 were prepared to investigate students' conceptual understanding of concepts in cellular respiration. Nine misconceptions were identified from these three items.

Result from item 11 showed that highest percentage of students understood the concept of the place where respiration occurs. The misconception held by few students was students considered that energy is released in all cells is because of lungs take oxygen and stomach digests food. The correct reason is that respiration occurs in all cells because every cell need energy and must respire.

Results from item 13 showed that considerable percentage of students especially in TG 2 have understood the concept of the difference between aerobic and anaerobic respiration while still some have misconceptions. From this item, three misconceptions were identified. The first misconception was that students considered that in aerobic respiration, there is metabolism but in anaerobic respiration there is no metabolism. The second misconception is that anaerobic respiration use oxygen but aerobic respiration does not use oxygen. The third misconception is that anaerobic respiration breaks food molecules partially and releases high energy. The correct conception is that anaerobic respiration is less efficient because it breaks food molecules partially and releases less energy.

Examining item 12 in detail, the result showed that only 31.29%, 50.54%, 30.61% and 23.72% from TG1, TG2, TG3 and CG respectively have understood the concept of respiration and some students have misconceptions. Relatively higher percentage of students in TG 2 (50.54%) understood the concepts in respiration. But 26% and 35% of students in TG 3 and CG respectively held misconceptions compared to 17% and 18% of students in TG 1 and TG2 respectively. Responses with percentage of 13.16% from (TG2), 16.28% (TG3), 11.93 and 16.67(CG) were taken as major misconceptions. From this item, three misconceptions were identified. The first misconception is that students considered respiration as oxidation of food and release of energy because food cannot be used by the body unless energy is used to break it down. The second misconception was they consider respiration as oxidation of food and release of energy because oxygen contains chemical energy which can only be released by breaking it down. The third misconception was they consider respiration as a process of taking and releasing energy and oxygen. The correct conception is that oxidation of food in respiration occurs because food contains chemical energy which can be released by using oxygen to break it down. Responses of students for item 12 were analyzed as shown in the table below (Table 38).

Table 38. Percentage of students' responses to item no. 12

Item			**TG1**	**TG2**	**TG3**	**CG**
12	Which of the following is true about respiration?					
	A	It involves the oxidation of food and release of energy*	48.37	68.96	56.19	58.46
	B	It involves the extraction of energy from oxygen.	26.71	13.42	11.63	32.1
	C	Energy is used to oxidize food.	19.5	15.77	30.04	2.38
	D	It involves extraction of oxygen from food.	4.86	2.63	2.33	7.12
	The reason for my answer is:					
	1	Food cannot be used by the body unless energy is used to break it down.	2.44	**13.16**	**16.28**	7.14
	2	Food contains chemical energy which can only be released by using oxygen to break it down*	31.29	50.54	30.61	23.72
	3	Oxygen contains chemical energy which can only be released by breaking it down.	4.88	2.63	4.65	**11.93**
	4	Respiration is a process of taking and releasing energy and oxygen.	9.76	2.63	4.65	**16.67**
	5	Other reason:				

For the fifth category, the human circulatory system, he items 14, 15, 16, 17 and 18 were prepared to examine students' conceptual understanding of circulatory system. According to the percentage of correct first tier choice and incorrect reason choice, higher percentage of students had misconceptions but also considerable percentage of students understood the concepts about circulatory systems. As a result, fourteen misconceptions were identified from these five items.

For instance, result from item 16 showed that three misconceptions were identified. Students considered that arteries have thick and elastic walls because: (1) they pump blood under high pressure to the nearest body parts; (2) they prevent heat loss as blood travels through them and (3) they maintain high blood pressure in human body. The correct conception is that arteries have thick and elastic walls because it helps them to stretch as blood forced in to them and to pump long distance from the heart throughout our body.

Similarly, the result from item 17 showed that relatively higher percentage of treatment groups than comparison groups have understood the concept of the type blood circulations in human being and some have misconceptions in all groups. Three misconceptions were identified from this item. The first one is that students considered that pulmonary circulation transports deoxygenated blood and systemic circulation transports oxygenated blood throughout the body. The second was pulmonary circulation transports deoxygenated blood from different part of the body to the heart and oxygenated blood from the heart to different parts of our body. The third one was systemic circulation transports deoxygenated blood to the lung and oxygenated blood to the heart. The correct conception is that systemic and pulmonary circulation in human being transports both oxygenated and deoxygenated blood because systemic circulation transports deoxygenated blood from different part of the body to the heart and oxygenated blood from the heart to different parts of our body. Similarly, pulmonary circulation transports deoxygenated blood from the heart to the lungs and oxygenated blood from the lung to heart.

In the same way, result from item 18 showed that though most of students have a problem in understanding the concepts, only two misconceptions were identified in relation to the contraction of right and left ventricle. Students considered that as the right and left ventricle contract, the right side of the heart pumps blood to the right side of the body whereas the left side pump blood to left side of the body and only oxygenated blood enters the heart because the heart needs pure blood. The correct conception is when the right ventricle contracts, blood pumped in to the lung and when the left ventricle contracts blood pumped in to the body.

From this category, item 14 and 15 were taken as an example for the analysis. Result from item 14, showed that 54.76 %, 42.64%, 30.61 and 30.86% from TG 1, TG 2, TG 3 and CG respectively have understood the concept of why left side of the heart has thick muscles wall. In this item, TG 1 performed better understanding the concept followed by TG 2. Three misconception with response percentages of 12.2 (TG1), 10.53 (TG2), 13.95 and 11.63 (TG3) and 11.93 from CG were taken as major misconceptions. Students considered that the left side of the heart is thicker than right side because: (1) it pumps blood to a relatively short distance; (2) it receives much of the digested food to build them and (3) the heart is found in the left of the chest. Responses of students for item 14 were analyzed as shown in Table 39

Table 39 Percentage of students' responses to item no. 14

Item			**TG1**	**TG2**	**TG3**	**CG**
14	Which part of the heart has thicker muscles wall?					
	A	The left side of the heart *	79.16	71.23	74.73	58.48
	B	The right side of the heart	21.45	28.95	25.58	42.21
	The reason for my answer is:					
	1	It protects the heart from external damage.	2.44	5.26	4.65	
	2	It pumps blood to a relatively long distance*	54.76	42.64	30.61	30.86
	3	It pumps blood to a relatively short distance.	7.32	**10.53**	**13.95**	**11.93**
	4	It receives much of the digested food to build them.		**10.53**	**13.95**	**11.93**
	5	The heart is found in the left of the chest.	**12.2**	2.63	**11.63**	4.76
	6	Other reason:	2.44			

Similarly, result from item 15 showed that 36.17%, 53.17%, 39.92 and 26.1% from TG 1, TG 2, TG 3 and CG respectively have understood the concept of blood transfusion but still students have misconceptions. Students in the TG 2 (53.17%) understood the concept better than the other groups. Students in TG 2 held less percentage of misconceptions (10%) and students in TG 3 held higher percentage of misconceptions (34%). Responses with percentage of 12.2 (TG1), 11.63 and 13.95 (TG3) and 11.9 (CG) were taken as major misconceptions. No misconception was identified from TG 2 but three misconceptions were identified from this item in other groups. The first one was that students considered that transfusion of blood from a person with O blood type to A blood type is possible because O blood type has no antibody that reacts with antigen of the red blood cells of the person with blood type A. The second misconception was that transfusion of O blood type is possible because it has antigen AB that do not react with antibody in the red blood cells of the person with blood type A. The third misconception was that the transfusion of O blood type was possible because it has no antigen and antibody that reacts with the red bloods of the person with blood type A. The correct conception was transfusion of O blood type to a person with blood type A is possible because it has no antigen that reacts with antibody of the red blood cells of the person. Responses of students for item 15 were analyzed as shown in the table below (Table 40).

Table 40 Percentage of students' responses to item no. 15

item			TG1	TG2	TG3	CG
15	If someone with blood group "A" has got a car accident and lost a lot of blood. Therefore, he needs blood transfusion. Which of the following blood group is used during the transfusion?					
	A	B	9.76	5.26	13.95	14.28
	B	AB	22.03	31.12	6.98	40.14
	C	O*	67.73	63.78	79.36	47.52
	The reason for my answer is:					
	1	It has no antibody that reacts with antigen of the red blood cells of the person.	9.76	7.89	**11.63**	4.76
	2	It has antigen AB that does not react with antibody in the red blood cells of the person.	9.76	2.63	**13.95**	**11.9**
	3	It has no antigen that reacts with antibody of the red blood cells of the person*	36.17	53.27	39.92	23.8
	4	It has no antigen and antibody that react with the red bloods of the person.	**12.2**	0	**11.63**	4.76
	5	Other reason:			2.33	2.38

4.1.5 Results from Students Interviews

After the implementation of the intervention, semi-structured interviews were conducted to gain detailed data on students' conceptual understandings on human biology concepts and misconceptions. There were twenty four students, 6 from each group, involved in the interview.

The interview results were treated under the five categories of sub-topics of the unit; food and nutrition, digestion system, respiratory system, cellular respiration, and circulatory system. Interviewees from the four groups were asked first general questions about these five sub topics in human biology and specific questions to assess their conceptual understanding and misconceptions.

The first general question was focused on the general concept of food and mechanism of testing foods from the subtopic food and nutrition. When we look at students' response, most the interviewees from all groups described that there are different types of food and mechanisms of testing foods. They mentioned the different food types that our body needs and testing mechanism as follows:

> *There are different nutrients such as carbohydrates, proteins, lipids and minerals required by our body. We can test these food types in laboratory using different substance like iodine, paper, etc (Student A, TG 1).*
>
> *Food types that our body needs include proteins, vitamins, carbohydrates, lipids and minerals. We can use different tests for example paper to test water and oil, iodine for starch, etc (Student J, TG 2).*
>
> *There are different types of food such as carbohydrates, fat and protein. For instance, when we test starch with iodine it gives blue black color (Student O, TG 3).*
>
> *The food substance for our body includes nutrients such as minerals, carbohydrates, proteins and lipids. For instance, we can test lipid by adding on paper (Student T, CG).*

However, when interviewees are asked specifically concerning testing the presence of glucose in a solution and the reason behind the result, only some of the interviewees from TG 1 and most of interviewees from TG 2 answered correctly that when we add Benedict's solution, orange red colour appears indicating the presence of glucose but they failed to answer the reason why orange colour. Interviewees from TG 2 described well about testing the presence of glucose indicating that the orange red colour is due to the reaction between glucose and Benedict solution but failed to mention the change of copper II to copper I which is the cause for the change in colour. Some of the interviewees confused with other types of food test for instance with protein test and starch test and answered that purple and blue black colour were observed when we add Benedict solution. Sample excerpts are presented as follows:

> *I think we use Benedict solution to test the presence of glucose in a solution. I think orange red colour will be formed in the test tube when we heat if there is glucose. I do not know the reason why the colour changes (Student A, TG 1).*
>
> *We can test using Benedict solution. The result is orange but slight red colour ("Fezaza key" in Amharic). The colour is because there is glucose that reacts with the solution (Student J, TG 2).*
>
> *We test the presence of glucose with Benedict solution and observe blue black color. This is because plants prepare glucose (Student O, TG 3).*
>
> *I think we can test using Benedict solution and the colour changes from red to orange on heating. This is because there is more glucose (Student T, CG).*

From this category, food and nutrition, it seems that interviewees from TG 2 better understood the concepts in food and nutrition. The quantitative data analysis result of item 2 from this category (Table 34) and line graph (Fig. 11) indicated that students in TG 2 have sound understanding of concepts in this category.

The second question was about the general concept of digestion of food from sub-topic digestive system and the role of enzymes. When we look at students' response to this general question, it can be said that majority of interviewees in all groups described the food digestion and mentioned the structures involved very well. Especially, all interviewees in TG 2 explained correctly digestion and all structures with different enzymes involved in digestion but most of them failed to recognize that enzymes can catalyze a reaction over and over again without taking part in a reaction. Responses of few students are quoted below.

Digestion is breaking down of food. It changes large molecules to smaller once. There are two types of digestions namely mechanical (physical change) and chemical (identity change) digestions. Digestion starts from our mouth and goes to stomach and small intestine to end digestion (Student C, TG 1).

Digestion is the breaking down of food in to smaller and soluble one. There are two type of digestion: physical digestion– changes food substance in to smaller size and chemical digestion–which occurs when other substances added, for instance enzymes, and changes food substance in to soluble substance. Digestion starts from mouth and passes through esophagus– stomach – intestine and removed out through anus (Student G, TG 2).

It is the breaking down of food. There are two type: mechanical and chemical digestion. It starts from our mouth and then the food inters in to stomach – small intestine - large intestine (Student P, TG 3).

Digestion is the breaking down of food ("Mefechet"in Amharic*). There are two types. These are mechanical digestion which is breaking of food, no change occurs and chemical digestion which is breaking of food to new substance. It starts from mouth – stomach- here there is chemical process then through blood cells it to our body (Student S, CG).*

However, with regards to specific questions on absorption of food after digestion, almost all interviewees from TG 2 and majority of the interviewees from TG 1 and some interviewees from TG 3 and CG answered correctly as absorption occurring in the small intestine and majority of intervieweesfrom TG 2 and some interviewees from TG 1 answered the reason behind absorption in small intestine correctly. Below is a sample excerpt from each group:

I think absorption of nutrients occurs in small intestine because digestion ends in small intestine and diffusion occurs from here and the presence of structure known as villi to facilitate diffusion (Student C, TG 1).

Digested food substances absorbed in to the blood in small intestine because last digestion occurs here and small intestine contains villi structure that increase surface area for absorption (Student G, TG 2).

Absorption occurs in the small intestine because it is the nearest to the rest part of our body and easy to transport (Student P, TG 3).

Absorption of food is in small intestine because nature designed it (Student S, CG):

Although interviewees from TG 3 and CG explained digestion and structures involved, only some students understood that absorption of nutrient takes place in small intestine and it was found that they hold two misconceptions. One of the misconceptions was held by students in TG 3 and another in CG. The first misconception was absorption occurs in small intestine because small intestine is the nearest to our body and easy to transport and the second one is it is because nature designed it.

From this category, the digestive system, it looks that interviewees from TG 2 and TG 1 well understood the concepts in digestion and digestive system but most interviewees from TG 2 answered with more explanations, an indication of their understanding. This result is supports findings of quantitative data analysis result especially for students in TG 2. For instance, analysis of item 4 from this category (Table 35) and line graph (Fig. 11) indicated that students in TG 2 have sound understanding in relation to concepts in digestion and digestive system.

The third question was about the general concept of respiratory system. When we look at students' response, to these general questions, interviewees in all groups described the respiratory system and structures involved very well. Particularly, majority of interviewees from TG 1 and almost all interviewees from TG 2 and some interviewees from TG 3 and CG explained the process of breathing with structures involved very well during interview. Sample excerpts are presented as follows:

> *Breathing is the process of gas exchange between our body and the environment. The process of breathing occurs in a respiratory system. The air that we breathe in contains different gases. They enter in to our body through respiratory system which includes mouth, nose, lung and exchange of gases occurs in the air sac alveoli in the lung (Student D, TG 1).*

Breathing is exchange of air between us and the environment. The process of breathing involves structures like nose, mouth, lung, bronchi and other structures. Oxygen and other gases enters through nose – mouth - lungs (expands to take the air) – bronchi. Carbon dioxide is removed out through these structures (Student G, TG2).

Breathing is inhaling and exhaling of air. We inhale oxygen and exhale carbon dioxide through nose, trachea and lungs (Student P, TG3).

Breathing means exchange of gases or "Atenefafes" in Amharic. Oxygen enters from outside through respiratory systems and reach lung passing through trachea. In the lung oxygen is received and carbon dioxide is removed by the blood (Student S, CG).

Moreover, in relation to composition of inhaled and exhaled air, most of the interviewees from TG 1, TG 2 and some of the interviewees from TG 3 and CG understood that the air we breathe in mainly contain oxygen, carbon dioxide and nitrogen and the air we breathe out contain oxygen, carbon dioxide and nitrogen. Some interviewees from TG 1 and TG2 and most interviewees from TG 3 and CG, however, did not realize the presence of oxygen in exhaled air because it was used up in respiration in our body and the presence of carbon dioxide in inhaled air because it is toxic. This indicates the existence of misconceptions among interviewees though the extent varies. Below is a sample excerpt from each group.

During breathing oxygen moves in and carbon dioxide moves out. Inhaled air consists of Nitrogen 80%, CO2 0.04%, oxygen 21%. Exhaled air consists of Nitrogen 80%, CO2 4% and oxygen 16%. The 4% CO2 is because each cell under goes respiration and releases CO2 (Student D, TG 1).

Inhaled air mainly consists of oxygen but nitrogen and carbon dioxide are also inhaled pith percentage of Nitrogen 80%, CO2 0.04%, oxygen 21%. Exhaled air consists of Nitrogen 80%, CO2 4%, and oxygen 16%. Exhaled air consists of more of carbon dioxide but nitrogen and some oxygen also removed out (Student G, TG2).

During in halation we take clean air that is needed by our body, example oxygen. During exhalation the burned air that our body does not need is removed; example, carbon dioxide which "disturbs our body". "Oxygen is very important for our body, we do not release it out because it gives peace for our body but other gases like from coal and cigarette affect our internal body" and, therefore, removed (Student P, TG3).

During inhalation oxygen and nitrogen enters in to our body and during exhalation carbon dioxide and methane moves out. After the oxygen finished its work in our body, it is removed in the form of carbon dioxide in a burnt form. We do not exhale oxygen but inhale carbon dioxide (Student S, CG).

Similarly, when students were asked specifically about what happens to the lungs, chest cavity, diaphragm, ribs and intercostals muscles during inhalation and exhalation interviewees from the four groups answered the question. Interviewees from TG 1, TG 2 and TG 3 explained what happens to the lungs, the diaphragm, the chest cavity and the ribs as air moves in and out of the body correctly. However, most of the interviewees from all groups especially from TG 3 and CG did not realize the change in volume of the lungs is due to change in thoracic (chest) cavity, intercostals muscles and diaphragm rather than due to structures of the lung and movement of air in and out. Most of them had misconception except few students from TG 1 and TG 2. Sample excerpts are presented as follows:

Chest cavity increases when we breathe in and decreases when we breathe out. A diaphragm contracts when we breathe in and relaxes when we breathe out. Lungs volume increase when we breathe in and decrease when we breathe out because the chest cavity increases to give space for lung (Student D, TG 1).

During inhalation lung volume increases; diaphragm leaves the place for lung (contracts), it moves down, chest cavity increases, ribs moves up. During exhalation the reverse occurs because the chest cavity increases and decreases due to intercostal muscles (Student G, TG2).

When we inhale, the volume of lungs increases and the size becomes large and the diaphragm contract. When we exhale the volume of the lungs decreases and diaphragm relaxes. The air that we take during in halation increases the volume and when air leaves lungs, the volume decreases (Student P, TG3).

During inhalation lung expands (relax) and contracts during exhalation. Diaphragm moves down to increase space for lung during inhalation and ribs move up. The gases in the lungs increase the volume (Student S, CG).

From this category, respiratory system, it seem that interviewees from TG 2 and TG 1 explained respiratory system and functions of structures, composition of inhaled and exhaled air, understanding the presence of oxygen in exhaled air and some of them even the cause for changes in lungs volume. This result supports the quantitative analysis results which show that students in the two groups performed better than the others. For instance, analysis of item 8 and 9 from this category (Table 36 and 37) and the line graph (Fig. 11) clearly show the better performance of students in the two groups. The misconception that the volume of the lungs change due to movement of air in to and out of the lung, identified during quantitative data analysis, also identified during interview.

The fourth question was about the general concept of respiration. When we look at students' response to these general questions, most of the interviewees described respiration and well differentiated its types in terms of the presence and absence of oxygen but some interviewees from CG confused it with breathing which can be considered as misconception while others explained it properly. Interviewees from TG 2 and TG 1 explained it very well with the reaction that occurs especially during aerobic respiration. Sample excerpts are presented as follows:

> *Respiration is the process that cells use to produce energy. That is: Glucose + oxygen carbon dioxide water and energy (ATP). There are two types: aerobic and anaerobic respiration. Aerobic respiration uses oxygen, as I said earlier, glucose + oxygen gives as carbon dioxide + water + ATP. In anaerobic respiration there is no use of oxygen (Student TG 1 A).*

> *Respiration is the process of producing energy in our body. I think there are two types, anaerobic and aerobic respiration. Aerobic respiration uses oxygen and anaerobic respiration occurs without oxygen. In aerobic respiration, glucose + oxygen give as carbon dioxide + water + ATP (Student H, TG2).*

Respiration produces energy for our body. It is divided in to aerobic and anaerobic respiration. Aerobic respiration uses oxygen and anaerobic respiration is without oxygen (Student M, TG3).

Respiration is mechanism of gas exchange and energy production. Two type: aerobic and anaerobic respiration. Aerobic respiration is with oxygen and anaerobic without oxygen to produce ATP (Student T, CG).

Students were also asked specific question to compare aerobic respiration with anaerobic respiration in relation to the amount of energy produced. When we look at the responses, majority of interviewees from TG1 and TG 2 responded more correctly with reasons behind. Most interviewees from TG3 and CG also answered correctly but not the reason. The followings are sample excerpts from the four groups.

Anaerobic respiration produces little energy but aerobic respiration produces more energy. I think it is because in aerobic respiration uses oxygen to breaks down glucose to release all energy in the food but in anaerobic respiration glucose forms lactic acid (Student A, TG 1).

Aerobic respiration produces more energy than anaerobic respiration because our body uses oxygen to break food completely and release all energy in the food molecules (Student H, TG2).

Aerobic respiration gives more energy but no reason mentioned (Student M, TG3).

Aerobic produces more ATP because there is exchange of gases during breathing (Student T, CG).

From this category, cellular respiration, it looks that majority of the interviewees from all groups understood the concept of respiration and the difference between aerobic and anaerobic respiration. Interviewees from TG 2 and TG 1 explained the reason behind production of more energy. This result also provides supportive evidence for quantitative data in which TG 2 students were better in understanding concepts. For instance, analysis of item 12 from this category (Table 38) and the line graph (Fig. 11) clearly show the better performance of students in TG 2. However, interview result showed that interviewees from TG 1 had sound understanding of the concepts in this category unlike the quantitative result.

The fifth question was about the general concept of circulatory system. When we look at students' response, to this general question, most of the interviewees from TG 1, TG 2, TG 3 and CG described what blood circulation mean and the difference between systemic and pulmonary circulatory system but failed to correctly trace the path of the whole circulatory system except some interviewees from TG1 and TG2. Sample excerpts are presented as follows:

> *Blood circulation is the transport of blood in the body. Blood circulation consists of three parts: Heart, blood vessels and blood. Blood from right heart goes to lung -- left auricle -- left ventricle –- then pumped to the body. Deoxygenated blood enters the right auricle -- right ventricle -- lung -- left auricle -- left ventricle – then oxygenated blood move to the body parts. Pulmonary circulation is transport of blood from heart to lung whereas systemic circulation is the transport of blood from heart to body part (Student A, TG 1).*

> *Blood circulation is the transport of blood to heart and lung and body parts. Blood from body parts – right part of heart – right auricle –right ventricle – lung -left auricle - left ventricle – then pumped to different parts of the body. Pulmonary circulation transports blood between heart and lung but systemic circulation transports blood between body and heart (Student G, TG2).*

> *Blood circulation is a system of blood transportation. Oh! …….. I think it is from heart to the body and from the body to the heart. Systemic circulation is from heart to different parts of the body (Student M, TG3).*

> *Blood circulation is the transport of blood in our body. I do not remember the exact path but I think it is from body to the heart… Imm…. no I can't. Pulmonary circulation pumps blood to the lungs and I think systemic circulation pumps blood to other body organs (Student T, CG):*

Nevertheless, when students are asked specifically about the function and nature of left and right side of the heart, almost all interviewees from TG 1 and TG 2 understood that the heart has four chambers and left and right part of the heart are different but some answered the reason correctly. Some of the interviewees from TG 3 and CG answered the difference correctly but none of them answered the reason behind. Sample excerpts are presented as follows:

The left and right side of the heart are different. They have left and right atrium and ventricles. Left side pump oxygenated blood and right side pump deoxygenated blood. Left side of the heart has strong muscles especially left ventricle because they pump blood long distance with high pressure in our body (Student A, TG 1).

The right and the left part of the heart are not the same. The difference depends on the blood they receive and transport. The right receives deoxygenated blood and passes it to the lung but the left receives oxygenated blood and passes to different parts of the body. I think the left side has strong muscles because it pumps oxygenated blood strongly to long distance to all body parts (Student G, TG2).

The left and right side of the heart are different. They receive oxygenated and deoxygenated blood respectively. I think the left is stronger than the right, no reason mentioned (Student M, TG3).

The two side of the heart are different. Right side carries deoxygenated blood and left side has oxygenated blood, no reason mentioned (Student T, CG).

The second specific question directed to students was about the type, function and nature of blood vessels. Majority of the interviewees from each group mentioned the types and described their function but variation occurred in explaining why arteries are thick and have elastic nature. In this case, some interviewees from TG 1 and majority of interviewees from TG 2 performed better in explaining the nature of arteries. The followings are sample excerpts from the four groups.

Blood vessels transports blood in our body. There are three blood vessels. These are arteries, veins and capillaries. The difference is that veins – carry deoxygenated blood except pulmonary vein; arteries – carry oxygenated blood except pulmonary artery and capillaries – link veins and arteries and carry both oxygenated and deoxygenated blood. Arteries are thick because they transport the blood with high pressure (Student B, TG 1).

Blood vessels carry blood in our body. There are three types of blood vessels; Arteries, Veins and Capillaries. They differ in that Arteries – take oxygenated blood away from the *heart with high pressure; veins take deoxygenated blood towards the heart with low pressure and capillaries connect small arteries and veins. Arteries have elastic nature that helps them to relax and contract because they transport oxygenated blood long distance away from the heart with high pressure (Student H, TG2).*

Blood vessels transport blood. There are three different types; capillaries, veins and arteries. Arteries – take oxygenated blood; veins take deoxygenated blood and capillaries connect arteries and veins. Veins are thick because they transport deoxygenated blood (Student M, TG 3).

There are different blood vessels such as arteries, veins, capillaries. Arteries carry oxygenated blood; veins carry deoxygenated blood and capillaries connect the two. I think arteries have elastic nature, no reason mentioned (Student T, CG).

The third specific question asked from circulatory system was about blood groups and blood transfusion. Most of the interviewees from all groups answered that there are four blood groups in human being. These are blood group A, B, AB and O based on blood grouping systems. Their understanding, however, differs on blood transfusion and the reason why all people cannot transfer blood to anyone. In this regard, majority of interviewees from TG 1 and TG 2 were better in understanding of blood transfusion. They explained that a person can give a blood to another person if they have the same blood type due to the presence of antigen and antibody. They also understood that blood type O is a universal donor because it has no antigen and blood type AB is universal recipient because it has no antibody. Some interviewees from TG 3 and CG also explained the transfusion well but most of them unable to do so. Misconception was also identified from TG 3. The followings are sample excerpts from the four groups.

Blood transfusion is the transfer of blood from one person to another. It is only possible if the blood type is the same that they can transfer from one person to another person. For example a person with blood group A can give for a person with blood group A. Similarly, a person with blood group B can give for a person with blood group B. If not the same blood type, they can take from blood O because it has no antigen which reacts with other. A person with blood group AB can receive blood from all type because no *antibody. Blood group O is universal donor and blood group AB is universal recipient (Student C, TG 1).*

Blood transfusion is the transfer of blood from one person to other person. Anybody cannot transfer blood for any one. For example if a person with blood group O got accident, he receives from a person with O blood type. A person with blood type AB can receive from all blood group types. Similarly, a person with blood group A can receive and give for a person with blood group A. A person with blood type O can give blood for all blood groups. This is because they are different type because of the presence of antigen. One antigen affects the other unless they are the same. For instance, a person with type O can give for all because it has no antigen (Student I, TG2).

Blood transfusion is the giving of blood to another person. Transfer of blood depends on the blood type. Transfer is not possible unless the blood type is similar based on antibody and antigen. A person with blood type A can take blood from blood group A. A person with blood type AB can take from blood group A and B. Blood group O is universal donor. I think it is because of antigen (Student M, TG 3).

Blood transfusion is the transfer of blood. It is only if they have the same blood type blood transfer possible because ..... no answer mentioned (Student W, CG).

From this category, circulatory system, it seems that almost all interviewees from all groups described what blood circulation means and the difference between pulmonary and systemic circulation but students from TG 2 were found better in describing the correct path of blood flow in our body. Similarly, in relation to function and nature of left and right side of the heart, function and nature of blood vessels and blood groups and blood transfusion, interviewees from TG 2 and TG 1 found to be better in explaining these concepts with reasons behind. This interview result also supports the quantitative result. For instance, analysis of item 14 and 15 from this category (Table 39 & 40) and the line graph (Fig. 11) clearly show the better performance of students in the two groups. However, the result of this analysis (Table 40 & Fig. 11) indicated that TG 3 also understood concepts better.

In summary, this interview results provided evidences for the results obtained from quantitative data analysis in terms of overall mean score and percentage of each items in which students in TG 2 found to have better mean score in understanding human biology concepts, higher percentage of sound understanding and lower percentage of misconceptions followed by students in TG 1. All misconceptions that were identified from all items during each item analysis and interviews are presented in appendix (appendix 12).

Moreover, classroom observation during implementation of the intervention and interview after intervention were conducted in order to assess proper implementation of the intervention as intended and teachers and students view bout the instructional methods. During classroom observation, a checklist with list of activities (appendix 7) which the teachers are expected to implement was used and found that teachers were implementing the intervention as expected. Similarly, teachers and students in treatment groups have positive response about the instructional models used particularly 7EIMMS and 7EIM. The teachers responded that 7EIM enabled them to organize the lesson effectively and the MS helped them to focus students' attention to learning because it enabled them to always ask themselves. Students responded that the instructional models helped them to actively engage in their learning especially those students that used the MS with 7EIM indicated that they actively involved and monitored their learning progress before, during and after teaching learning process. They also indicated that the MS helped them while they are doing their home works, assignments and studying for exam.

4.1.6 Metacognitive Awareness

In addition, MAIT was administered after the implementation of the intervention was completed in order to assess the effect of training on metacongitive strategies on students' metacognitive awareness about regulation of cognition. This helps the researcher on one hand as mechanism of checking the effectiveness of the training and on the other hand to fill the gap in literature because in literature there are two claims. The first claim is that the learning cycle could create an opportunity for students to develop metacognitive awareness and the second claim is that MS should be taught to develop students' metacognitive awareness. To see the result, the analysis was made as follows staring with descriptive statistics and followed by ANOVA and post hoc multiple comparison tests.

The descriptive statistics result (Table 41) revealed that the mean score of Post-MAIT for those groups who received training on metacognitive strategies (TG 2 and TG 3) were higher than the other groups who did not receive the training (TG 1 and CG). The descriptive statistics of Post-MAIT tests scores of the groups were summarized in table 41.

Table 41 The descriptive statistics of post-metacognitive awareness scores of the groups

Variables	**Groups**											
	Treatment Group 1			**Treatment group 2**			**Treatment group 3**			**Comparison group**		
	N	M	SD	N	M	SD	N	M	SD	N	M	SD
Post-MAIT	41	3.71	.43	38	4.04	.34	43	3.94	.42	41	3.67	.58

From the results obtained, there was mean difference between the groups. Therefore, ANOVA was conducted to check whether there is significance difference between comparison and treatment groups on their Post-MAIT tests after checking assumptions. Result from one way ANOVA analysis (Table 32) revealed that there was statistically significant mean difference between the groups in Post-MAIT F (3, 163) = 6.17, p = .00).

Table 42 ANOVA result comparing groups in terms of post- MAIT scores

		Sum of Squares	**df**	**Mean Square**	**F**	***p***
Post- MAIT	Between Groups	3.76	3	1.25	6.17	.00
	Within Groups	32.47	160	.20		
	Total	36.22	163			

Although the ANOVA result showed that there was a significant mean difference between treatment groups in all dependent variables, it did not show which group differs from which one. Therefore, in order to see which group differs from the other, post hoc multiple comparisons was conducted. The post hoc multiple comparison result (Table 43) revealed that there was a statistically significant mean difference between pairs of groups (TG 1 and TG 2, p = .01; TG 2 and CG, p = .00; TG 3 and CG, p = .04) in post-MAIT. However, there was no statistically significant mean difference between pairs of groups (TG 1 and TG 3, p = .09; TG 1 and CG, p = .98 and TG 2 and TG 3, p = .76) in post-MAIT.

Table 43 post hoc multiple comparison test result

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	*p*
Post-MAIT	TG 1	TG 2	$-.33^{*}$	.10	.01
		TG 3	-.23	.10	.09
		CG	.04	.10	.98
	TG 2	TG 3	.10	.10	.76
		CG	$.36^{*}$	.10	.00
	TG 3	CG	$.27^{*}$	.10	.04

The result showed that students that received MS training (TG 2) had more awareness than those who didn't receive the training (TG 1 and CG). The result also revealed that those students that received MS training (TG 3) had more awareness than (CG). This implies that the training on metacognitive strategies has created an opportunity to increase metacognitive awareness of students. On the other hand, although students in TG 3 had higher mean score than students in CG indicating that learning cycle could create an opportunity to increase metacognitive awareness, it was not significantly different. Hence, supporting 7EIM with MS training was better than using only 7EIM and CI to help students in improving metacognitive awareness. Similarly, supporting CI with MS training was also better in enhancing students' metacognitive awareness. Therefore, teaching metacognitve strategies was better in enhancing students' metacognitive awareness than the opportunity the learning cycle created.

4.1.7 Results of Delayed Post Test Scores Analysis

In order to examine the effects of the treatment on students' retention of information gained during the intervention, delayed post tests were administered. To this end, delayed post human biology achievement test (del-post HBAT) and delayed human biology conceptual understanding test (del-post HBCUT) were used. Hence, the descriptive and inferential statistics of del-post HBAT scores and del-post HBCUT were computed.

The descriptive statistics result showed that, there were differences across groups and gender in mean scores of delayed post-HBAT and delayed post-HBCUT tests. The mean score of del-post-HBAT for TG 2 (56.47) was higher than the other groups whereas the mean score of CG was lower than the other groups. Likewise, the mean score of del-post-HBCUT for TG 2 (41.08) was higher than the other groups. Table 44 summarizes the descriptive statistics of the delayed post test across groups.

Table 44 Descriptive statistics for Del-post-HBAT and Del-post-HBCUT tests scores across groups

Variables	**Groups**											
	Treatment Group 1			**Treatment group 2**			**Treatment group 3**			**Comparison group**		
	N	M	SD	N	M	SD	N	M	SD	N	M	SD
Del-Post-HBAT	41	48.50	13.65	38	56.47	12.85	43	39.73	10.2	42	37.28	9.08
Del-Post-HBCUT	41	35.64	8.24	38	41.08	6.65	43	25.71	6.42	42	25.53	6.84

Similarly, the mean del-post-HBAT score of female students in TG 1 and TG 2 (51.07 and 57.66) were higher than male students (44.47 and 54.82) respectively but male students in CG (39.82) scored higher than female students (35.71). In TG 3 both male and female students scored almost similar result (40.18 and 39.47) respectively. Similarly, the mean del-post-HBCUT score of female students in TG 1 and TG 3 (37.11and 26.75) were higher than male students (33.33 and 23.96) respectively. Table 45 summarizes the descriptive statistics of the delayed post test across gender.

Table 45 Descriptive statistics for Del-post-HBAT and Del-post-HBCUT tests scores across gender

Variables		Groups											
		Treatment Group 1			**Treatment group 2**			**Treatment group 3**			**Comparison group**		
		N	M	SD	N	M	SD	N	M	SD	N	M	SD
Del-Post-HBAT	M	16	44.47	15.68	16	54.82	16.20	16	40.18	12.14	16	39.82	9.92
	F	25	51.07	11.79	22	57.66	10.00	27	39.47	9.11	26	35.71	8.33
Del-Pos-HBUT	M	16	33.33	7.03	16	40.62	8.54	16	23.96	6.64	16	25.69	5.32
	F	25	37.11	8.74	22	41.41	5.06	27	26.75	6.17	26	25.43	7.72

The descriptive statistics revealed that there were differences between the four groups and between male and female students. In order to see if there is any significant difference between post test and delayed post test that indicates students' retention of concepts in each group, paired sample t-test was conducted. The descriptive statistic result revealed that the mean of the TG 1, TG 2 and TG 3 in the post HBAT were (51.92, 60.98 and 42.46) respectively and the mean in the post del-post HBAT were (48.50, 56.47 & 39.73) respectively with some difference in favor of the post HBAT. The achievement score analysis revealed that there was no statistically significant mean difference between post HBAT(M = 51.92, SD = 12.44) and del-post HBAT(M = 48.50, SD = 12.44, t(40) = 1.76, p = .09) of TG 1; post HBAT (M = 60.98, SD = 16.87) and del-post HBAT(M = 56.47, SD = 16.87, t(37) = 1.65, p = .11) of TG 2 and post HBAT (M = 42.46, SD = 11.61) and del- post HBAT(M = 39.73, SD = 11.61, t(42) = 1.54, p = .13) of TG 3. This indicates that there was retention of concepts within each treatment group students in relation to achievement test. This implies that using the 7EIM alone, 7EIMMS and CIMS was effective in the retention of concepts among the students in achievement test.

However, the result revealed that the mean of the CG in the post HBAT was (40.68), and del-post HBAT was (37.28), with a difference in favor of the post HBAT. There was statistically significant mean difference between post HBAT (M = 40.68, SD = 8.79) and del-post HBAT (M = 37.28, SD = 8.79, t (41) = 2.51, p = .02) of CG. This indicates that there is lack of retention of concepts in relation to achievement test among the CG students. This implies that the conventional instruction was not effective in the retention of concepts among students in achievement test.

Table 46 paired sampled t-test result post and delayed post -HBCUT

		N	Mean	SD	t	df	*P*
Treatment group 1	Post-HBAT	41	51.92	12.44	1.76	40	.09
	Del-post- HBAT	41	48.50				
Treatment group 2	Post- HBAT	38	60.98	16.87	1.65	37	.11
	Del-post- HBAT	38	56.47				
Treatment group 3	Post- HBAT	43	42.46	11.61	1.54	42	.13
	Del-post- HBAT	43	39.73				
Comparison group	Post- HBAT	42	40.68	8.79	2.51	41	.02
	Del-post- HBAT	42	37.28				

Similarly, the result revealed that the mean of TG 1 and TG 2 in post HBCUT were (37.94 & 44.44) respectively and the mean in the del-post HBCUT were (35.64 & 41.08) respectively with some difference in favor of the post HBCUT. Analysis of conceptual understanding test scores revealed that there was no statistically significant mean difference between post HBCUT (M = 37.94, SD = 12.04) and del-post HBCUT(M = 35.64, SD = 12.04, t(40) = 1.23, p = .23) of TG 1; post HBCUT (M = 44.44, SD = 10.86) and del- post HBCUT(M = 41.08, SD = 10.86, t(37) = 1.74, p = .09) of TG 2. This indicates that there is retention of concepts in relation to understanding among students in the two treatment groups. The result indicates that using the 7E IM alone and 7EIMMS was effective in the retention of concepts among the students in conceptual understanding test.

Moreover, the result revealed that the mean of TG 3 and CG in post HBCUT were (31.91 & 30.69) and the mean in del-post HBCUT were (25.71 & 25.52) with a difference in favor of the post HBCUT. There was statistically significant mean difference between post HBCUT (M = 31.91, SD = 9.41) and del- post HBCUT (M = 25.71, SD = 9.41, t(42) = 4.32, p = .00) of TG 3; post HBCUT (M = 30.69, SD = 10.07) and del-post HBCUT (M = 25.52, SD = 10.07, t(41) = 3.32, p = .000) of CG. This indicates that there is lack of retention of concepts among students' in TG 3 and CG conceptual understanding test. This implies that CIMS and CI alone were not effective in retention of concepts among students.

Table 47 paired sampled t-test result of post and delayed post- HBCUT

		N	**Mean**	**SD**	**t**	**df**	***p***
Treatment group 1	Post -HBUT	41	37.94	12.04	1.23	40	.23
	Del-post-HBUT	41	35.64				
Treatment group 2	Post- HBUT	38	44.44	10.86	1.74	37	.09
	Del-post- HBUT	38	41.08				
Treatment group 3	Post - HBUT	43	31.91	9.41	4.32	42	.00
	Del-post- HBUT	43	25.71				
Comparison group	Post- HBUT	42	30.69	10.07	3.32	41	.00
	Del-post- HBUT	42	25.52				

In summary, HBAT analysis result showed that all treatment groups retained what they have learned but comparison group students did not retain the biology concept they have learned after some period of time. However, analysis of HBCUT revealed that TG 1 and TG 2 retained what they have learned but TG 3 and CG students did not retain the biology concepts they have learned after some period of time.

The above analysis result was to see students' retention of concepts in each group. The result revealed that students in TG 3 and CG did not retain what they gained at the end of the intervention (post test). Therefore, in order to see the difference between groups in retention of concepts, MANOVA was run. The MANOVA result revealed that there was a statistically significant mean score difference between the four groups on delayed post test scores: F (6, 310) = 21.89, p = 0.00; Wilks' Lambda = .49; η^2 = .30. The eta squared (η^2) value is .30 indicating that 30 % of multivariate variance of dependent variables was explained by treatment effect. The eta squared value (η^2) is much larger than typical value based on the (Cohen, 1988). Nevertheless, there was no statistically significant mean score difference between males and females on delayed post test scores: F (2, 155) = 1.23, p = .29; Wilks' Lambda = .98; η^2 = .02. Furthermore, there was no statistically significant interaction effect between gender and treatment group F (6, 310) = .98, p = .44; Wilk's λ = .96; η^2 = .02. The eta squared (η^2) value of interaction effect is .02 which is quite smaller based on the (Cohen, 1988). Table 48 shows the delayed post test MANOVA result.

Table 48 Delayed post test MANOVA Result

	Wilks' Lambda	**F**	**df**	**Error df**	***P***	**η^2**
Treatment group	.49	21.89[b]	6.00	310.00	.00	.30
Gender	.98	1.23[b]	2.00	155.00	.29	.02
Gender * Treatment group	.96	.98[b]	6.00	310.00	.44	.02

Tests of Between-Subjects Effects result table (Table 49) shows that there was statistically significant mean score difference between groups in del- post-HBAT (p = .00), Eta-Squared .28 and de-post-HBCUT (p = .00), Eta-Squared .46. The eta squared values (η^2) are much larger than typical value based on the (Cohen, 1988). The eta squared (η^2) values are .28 and .46 indicating that 28% and 46% of multivariate variance of dependent variables of del-post-HBAT and de-post-HBCUT was explained by treatment effect. This means that the difference in retention of concepts between the groups is accounted for by the intervention. However, there is no statistically significant difference between males and females in del-post-HBAT (p = .53), Eta-Squared .00 and in del-post-HBCUT (p = .12), Eta-Squared .02. The results revealed that there was no statistically significant interaction effect between gender and treatment group, p = .20; η^2 = .03 for del- post-HBAT and, p = .57, η^2 = .01 for del-post-HBCUT.

Table 49 Test of Between-Subject Effect-Delayed posttest

	Dependent variables	**Type III Sum of Squares**	**df**	**F**	***p***	**η^2**
Treatment group	Del-Post-HBAT	8126.07	3	20.47	.00	.28
	Del-Pos-HBUT	6811.49	3	45.56	.00	.46
Gender	Del-Post-HBAT	52.55	1	.40	.53	.00
	Del-Pos-HBUT	112.24	1	2.45	.12	.02
Gender * Treatment group	Del-Post-HBAT	626.83	3	1.58	.20	.03
	Del-Pos-HBUT	99.77	3	.67	.57	.01

In order to see which groups is different from the others, post hoc multiple comparisons was computed. In this case, the alpha level adjusted to .025 by dividing 0.05 to 2 because there are two dependent variables measured through del-post HBAT and del-post HBCUT.

The post hoc multiple comparison result revealed that there was statistically significant mean difference between each pair of the group (p = .01 & .00) except between TG 3 and CG (p= .76) in delayed post-HBAT mean scores**.** Students in TG 2 performed better than TG 1, TG 3 and CG in retention with mean gain of 7.89, 16.73 and 19.19 respectively. Similarly, students in TG 1 performed better than TG 3 and CG in retention with mean gain of 8.77 and 11.22 respectively in delayed HBAT mean scores.

This indicates that students in TG 2 retained the concept learned significantly better than the other groups. Similarly, students in TG 1 retained concepts significantly better than TG 3 and CG. But students in TG 3 and CG did not significantly differ in retaining what they gained in post HBAT though students in CG didn't retain what they gained in post test.

Similarly, the post hoc multiple comparison result revealed that there was statistically significant mean difference between each pair of the group (p = .00) except between TG 3 and CG (p= .98) in delayed post-HBCUT mean scores**.** Students in TG 2 performed better than TG 1, TG 3 and CG in retention with mean gain of 5.45, 15.37 and 15.55 respectively. Similarly, students in TG 1 performed better than TG 3 and CG in retention with mean gain of 9.92 and 10.11 respectively in delayed HBCUT mean scores. But students in TG 3 and CG did not significantly differ in retaining concepts in HBCUT though they did not retain post test result.

This implies that students in TG 2 retained the concept learned significantly better than the other groups. Similarly, students in TG 1 retained concepts significantly better than TG 3 and CG. But students in TG 3 and CG did not significantly differ in retaining concepts in conceptual understanding test. The following table shows the multiple comparison result.

Table 50 multiple comparisons of delayed post test scores

Dependent Variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	*p*
Del-Post-HBAT	TG 1	TG 2	-7.89*	2.59	.01
		TG 3	8.77*	2.51	.00
		CG	11.22*	2.53	.00
	TG 2	TG 3	16.73*	2.56	.00
		CG	19.19*	2.58	.00
	TG 3	CG	2.46	2.50	.76
Del- Post-HBUT	TG 1	TG 2	-5.45*	1.59	.00
		TG 3	9.92*	1.54	.00
		CG	10.11*	1.55	.00
	TG 2	TG 3	15.37*	1.57	.00
		CG	15.55*	1.58	.00
	TG 3	CG	.18	1.53	.98

In summary, HBAT and HBCUT analysis result showed that TG 2 students retained what they have learned significantly better than TG 1, TG 3 and CG. This implies that supporting 7EIMMS was effective in helping students to retain what they have learned in classroom. Similarly, TG 1 students retained what they have learned significantly better than TG 3 and CG. This means, using 7EIM alone is also better than the other two methods of teaching in helping students to retain concepts.

4.2 Discussion of Results

In the previous sections, the researcher presented the data analysis results and interpretation of both quantitative and qualitative data. In this section, the findings from the data analysis results in relation to achievement, conceptual understanding, retention of concepts and motivation are presented, triangulated and discussed in relation to findings from different related literature.

As it is mentioned, the aim of this study was mainly to investigate the effect of 7E instructional model with metacognitive strategies on 9^{th} grade students' achievement, conceptual understanding, retention of concepts in human biology and motivation. The topics covered in this study included food and nutrition, the digestive systems, respiratory systems, cellular respiration and circulatory systems. To this end, four schools were purposely selected and randomly assigned as treatment groups and comparison group and the intervention was carried out for 10 weeks. Data were collected through pretest and post test using human biology achievement test, human biology conceptual understanding test and science motivation questionnaire and delayed post test using human biology achievement test and human biology conceptual understanding test to assess students' achievement, conceptual understanding, retention and motivation. While assessing students' conceptual understanding, misconceptions were also identified. In addition, semi-structured interviews were conducted with 24 students to determine students' conceptual understanding and misconceptions held by students to triangulate the quantitative data obtained from human biology conceptual understanding test.

Before the start of the intervention, human biology achievement test, human biology conceptual understanding test and science motivation questionnaire were administered as pretests to all groups. The descriptive statistics result of the pretest for human biology achievement test, human biology conceptual understanding test and science motivation questionnaire (Table 20) showed that the mean score of the groups seems somewhat different. However, the ANOVA result (Table 21) showed that there was no significant difference between the groups in relation to human biology achievement test, human biology conceptual understanding test and science motivation questionnaire mean scores. Therefore, the groups were assumed to be equal in terms of their knowledge, understanding of concepts and motivation before the start of the intervention. Hence, the findings of this study on achievement, conceptual understanding, retention, motivation and misconception are accredited to the effectiveness of the intervention and not to students' prior difference.

After ensuring that there was no significant difference between the groups, the intervention was implemented. After the implementation of the intervention, all groups took post tests on human biology achievement test, human biology conceptual understanding test and science motivation questionnaire. Then, a delayed post test on human biology achievement test and human biology conceptual understanding test were administered for all groups 6 weeks later after the implementation of the intervention was completed. After checking the assumptions for the MANOVA and computing descriptive statistics of the post test score of human biology achievement test, human biology conceptual understanding test and science motivation questionnaire and delayed post test score of human biology achievement test and human biology conceptual understanding test, analyses were made with each dependent variable in relation to the independent variables. In addition to achievement, conceptual understanding, retention and motivation, misconceptions were also identified and discussed from human biology conceptual understanding test and interview results.

The first research question of the study was to investigate if there is a significant mean score differences in students' achievement, conceptual understanding and retention of human biology concepts between groups. In relation to achievement, which was measured by post human biology achievement test, treatment group 1 and treatment group 2 students achieved greater mean scores (M= 51.92; M = 60.98) respectively than treatment group 3 and comparison group students (M = 42.46; M = 40.68) respectively. To put in descending order, the mean score of students in treatment group 2 > treatment group 1 > treatment group 3 > comparison group.

Similarly, in relation to conceptual understanding, which was measured by post human biology conceptual understanding test, treatment group 1 and treatment group 2 students have higher mean scores (M = 37.94; M = 44.44) respectively than treatment group 3 and comparison group (M = 31.91; M = 30.69) respectively in a similar order as for achievement.

In terms of retention, similar results were obtained as achievement and conceptual understanding. Retention of concepts was measured through delayed post human biology achievement test and delayed post human biology conceptual understanding test. Treatment group 1 and treatment group 2 students have higher retention mean sores (M = 48.50, M = 56.47) than treatment group 3 and comparison group (M= 39.73, M = 37.28) respectively in achievement test. Similarly, treatment group 1 and treatment group 2 students have higher retention mean score (M =35.64, M = 41.08) than TG 3 and CG (M = 25.71, M = 25.53) respectively in conceptual understanding test.

The descriptive statistics results showed that students in treatment group 2 have higher achievement, conceptual understanding and retention mean scores than the other groups after the implementation period of the intervention followed by students in treatment group 1. There was slight difference between treatment group 3 and comparison group in the mean score of these variables.

As it can be seen from the descriptive statistics, all groups have different mean scores in achievement, conceptual understanding and retention of concepts. To check whether the differences are statistically significant, MANOVA was run. MANOVA result revealed that there was a significant mean difference between groups in achievement, conceptual understanding and retention of concepts between groups. A statistically significant difference was found between groups in these dependent variables in favor of mainly the treatment group 2 and then treatment group 1 compared to the other groups.

The findings showed that students in treatment group 2 who received 7E instructional model with metacognitive strategies outperformed treatment group 1, treatment group 3, and comparison group who received 7E instructional model alone, conventional instruction with metacognitive strategies and conventional instruction alone respectively in achievement, conceptual understanding and retention of concepts. Similarly, students in treatment group 1 who received 7E instructional model alone outperformed treatment group 3 and comparison group who received conventional instruction with metacognitive strategies and conventional instruction alone. In other words, 7E instructional model with metacognitive strategies has more significant effect on students' achievement, conceptual understanding and retention of concepts than the other three types of instructional methods. Moreover, 7E instructional model alone also has more significant effect on students' achievement, conceptual understanding and retention of concepts than the other two instructional methods. The effect size 28%, 27%, 28% and 46% for post human biology achievement test, post human biology conceptual understanding test, del post human biology achievement test and del post human biology conceptual understanding test respectively, which is much larger than typical value according to Cohen (1988). This also indicates that the difference between groups was due to the intervention ensuring its effectiveness to impact students learning.

However, the result revealed that, though the mean score was different, there was no statistically significant achievement, conceptual understanding and retention mean scores difference among treatment group 3 and comparison group. This means that the effect of conventional instruction with metacognitive strategies on students' achievement, conceptual understanding and retention is not statistically different from conventional instruction. In other words, students who received conventional instruction with metacognitive strategies did not perform well than those who received conventional instruction in terms of the three dependent variables.

In addition to human biology conceptual understanding test mean score analysis, each item of the human biology conceptual understanding test and interviews were analyzed. The results of the analysis of each of the human biology conceptual understanding test item and interview supported the findings of human biology conceptual understanding test mean score analysis result. When we categorize the percentage of students' responses in to sound understanding, partial understanding, misconceptions and no understanding, the mean percentage of students' response in the table (Table 39) showed that students in treatment group 2 have sound understanding on the concepts in human biology than the other groups. This implies that 7E instructional model with metacognitive strategies was relatively superior to the other instructional methods in helping students understand the concept. Moreover, 7E instructional model alone is also relatively superior to the two instructional methods in helping students understand the concept.

On the other hand, result showed that the mean percentages of students' response who have partially understood the concepts were almost equal in treatment group 1, treatment group 2 and treatment group 3 but a little bit higher for students in comparison group. Moreover, the mean percentage of students' response that has no understanding of the concepts was relatively low for students in treatment group 2 (19.30). This means that the 7E instructional model with metacognitive strategies helped students to learn effectively and understand concepts better than the others instructional methods.

When we examine each conceptual understanding test item, treatment group 2 students performed better in understanding the concepts in 67% of the items than treatment group 1 students, in 83% of the items than treatment group 3 students and in 89% of the items than comparison group students. Students in treatment group 2 have sound understanding in majority of test items than the other groups.

Interview result also showed that interviewees from treatment group 2 and treatment group 1explained questions very well indicating their understanding of concepts. During interview most of the interviewees from these groups explained the questions asked with the reason behind their explanation but interviewees from the other groups were observed struggling to provide correct explanation to some questions with reasons behind. However, interviewees from treatment 2 were much better in explaining the questions during interview. This implies that interviewees from treatment group 2 have understood the concepts in human biology. Moreover, interviewees from treatment group 1 also have understood concepts in human biology. This provides evidence in support of the result of quantitative data analysis.

The difference among groups can be explained by the method the teachers used to teach their students. The result from both quantitative and qualitative data analysis revealed that students taught using 7E instructional model with metacognitive strategies learned human biology better than the other groups. Hence, students in this group achieved higher, well understood and retained concepts better than the other groups. Similarly, 7E instructional model alone also helped students to learn biology better than conventional instruction alone and with metacognitive strategies.

The positive effects of 7E instructional model with metacognitive strategies on students achievement, conceptual understanding and retention of concepts is because, according to Santrock (2001), for best achievement in learning, learners must actively participate in the teaching learning process through discovery, reflection and critical thinking. Similarly, to conceptually understand concepts, an explicit confrontation between pre-knowledge and new knowledge is the critical element in learning process (Posner, George, Strike, Hewson & Gertzog, 1982; Tanner & Allen; 2005). In other words, for conceptual understanding to occur, there should be shifting and restructuring of pre existing knowledge in to new knowledge (Tanner and Allen, 2005). This type of learning, according to Posner et al. (1982), occurs through assimilation and accommodation. Similarly, according to Piaget (1953), children mental structures (schema) which are basic for learning, are constructed through the process of assimilation and accommodation leading towards equilibrium. Assimilation is using pre existing knowledge to deal with new knowledge and accommodation is replacing and reorganizing preexisting knowledge to develop a new knowledge (Posner et al., 1982). This type of learning process helps students to have deep understanding of science concepts and achieve better in their learning (Jonassen, Strobel & Gottdenker, 2005) which in turn affects students' retention of concepts.

7E instructional model is one of the learning cycles that are found to be useful to actively engage students, extract students' prior knowledge and misconceptions, discover new knowledge leading to conceptual understandings (Byee et al., 2006; Eisenkraft, 2003). In addition, literatures reported that metacognition has an effect on students learning and performance because the learners' awareness about their learning and control of the way they are learning is important in meaningful learning (Azevedo, 2005; Efklides 2006; Lin, 2001). This is because, according to Schraw, Crippen, and Hartley (2006), scientific inquiry requires metacognitive skills such as planning, monitoring, reflection, and self-evaluation of learning. Moreover, metacognition helps the learners to be independent self-directed learners (Shannon, 2008). Independent self-directed learners are responsible owners and managers of their own learning process (Hayati, 2001).

This study used 7E instructional model and metacognitive strategies to teach human biology for grade 9 students. The 7E instructional model has 7 phases. These phases are elicit, engage, explore, explain, elaborate, evaluate and extend. The first phase enables students to brainstorm prior knowledge so as to know what they know and identify misconceptions. According to Piaget (1953), the prior knowledge serve as a back ground information on which the new information either fit with it through the process of assimilation or reorganized changing their schema through the process of accommodation. The second phase is engagement in which students are actively engaged mentally in their learning through activities that focus their attentions and curiosity (Bybee, et al., 2006). At this stage either students try to assimilate the new information with existing mental structures or reorganize to develop new knowledge, accommodation. The third phase is exploration in which students observe, explore, formulate hypothesis, test and record results and discuss with students. This leads to the process of equilibration between existing mental structure and new information either through assimilation or accommodation. The fourth phase is explanation in which student presents concepts, processes and skills briefly to the teacher and the classmates. In this phase equilibration continues and misconceptions can be corrected. The fifth phase is elaboration in which students further discuss the concepts. This helps them to understand concepts and minimize misconceptions. The sixth phase is evaluation in which students assess their understanding and skills acquired with feedback from the teacher. The seventh phase is extend phase in which students apply what they have learned in their day to day life.

Metacognitive strategies used in this study include the strategies of regulations of cognition in metacognition. These are planning, monitoring and evaluation. The metacognitive strategies enable learners to develop metacognitive skills of planning, monitoring and evaluation which are important skills in scientific inquiries (Schraw, Crippen, and Hartley, 2006). These strategies also enable students to use their prior knowledge and continuously monitor the learning progress. This is an important aspect of meaningful learning in science.

Therefore, students in this study benefited from combined advantages of 7E instructional model and metacognitive strategies so as to enhance their achievement, conceptual understanding and retention of concepts in learning biology. The use of the metacognitive strategies contributed to the superiority of the 7E instructional model with metacognitive strategies over 7E instructional model alone in improving students' achievement, conceptual understanding and retention of concepts in biology. This is because, in addition to the opportunities the 7E instructional model provided for students to think and reflect what is in their mind (elicit), actively engage in investigations, explain and relate what they have learnt with their day to day life, the metacognitive strategies gave opportunities for students to plan ahead what they want to learn, monitor their learning progress while learning and to evaluate what they have learned before the actual assessment by the classroom teacher.

As a result, students taught by 7E instructional model with metacognitive strategies outperformed in achievement, understanding and retention of concepts than students taught with 7E instructional model alone. Moreover, students instructed with 7E instructional model alone also performed better than those instructed with conventional instruction alone and conventional instruction with metacognitive strategies.

However, the use of metacognitive strategies with conventional instruction was not effective in enhancing students learning. The reason might be in conventional instruction most of the time teachers used lecture method, commonly known as traditional method, which didn’t give opportunities for students to actively engage in their learning because they are expected to listen to the teacher and take note at the same time. This in turn did not give opportunities for students to use metacognitive strategies because they are busy so as not to miss what the teacher is writing and talking about. Moreover, in traditional approach, most of the time students expect more knowledge from the teacher rather than searching knowledge using their own strategies. This also might be affected students using metacognitive strategies.

Research findings point out that the traditional instructional approach encourages memorization and recalling of facts which is gaining knowledge than conceptual understanding (Zakaria & Iksan, 2007). In this approach, students are passive listeners than active participants in learning. Similarly, Dhaaka (2012) also reported that this approach encourages students to memorize the content and reproduce the same to pass the examination without understanding the concept of the subject. Researchers indicated that students' academic achievement cannot be determined by acquiring knowledge to pass examination but rather by acquiring deep meaningful understanding of the materials presented to the students (Sakiyo & Waziri, 2015).

Another result of this study was that students may score higher in examination prepared based on commonly used multiple choice assessment techniques but this is not a guarantee for meaningful learning with conceptual understanding. For instance, according to the findings of this study the mean score of human biology achievement test was greater than the mean score of human biology conceptual understand test. This is because students may gain knowledge but lack understanding of concepts. According to Wiggins & McTighe (1998), gaining knowledge about science may not be understanding science. They associated the term knowing with facts, memorization, and superficial knowledge, whereas the term understanding with more complex, multidimensional integration of information into a learner's own conceptual framework.

The achievement in this study, the knowledge gained, was measured with traditionally used multiple choice test (human biology achievement test) items which does not require learners to provide reasons why they selected the answer for the question. This assesses only the knowledge gained. Whereas the two tiers multiple choice tests (human biology conceptual understanding test) used to measure conceptual understanding requires students to provide reasons for the answer they selected as correct answers. This assesses conceptual understanding of concepts. The result implies that higher scores in traditional multiple choice test do not imply learning with conceptual understanding. As indicated in the statement of the problem of this study, the national learning assessment result in Ethiopia showed that students are unable to attain the minimum requirement. National learning assessment used the traditional multiple choice test to assess students. So, if the students did not score the required result with this type of assessment, it is not difficult to imagine what happens to students score national learning assessment if they were provided with two tiers multiple choice tests that require them to provide the reasons for their answer. According to the finding of this study, students scored higher in achievement test but not as such in conceptual understanding test. It is possible to infer that they could score even lower than what was reported in the national learning assessment result if two tiers multiple choice tests were used instead of the traditional multiple choice tests. The 7E instructional model with metacognitive strategies was found to be useful instructional model in order to enhance both students' achievement and conceptual understanding.

Related literatures indicated that learning cycle has positive effect on students learning. Different researchers investigated the effect of learning cycles on students achievement, conceptual understanding and retention in biology (Appamaraka, Suksringarm, & Singseewo, 2009; Cakiroglu, 2006; Doğru and Tekkaya, 2008; Kaynar, Tekkaya, and Cakıroğlu, 2009; Sadi & Cakiroglu, 2010). The results of these studies show that the treatment groups instructed with the learning cycles better performed in biology results than the controlled group instructed with traditional approach. For instance, studies conducted on high school students understanding of diffusion and osmosis found that learning cycle instruction promoted students understanding (Marek, Cowan, and Cavallo, 1994; Odom and Kelly, 2001). According to these findings, students taught with learning cycle had better understanding about the concept of diffusion and osmosis than those taught with expository instruction. Other results obtained from researches conducted on the effectiveness of 5E learning cycle shows that students' achievement, conceptual understanding and retention improved after the instruction of 5E learning cycle (Ajaja, 2013; Artun and Coştu, 2012; Ates, 2005; Cakiroglu, 2006; Ceylan & Geban, 2009; Lee, 2003; Lord, 1999; Musheno & Lawson, 1999; Nuhoglu and Yalcin, 2006; Sadi and Çakiroğlu, 2010).

Similarly, different studies conducted to compare the effectiveness of 7E learning cycle with traditional instruction on students' achievement, conceptual understanding and retention of concepts reported significant result in favor of 7E learning cycle (Gök, 2014; Mecit, 2006; Polyiem, Nuangchalerm & Wongchantra, 2011; Shaheen & Kayani, 2015). The results of these studies revealed that 7E instructional model significantly improved students' achievement conceptual understanding and retention of concepts than traditional instruction. For instance, a research conducted by Shaheen & Kayani (2015) found that 7Einstructional model was more effective than traditional instruction in terms of students' biology achievement.

Even though, 7E learning cycle was found to be effective in enhancing students' learning, few researches have been conducted by combining 7E learning cycle with other strategies. For instance, a research conducted by Bulbul (2010) shows the effectiveness of 7E learning cycle with computer animation on students' conceptual understanding. Students in this group performed better in understanding of concepts in osmosis and diffusion. Parallel to this result Kunduz & Secken (2013) conducted a research in chemistry and found that experimental groups taught with 7E learning cycle with computer assisted teaching material performed better in achievement than control group. Another research conducted by Warliani, Muslim and Setiawan (2016) on effects of 7E learning cycle model using technology based constructivist teaching shows that students in experimental group performed better in understanding than control group instructed with 7E learning cycle model alone in physics.

Some studies compared the effectiveness of learning cycle with metacognitive strategies on students' learning. For instance, Blank (2000) found that the learning cycle with metacognitive strategies has positive effect on students' ecology understanding than traditional instruction but not on content knowledge. Appamaraka, et al, (2009) also investigated the effect of 5E learning cycle with metacognitive techniques of intelligibility, plausibility and wide – applicability on students learning and reported that the experimental groups gained more learning.

Nevertheless, few studies has been conducted on the effect of 7E instructional model with metacognitive strategies on students' achievement, conceptual understanding and retention and reported significant result in favor of the 7E instructional model with metacognitive strategies. For instance, a research conducted by Sornsakda, Suksringarm & Singseewo (2009) on the effect of using 7E instructional model with three metacognitive techniques of intelligibility, plausibility and wide applicability in environmental education found that the experimental groups performed better in learning achievement, integrated science process skills and critical thinking than control group. The other research conducted by Yerdelen-Damar & Eryilmaz (2016) on the effectiveness of metacognitive 7E learning cycle using metacognitive activities on the students' epistemological understandings in physics revealed that students with in experimental group performed better. They found that the group assigned with metacogntive 7E learning cycle performed better than those taught with teacher-centered instruction. However, the type and the way they used the metacognitive strategies was different from the type and the way metacognitive strategies are used in this study. In this study, metacognitive strategies of planning, monitoring and evaluation in regulation of cognition, one component of metaconition, were used and implemented in classroom using KWHAL chart, self regulation check list and metacognitive prompts.

Generally, the findings of this study supported the previous research findings that revealed 7E instructional model with technology and with some metacognitive strategies is more effective than the other approaches to enhance students' biology achievement, conceptual understanding and retention of concepts and extended the previous findings because this study used different approaches. Moreover, the result provides further empirical support for the studies that reported significant results about the effectiveness of 7E instructional model alone over conventional instruction on students' biology achievement, understandings and retention of concepts. The finding ensures that using 7E instructional model alone is important in enhancing students learning but supporting the 7E instructional model with metacognitive strategies is even significantly better to increase students learning than using 7E instructional model alone.

The second research question of the study was to examine if there is significant mean score difference in students' motivation between groups. Students' motivation was measured by administering science motivation questionnaire before and after the intervention. As it is indicated in pretest analysis no significant difference were observed between groups. After the implementation of the intervention, there was a difference between groups in which treatment group 1 and treatment group 2 (M= 2.99, M = 3.02) have higher science motivation questionnaire mean score than treatment group 3 and comparison group (M = 2.57, M=2.55). The MANOVA result revealed that the mean score of some groups statistically differs from the others. The science motivation questionnaire mean score of treatment group 2 was statistically different from treatment group 3 and comparison group. The science motivation questionnaires mean score of treatment group 1 was also statistically different from treatment group 3 and comparison group. Though the science motivation questionnaires mean score of treatment group 2 is higher than science motivation questionnaire mean score of treatment 1, the difference between them was not statistically significant. Similarly, the difference in science motivation questionnaire mean score between treatment group 3 and comparison group was not statistically significant.

Students taught using 7E instructional model with metacognitive strategies seem to be more motivated than students instructed with conventional instruction alone and conventional instruction with metacognitive strategies but not more than those taught with 7E instructional model alone. Similarly, students instructed with 7E instructional model alone seem to be more motivated than those instructed with conventional instruction with metacognitive strategies and conventional instruction alone. This implies that metacognitive strategies did not contribute significantly for students' motivation rather it is the 7E instructional model because students in treatment group 1 and 2 motivated significantly better than students in treatment group 3 and comparison group and students in treatment group 2 didn't significantly motivate than students in treatment group 1. Moreover, no difference in motivation between those students instructed with conventional instruction with metacognitive strategies and conventional instruction because of no significant contribution of metacognitive strategies.

Literature indicated that students' motivation is very important in enhancing their achievement and conceptual understanding at all levels of schools (Cavas, 2011; Pintrich & Schunk, 2002; Rehman and Haider, 2013). Students with high motivation to learn also have high level of achievement in science than with low motivation to learn science (Chan & Norlizah, 2017; Glynn et al., 2009). This is because, according to Athman & Monroe (2004), a highly motivated person develops high levels of internal achievement and engaged in deep learning and self-regulation. Motivation has direct relation with students' achievement and understanding (Athman & Monroe, 2004; Cavas, 2011; Chan & Norlizah, 2017; Glynn et al., 2009; Pintrich & Schunk, 2002; Rehman and Haider, 2013).

As it is reported in literature, motivation of students can be influenced by the instructional method used in classroom (Mills, 1991; Tuan, et al., 2005; Williams & Williams, 2011). Teaching approaches that actively involve learners would likely lead to higher motivation and meaningful learning compared to those where they remain passive (Shihusa and Keraro, 2009). Among teaching methods, according to Kim (2005) and Turk and Calik (2008) learning cycle is effective method in improving student motivation to learn science. Motivation has also positive relation with the use of metacognitive strategies (Landine and Stewart, 1998). According to Aydın (2016), the use of metacognitive strategies has positive effects on students' intrinsic motivation to learn biology.

The research findings of Shihusa and Keraro (2009) on teaching methods that actively involve learners and Kim (2005) and Turk and Calik (2008) on learning cycle support the findings of this study because students taught with 7E instructional model, one of the learning cycle that actively involve learners, were more motivated than students taught with conventional instruction. This is because 7E instructional model is one of the inquiry methods that help students to actively engage in learning. Similarly, students taught using 7EIMMS and 7EIM were found to be motivated more significantly than those taught with conventional instruction with metacognitive strategies and conventional instruction. Hence, the low performance of students instructed using conventional instruction with metacognitive strategies and conventional instruction might be also due to low motivation in addition to instructional approach.

Contrary to the expectation, the use of metacognitive strategies with 7E instructional model and conventional instruction did not have significant effect on students' motivation than using 7E instructional model alone and conventional instruction alone respectively. This is not in parallel with the findings of research conducted by Aydın (2016) and Landine and Stewart (1998) which revealed that the use of metacognitive strategies has positive effect on students' motivation. This might be due to the time of the intervention that might not have been enough to influence students' motivation. Moreover, this study used only metacognitive strategies of regulation of cognition which might again affected the influence of metacognitive strategies on students' motivation. Therefore, further research is required in this regard.

The third research question of this study was to examine whether there is a significant mean score difference across gender in achievement, conceptual understanding, retention of human biology concepts and motivation or not. In this study, therefore, these variables were also investigated in relation to gender.

In relation to these dependent variables, after the implementation of the intervention, there were mean score difference between male students and female students in all variables. The MANOVA results of this study, however, revealed that there was no significant mean difference between male and female students in achievement, conceptual understanding, retention of human biology concepts and motivation. Moreover, the interaction between gender and treatment had no significant effect on students' conceptual understanding, retention of concepts in human biology and motivation except for post achievement. Therefore, it can be said that male and female students gained similar benefits from the implementation of the intervention.

Research findings indicated that science was one of the areas in which gender difference was most strongly pronounced and reported some favoring male, some females and the others showing no difference between them in achievement, understanding retention of concepts and motivation. The results of this study are consistent with the studies that investigated the effectiveness of learning cycle across gender. Several studies indicated no significant difference between males and females with respect to science learning (Cakiroglu, 2006; Hupper et al., 2002; Ugwu & Soyibo, 2004; Thompson & Soyibo, 2002). For example, Ugwu and Soyibo (2004) indicated that there is no significant gender difference in performance on nutrition and plant reproduction concepts among students.

Similarly, the finding of this study is compatible with the studies that conducted and found no significant difference between male and female students in students' motivation towards science learning (Akbaş & Kan, 2007; Albert, 2010; Ongowo & Hungi, 2014). Therefore, the intervention has no effect on both males and females motivation to learn biology.

The fourth and the fifth research questions were about misconceptions held by students and extent of these misconceptions among groups. Hence, one of the purposes of this study was to identify misconceptions in human biology concepts and compare the effects of the instructional methods with respect to misconceptions and in relation to conceptual understanding of concepts. As indicated in literature, students generally come to science classroom with their own understandings, commonly referred to prior knowledge, about how the natural world works (Madu, 2012). Some of these understandings may be inconsistent with the scientific views and are labeled as misconceptions (Nakhleh, 1992; Treagust, 1988; Schmidt, 1997).

Misconceptions can be an obstacle for learning since the knowledge construction occur based on already existing understandings (Guzzetti, 2000, Stavy, 1991; Wandersee, Mintzes, Novak, 1994). Therefore, identifying and finding ways of minimizing misconceptions is very important for meaningful learning. Being aware of the students' misconceptions is very important for teachers for designing their instruction to remedy these misconceptions and overcome the difficulties of students in learning concepts.

Hence, this study investigated misconceptions held by students' in human biology concepts from human biology conceptual understanding and interviews. According to the findings of this study, 7E instructional model with metacognitive strategies was effective than the other instructional methods in terms of conceptual understanding of human biology concepts and reduction of misconceptions. The analysis of students' post human biology conceptual understanding scores showed that students taught by 7E instructional model with metacognitive strategies understood the concepts well and reduced misconceptions compare to students instructed with 7E instructional model alone, conventional instruction alone and conventional instruction with metacognitive strategies. For instance, when we categorize the percentage of students responses from human biology conceptual understanding test in to sound understanding, partial understanding, misconceptions and no understanding, lower mean percentage of misconceptions was recorded for students in TG2 (25.13). But relatively higher mean percentage of misconceptions was recorded from students in TG 3 (31.52) and CG (30.87). This implies that the misconceptions held by students in TG 2 are relatively lower than the other groups ensuring the effectiveness of 7EIMMS than the others in minimizing misconceptions followed by TG 1 (27.65) with 7EIM.

The relatively lower mean percentage of misconception found among students instructed by 7E instructional model with metacognitive strategies implies that the use of metacognitive strategies with 7E instructional model helped students in understanding concepts better than using 7E instructional model alone. This is because, although students instructed by 7E instructional model elicit their prior knowledge, engaged in exploration of concepts by their own, the use of metacognitive strategies of planning, monitoring and evaluation helped them more to manage their learning, enhance their understanding and minimize misconceptions.

Although the students instructed with 7E instructional model with metacognitive strategies understood the concepts better and reduced misconceptions than the other instructional methods, still there are misconceptions held by students in the groups. This is because some misconceptions are resistant to change and can remain after instruction (Guzzetti, 2000; Kaynar, Tekkaya and Cakiroglu, 2009). Analysis of post human biology conceptual understanding test and interview result revealed that students' in all treatments and comparison group hold some misconceptions though the extent of the percentage of the misconceptions held varies between groups.

When we examine each item of human biology conceptual understanding test in relation to misconceptions, students in treatment group 2 holds less percentage of misconceptions in 61% of the items than treatment group 1 and in 67% of the items than treatment group 3 and 72% of the items than comparison group. Similarly, students in treatment group 1 hold less percentage of misconceptions in 67% of the items than treatment group 3 and in 61% the items than comparison group. This implies that, though it is difficult to remove all misconceptions, the misconceptions held by students in treatment group 2 were highly reduced compared to the other groups followed by students in treatment group 1.

Highest percentages of misconceptions were recorded from different items for the groups. For instance, for treatment group 1 the highest percentage was recorded from item number 10 with percentage of 51.22%; for treatment group 2 from item 16 with percentage of 50%; for treatment group 3 and comparison group from item 13 with percentage of 58.13 and 54.76 respectively. This might be due to the nature of the concepts and extent of the emphasis the teachers gave while they teach. Item 10, 13 and 16 deals about gas exchange, energy production and blood circulation respectively. Literature indicated that concepts in these areas were among the most difficult biology topics to be learnt by students (Anderson, Sheldon and Dubay, 1990; Jennison and Reiss, 1991 and Seymour and Longdon, 1991).

The result obtained from the analysis of human biology conceptual understanding test is supported with results obtained from the interview. Interview result showed that interviewees from treatment group 2 and treatment group 1 explained questions very well. During interview most of the students in treatment group 1 and 2 explained the question raised but students in the other groups were observed struggling to provide correct explanation to questions and misconceptions were found in all groups though the extent varies.

Misconceptions in relation to digestion, presence of oxygen in exhaled air, causes for change in volume of the lungs and nature of the heart were mainly identified from treatment group 1, treatment group 3 and comparison group. For example, from analysis of human biology conceptual understanding test, two major misconceptions were indentified from treatment group 3 and comparison group in concepts of food and nutrition. One of the items asked from this category was about the result of glucose test with Benedict's solution and reason behind the change in colour during glucose test with Benedict's solution. Students in treatment group 3 answered the formation of orange red colour was due to when water boils, it changes its colour and students in CG answered due to monosaccharide is reduced in the reaction to disaccharides. The correct conception is that the colour change is due to the reduction of copper II to copper I compound during the reaction. From my observation, this concept was presented in the form of activity in the text book (in a box) but most of the time teachers did not give emphasis for such activities in the textbook because of lack of materials, their focus on theoretical aspects and they think that it takes time to do the activities which in turn affects their pace to complete the course on time at the end of the academic year. This might be the cause to hold these misconceptions.

From digestive system category, students know that mechanical digestion breaks food in to smaller soluble ones but they considered that mechanical digestion release enzymes from glands and involves enzyme action to break large food substance. These misconceptions were also obtained from treatment group 3 and comparison group respectively. The correct conception is that mechanical digestion breaks dawn food in to smaller pieces by teeth bite and chewing and muscular tubes so as to increase the surface area for enzymes action. This misconception may be due to the general information that enzymes speed up chemical reaction in digestion. However, this one occurs in chemical digestion.

Similarly, with regards to absorption of food in small intestine is that students considered absorption of food from small intestine in to blood stream is because of the process of peristalsis to move substance through villi. They confused with the movement of food through the digestive track. The correct conception is that absorption occurs in small intestine because digestion is completed in small intestine and contains structure called villi that increase surface area for diffusion to occur rapidly in to the blood stream.

From respiratory system category, students know that the lungs change the volume during inhalation and exhalation but they considered that change in volume of the lungs is due to the movement of air in to and out of the lungs during inhalation and exhalation and this results change in volume of thoracic cavity. These misconceptions were observed in all groups. The reasons for these misconceptions were the way the activities are designed and the way the teacher explains the process. From my classroom observation, I realized that this might be due to the model that was prepared by students from two balloons, plastic bottle, tube and string based on the activities in the text book. The two balloons represent the lungs, the plastic bottle the thoracic cavity and the tube the trachea. Students used the model in classroom while learning by blowing air in to the balloon through the tube but the model does not show clearly what happens to the thoracic cavity, ribs, intercostals muscles and diaphragm except an increase in the volume of the balloon. They observe when the two balloons expand as they blow air in to it and contract when air leaves the balloon. This seems that it is the air that moves in and out that changes the volume of the lung. However, the correct conception is that it is due to an increase in the volume of the thoracic cavity, the contraction and relaxation of diaphragm, intercostals muscles and movement of ribs. It is because of the surface tension between the thoracic (chest) cavity that the thoracic cavity increases in volume (size) and the lungs increase in volume as well.

Figure 13 Classroom Activities

The other misconception was that students faced a difficulty in differentiating between breathing and respiration. They considered that breathing is the process of getting oxygen into the lungs and carbon dioxide out while respiration is the process of getting oxygen from the lungs to the body and carbon dioxide from the body into the lungs and moves these gases around the body. This misconception was also observed in all groups. This might be because both processes are related with oxygen and carbon dioxide. The other reason may be within the text book it was written as respiratory system for breathing which confuses students with respiration. The correct conception is that breathing is the process of getting oxygen from the atmosphere in to the cells and carbon dioxide out of the cells and in to the atmosphere while respiration is the process in which the cells produce energy and carbon dioxide.

From circulatory system, students know that the left side of the heart is thicker and muscular than the right side but they answered this is because of it pumps blood to a relatively short distance, it receives much of the digested food to build them and it is found in the left side of the chest. Most of these misconceptions were observed in treatment group 3 and comparison group. The correct conception is that left side of the heart is thicker and muscular because they pump blood long distance from the heart throughout the body. This may be due to the diagram of the heart which did not show the difference clearly muscles and thickness.

The other misconception identified was about the reason behind the transfer of blood from one person to another person. Although students know that blood type O is universal donor, they hold misconceptions. They considered that blood type O is universal donor because it has no antibody that reacts with antigen of the red blood cells of the person; has antigen that do not react with antibody in the red blood cells of the person and has no antigen and antibody that reacts with the red bloods of the person. The correct conception is that a person with blood type A can receive blood from blood type O because blood type O has no antigen that reacts with antibody of the red blood cells of the person with blood type A. This helps the blood type O not to be recognized by other cells. The misconception may be due inability of students to differentiate the concepts of the function of antigen and antibody clearly due to prefix similarity.

Literature indicated that there are different sources of misconception in science education. Some of them, according to Duit & Treagust, (1995) and Harrison & Treagust (1996) include the text books; the teachers; the culture and language; the mass media; daily usage of concepts; personal real-life experiences and lack of understandings from previous school courses. Moreover, innate structures of the brain (Duit 1991) and traditional instruction (Kindfiled, 199) were also reported as source of misconceptions. So, the source of misconception identified in this study could not be different from the sources of misconceptions indicated in the literature.

There are different research findings that support the findings of the current study. For instance, according to Marek, et al. (1994), using learning cycle is useful to minimize misconceptions and to help students understand the concepts. Moreover, the results obtained from the research conducted on the effectiveness of 5E learning cycle show that students' misconceptions reduced after the instruction of 5E instructional model (Ajaja, 2013; Artun and Coştu, 2012; Cakiroglu, 2006; Nuhoglu and Yalcin, 2006; Sadi and Çakiroğlu, 2010).

Similarly, in this study, students assigned with 7E instructional model with metacognitive strategies minimized misconceptions than students taught with 7E instructional model alone, conventional instruction alone and conventional instruction with metacognitive strategies because they were engaged in eliciting and exploring concepts by their own and they planned, monitored and evaluated themselves using metacognitive strategies with the help of the teacher. Students taught with 7E instructional model alone were also able to understand human biology better and minimized misconceptions than the two groups taught with conventional instruction alone and conventional instruction with metacognitive strategies.

However, some misconception in this study also remained after the implementation of the intervention. This is because literature reported that it is difficult to completely eliminate misconceptions as there are various misconceptions (Duit & Treagust, 1995; Harrison & Treagust, 1996). Several researchers, in support of the findings of this study, reported that students had misconceptions after instructions (Guzzetti, 2000; Kaynar, Tekkaya and Cakiroglu, 2009; Stavy, 1991; Wandersee, Mintzes, Novak, 1994).

Chapter Five: Summary, Conclusion and Recommendation

Introduction

This chapter presents the main ideas about the process of the study, findings of the study and the way forward. The first section depicts the summary, the second section present conclusion and the third section covers the recommendations made by the researcher.

5.1 Summary

The main purpose of this study was to investigate the effects of 7E instructional model with metacognitive strategies on students learning biology and motivation. Learning biology in this study expressed in terms of biology achievement, conceptual understanding and retention of biology concepts which are measured through human biology achievement test and human biology conceptual understanding test. Furthermore, effects of 7E instructional model alone and conventional instruction with metacognitive strategies were also investigated. The research was conducted on 9^{th} grade students in Addis Ababa, Ethiopia. For this study, nonequivalent quasi experimental research design was employed. Four schools were selected purposely and assigned as treatment and comparison group randomly. Four different instructional methods were designed and implemented in these four schools on one group from each school. Treatment group 1 was taught by 7E instructional model alone. Treatment group 2 was taught by 7E instructional model with metacognitive strategies. Treatment group 3 was taught by conventional instruction with metacognitive strategies and comparison group was with conventional instruction.

The study was carried out for 10 weeks using four teaching periods per week each with 45 minute. At the beginning, metacognitive awareness inventory test was administered to students in all groups and then teachers and students from treatment group 2 and treatment group 3 were trained about the metacognitive strategies. Teachers from teachers from treatment group 2 and treatment group 1 were trained about 7E instructional model and ways of the implementation of the intervention. In addition, before the beginning of the implementation of the intervention human biology achievement test, human biology conceptual understanding test and science motivation questionnaire were administered as pretests. At the end of the implementation of the intervention, human biology achievement test, human biology conceptual understanding test and science motivation questionnaire were administered as post test. Moreover, after 6 weeks of the implementation of the intervention, human biology achievement test, human biology conceptual understanding test were administered as delayed post test to assess retention of concepts. The analyses of data were made with ANOVA and MANOVA beyond other descriptive analysis.

The result of the ANOVA revealed that there was no significant mean difference between the four groups in terms of students' achievement, understanding on human biology concepts and motivation before the intervention. So, the four groups were assumed to be the same in relation to achievement, understanding and motivation. Hence, the difference observed at the end of the intervention was due to the intervention carried out during the implementation period.

To address the objectives of the study, intervention was made and quantitative and qualitative data were collected after the implementation of the intervention and computed using MANOVA, follow-up ANOVA, percentage and qualitative analysis. The findings of this study revealed that students in treatment group 2 outperformed than the other three groups in achievement, conceptual understanding and retention of biology concepts. This implies that 7E instructional model with metacognitive strategies was effective in enhancing students' achievement, conceptual understanding and retention of concepts than the three instructional methods. The findings also revealed that students in treatment group 1 outperformed the other two groups. This implies that 7E instructional model alone was also effective in enhancing students' achievement, conceptual understanding and retention of concepts than the two instructional methods but not better than 7E instructional model with metacognitive strategies. However, the findings revealed that supporting conventional instruction with metacognitive strategies did not help much in enhancing students' achievement, conceptual understanding and retention of concepts than conventional instruction. Moreover, the findings indicated that the intervention did not prefer any of the gender in enhancing students learning in terms of achievement, conceptual understanding and retention of concepts.

In relation to motivation, the finding revealed that students in treatment group 2 were more motivated than treatment group 3 and comparison group but not than students in treatment group 1. Likewise, students in treatment group 1 were more motivated than treatment group 3 and comparison group. This implies that students taught using 7E instructional model with metacognitive strategies and 7E instructional model were more motivated than students taught using conventional instruction with metacognitive strategies and conventional instruction alone but students in the two groups were not different in motivation. This indicates that it is not the metacognitive strategies that contributed for their motivation rather it is the 7E instructional model. Moreover, students instructed with conventional instruction with metacognitive strategies and conventional instructions were not different in motivation.

In relation to misconceptions held by students, in a similar way treatment group 2 students were better in minimizing misconceptions than the others followed by students in treatment group 1. Hence, 7E instructional model with metacognitive strategies helped students to minimize misconceptions than the other methods. In the same way, 7E instructional model alone was also helpful in minimizing misconceptions compared to conventional instruction with metacognitive strategies and conventional instruction alone.

5.2 Conclusion

Science education is one of the determinant factors in the development of a nation. Biology, is one of the science subjects, that contributes for the development of the country. Biology education equips learners with the basic knowledge and skills that are essential in the study of such fields as medicine, agriculture and biotechnology and plays a great role in many of the contemporary issues and problems such as nutrition, health, drug abuse, agriculture, pollution, rapid population growth, environmental degradation, global warming and conservation. Therefore, understanding of biological knowledge is necessary. However, national learning assessment results indicated that students achievement in biology were not satisfactory. Literature indicated that one of the causes for low achievement is the instructional approaches in classroom. Hence, there is a need for instructional approaches that help students to understand biology and be able to apply their knowledge in their day to day life. From the finding of this study, 7E instructional model with metacognitive strategies is found to be effective in enhancing students learning than the other instructional approaches. This implies that using metacognitive strategies with 7E instructional model help students to learn biology concepts better. When students are supported with metacognitive strategies of planning, monitoring and evaluation, they benefited much from 7E instructional model. 7E instructional model alone is also found to be effective than conventional instruction with metacognitive strategies and conventional instruction in enhancing students learning. Hence, using 7E instructional model in classroom than using the conventional instruction is also most likely to enhance students learning. However, using metacognitive strategies with conventional instruction is not useful to enhance students learning and is not better than conventional instruction alone. Metacognitive strategies seem to work better with 7E instructional model than conventional instruction because conventional instruction with metacognitive strategies did not help students in enhancing their learning better than conventional instruction. The 7E instructional model with metacognitive strategies is also found to be very useful in reducing misconceptions held by students followed by 7E instructional model alone. These instructional approaches served both male and female students apparently at the same scale. Moreover, the finding indicated that 7E instructional model have positive effect on students' motivation. Hence, using 7E instructional model helps to enhance students' motivation.

Hence, using 7E instructional model with metacognitive strategies can significantly enhance students' achievement, conceptual understanding and retention of scientific concepts related to human biology and reduction of misconceptions than the other instructional methods provided that similar conditions but further research is required.

5.3 Recommendation

The Ethiopian education policy developed in 1994 clearly indicated that one of the aims was to produce citizens who are physically and mentally well developed and are capable of solving problems of the society and contribute for the development of the nation through education (TGE, 1994). To attain this aim there should be quality education that results in meaningful learning. Students also need to meet the expected standards. To this end, they must grasp the necessary knowledge, skills and attitude from an appropriate school curriculum. But national learning assessment and examination results of the students in the country are not promising. It is obvious that one of the factors that affect students' meaningful learning is the teaching learning process. The method of instruction in and outside of the class is part of the teaching learning process. Therefore, searching appropriate method of teaching learning becomes very important so as to have meaningful learning and to improve students' learning to meet expected standards.

According to the finding of this study using 7EIMMS may be a better option in enhancing students learning biology. Consequently, the findings of this research suggest that if 7EIMMS is used, it will help students to enhance their learning and motivation. Hence, the researcher recommends to teachers and students to use this method of teaching and learning to enhance students learning of biology as well as other subjects. The researcher developed the following model and proposes for use by all concerned (Fig. 12):

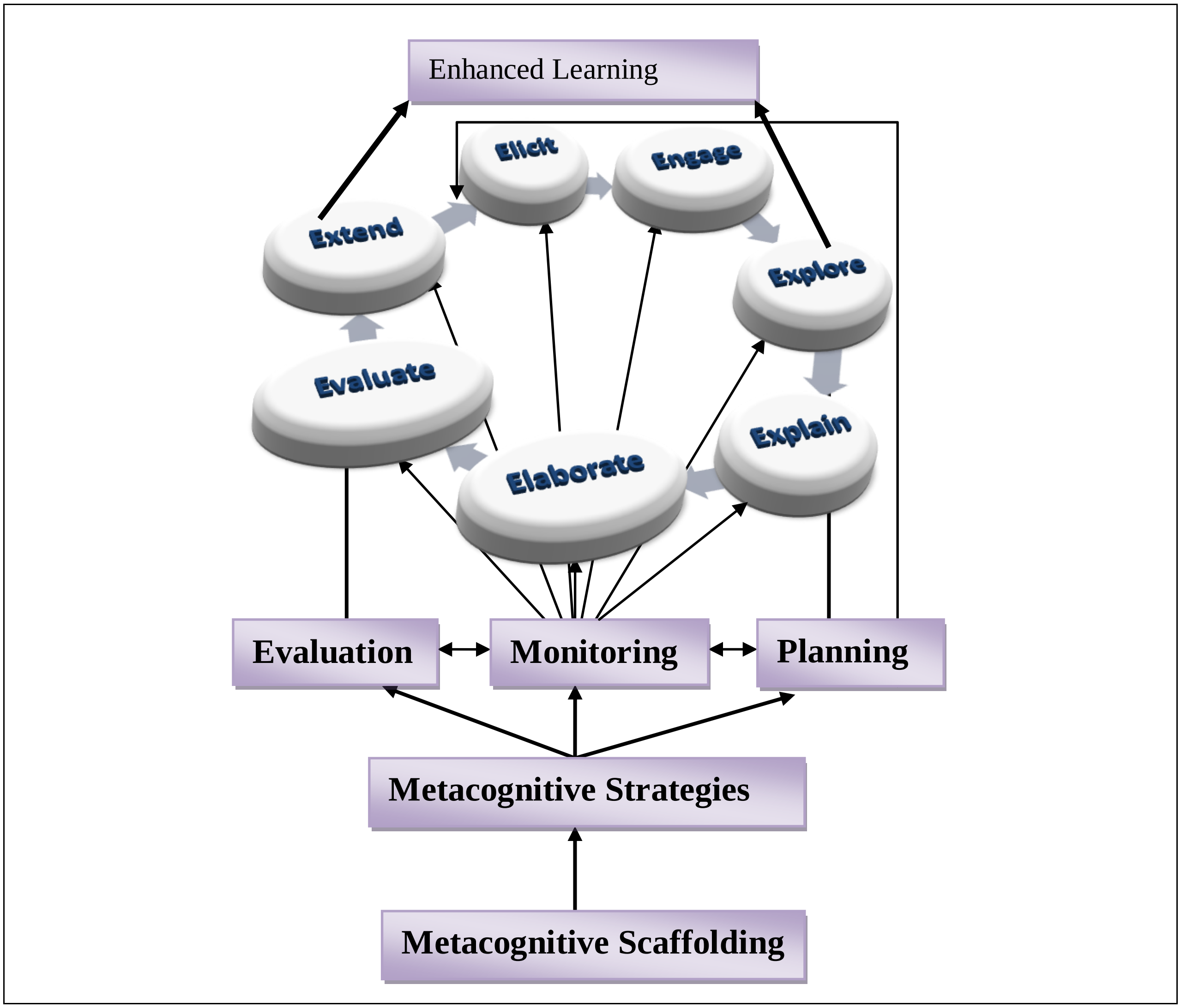

Figure 14 7E Instructional Model with Metacognitive Strategies proposed by the researcher (7EIMMS)

Moreover, the findings of this study suggests to different stakeholders; such as, policy makers, curriculum, text book and other supplementary material developers to incorporate appropriate pedagogy (like 7E instructional model with metacognitive strategies in this case) that fits today's leading learning theory, constructivism, in order to maximize students learning. However, this is a preliminary research to entirely inform these stakeholders. Thus, further research is needed to provide more empirical evidence for the effectiveness of the method.

Moreover, based on the findings the researcher recommends more research in the following areas:

- Widening the target population: this research was conducted in four government schools in the capital city, Addis Ababa for about ten weeks. Therefore, research can be conducted in different government and private schools and grade levels with a larger sample size at different regions for a long period of time to increase generalizability of conclusions.
- Widening the subject/content areas: this research was conducted on biology, specifically on human biology contents. Further research, however, can be conducted to investigate the effect of the 7Einstructional model with metacognitive strategies on students' achievement, understanding, retention of concepts, misconception and motivation other than human biology concepts and other science subjects. Such research may be able to provide evidence about the effectiveness of the method over different biology topics and other science subjects like chemistry, physics physical education and mathematics.
- Using variety of assessment techniques: the research findings of this study showed that students did not score similar results on achievement test and conceptual understanding test. Research, therefore, can be conducted on the assessment techniques that we are using. It would be good to develop a two-tier diagnostic test so as to measure students' conceptual understanding on different biology concepts instead of using the traditional multiple choice test.

- Metacognitive strategies: this study employed some parts of metacognitive strategies mainly regulation of cognition. It is better to extend and consider other metacognitive strategies in knowledge of cognition.

Reference

Adamuti-Trache, M., & Andres, L. (2008). Embarking on and persisting in scientific fields of study: Cultural capital, gender, and curriculum along the science pipeline. *International Journal of Science Education, 30(12),* 1557-1584.

Adesoji, F. A. & Idika M. I. (2015). Effects of 7E learning cycle model and case-based learning strategy on secondary school students' learning outcomes in chemistry. *Journal of the International Society for Teacher Education.19 (1),* 7-17.

Adunola, O. (2011). The Impact of Teachers' Teaching Methods on the Academic Performance of Primary School Pupils in Ijebu-Ode Local cut Area of Ogun State. Nigeria: Ogun State, Ego Booster Books.

Agaba, K. C. (2013). Effect of Concept Mapping Instructional Strategy on Students Retention in Biology. *African Education Indices, 5(1),* 1-8.

Ahmed, M. A., & Abimbola, I. O. (2011). Influence of teaching experience and school location on biology teachers' rating of the difficult levels of nutrition concepts in Ilorin, Nigeria. *Journal of science, technology, and mathematics education, 7*(2), 52-61.

Ainley, M. (2004). Connecting with learning: Motivation, affect and cognition in interest process. *Educational Psychology Review, 18 (4),* 391-405.

Ajaja, O. P. (2013). Which strategy best suits biology teaching? Lecturing, concept mapping, cooperative learning or learning cycle? *Electronic Journal of Science Education, 17(1)*, 1-37.

Akbas, A. & Kan, A. (2007). Affective factors that influence chemistry achievement (motivation and anxiety) and the power of these factors to predict chemistry achievement. *Journal of Turkish Science Education, 4 (1),* 10-20.

Albert, Z. (2010). Motivation to learn science and cognitive style. *Eurasia Journal of Mathematics, Science & Technology Education*, 6 (2), 123-130.

Alkhawaldeh, S. A. (2007). Facilitating conceptual change in ninth grade students' understanding of human circulatory system concepts. *Research in Science and Technological Education, 25(3),* 371-385.

Alparslan, C., Tekkaya, C., & Geban, Ö. (2003). Using the conceptual change instruction to improve learning. *Journal of Biological Education, 37(3),* 133-137.

Amedu, O. I. (2015).The Effect of Gender on the Achievement of Students in Biology Using the Jigsaw Method. *Journal of Education and Practice, 6(17),* 176-179.

Anderman, E. M. & Young, A. J. (1994). Motivation and strategy use in science: Individual differences and classroom effects. *Journal of Research in Science Teaching, 31* (8), 811-831.

Anderson, C. W., Sheldon, T. H., & Dubay, J. (1990). The Effects of Instruction On Collage Nonmajors' Concepts of Respiration and Photosynthesis. *Journal of Research in Science Teaching, 27(8),* 761 - 776.

Anderson, N. J. (2002). The Role of Metacognition in Second Language Teaching and Learning. Washington DC: ERIC Publications, ERIC Digests.

Appamaraka, S., Suksringarm, P., & Singseewo, A. (2009). Effects of learning environmental education using the 5Es-learning cycle approach with the metacognitive moves and the teacher's handbook approach on learning achievement, integrated science process skills and critical thinking of high school (grade 9) students. *Pakistan Journal of Social Sciences*, *6*(5), 287-291.

Areaya, S. (2008). Policy formulation curriculum development and implementation in Ethiopia. Addis Ababa University: The Book Center.

Arslan, H. O., Cigdemoglu, C., & Moseley, C. (2012). A three-tier diagnostic test to assess pre-service teachers' misconceptions about global warming, greenhouse effect, ozone layer depletion, and acid rain. *International Journal of Science Education, 34(11),* 1667-1686.

Artun, H. & Costu, B. (2012). Effect of the 5E Model on Prospective Teachers' Conceptual Understanding of Diffusion and Osmosis: A Mixed Method Approach. *Journal of Science Education and Technology,* 22,1-10.

Ary, D., Jacobs, L. C. & Sorensen, C. K. (2010). Introduction to Research in Education (8th ed.). Canada: Wadsworth, Cengage Learning.

Asabere-Ameyaw, A., Sefa Dei, G. J., Raheem, K. (2012). Contemporary Issues in African Sciences and Science Education. Netherlands: Sense Publishers.

Ates, S. (2005). The effectiveness of the learning cycle method on teaching dc circuits to prospective female and male teachers. *Research in Science & Technological Education, 23(2)*, 213-227.

Athman, J.A., & Monroe, M.C. (2004). The effects of environment- based education on students' achievement motivation. *Journal of Interpretive Research*, 9(1), 9-25.

Atilboz, N. G. (2004). 9th Grade students' understanding levels and misconceptions about mitosis and meiosis. *Journal of Gazi Education Faculty, 24*(3), 147-157.

Atkin, J., & Karplus, R. (1962). Discovery of invention? *Science Teacher, 29(5),* 45–47.

Ausubel, D. (1968). *Educational psychology:A cognitive view*. NewYork: Holt, Rinehart, & Winston.

Aydın, G., & Balım, A. G. (2009). Students' misconceptions about the subjects in the unit: The systems in our body. *Procedia-Social and Behavioral Sciences, 1*(*1*), 2258-2263.

Aydın, S. (2016). An Analysis of the Relationship between High School Students' Self-efficacy, Metacognitive Strategy Use and their Academic Motivation for Learn Biology. *Journal of Education and Training Studies, (4)2,* 53-59.

Azevedo, R. (2005). Using hypermedia as a metacognitive tool for enhancing student learning? The role of self-regulated learning. *Educational Psychologist*, *40*(4), 199–209.

Baeten, M., Dochy, F., & Struyven, K. (2012). Using students' motivational and learning profiles in investigating their perceptions and achievement in case-based and lecture-based learning environments. *Educational Studies, 38,* 491–506.

Bahar, M., Johnstone, A. H. & Hanseli, M. H. (1999). Revisiting Leaming Difficulties in Biology. *Journal of Biological Education, 33(2),* 84 - 86.

Balcı, S., Çakıroğlu, J. & Tekkaya, C. (2006). Engagement, Exploration, Explanation, Extension, and Evaluation (5E) Learning Cycle and Conceptual Change Text as Learning Tools. *Biochemistry andMolecular Biology Education*, 34(3), 199-203.

Bannert, M. (2006). Effects of reflection prompts when learning with hypermedia. *Journal of Educational Computing Research*, *35*(4), 359–375.

Bannert, M., & Mengelkamp, C. (2013). Scaffolding hypermedia learning through metacognitive prompts. *In R. Azevedo & V. Aleven (Eds.), International handbook of metacognition and learning technologies* (pp. 171–186). New York: Springer.

Bannert, M., & Reimann, P. (2012). Supporting self-regulated hypermedia learning through prompts. *Instructional Science*, *40*(1), 193-211.

Barman, C. (1997). *The learning cycle revisited: A modification of an effective teaching model.* Monograph 6. Washington, DC: Council for Elementary Science International.

Bekele, A. & Melesse K. (2010). Enactment of student-centered approach in teaching mathematics and natural sciences: the case of selected general secondary schools in Jimma Zone, Ethiopia. *Ethiop. J. Educ. and Sc.* 5(2), 29-50

Bekele, A. (1991). Principles of Curriculum inquiry. A Technical Material for the course principle of curriculum inquiry. Addis Ababa

Berhanu A. (2013). The plasma-based instruction in Ethiopia: Utopia or Dystopia? Educational Research and Reviews. *Academic Journals, 8(24),* 2325-2338.

Berhe, D. (2006). Investigating the effects of metacognitive instruction in learning primary school science in some schools in Ethiopia. Unpublished Dissertation, Ethiopia.

Best, J. and Kahn, J. (2006). *Research in education*(10th ed.) Boston: Pearson Education, Inc.

Betül, S., Haluk Ö. & Netzat, Y. (2011). Investigation of primary students' motivation levels towards science learning. *Science Education International, 22 (3),* 218-232.

Beyessa, F. (2014). Major Factors that Affect Grade 10 Students' Academic Achievement in Science Education at Ilu Ababora General Secondary of Oromia Regional State, Ethiopia. *International Letters of Social and Humanistic Sciences Online,* 32*, 118-134.*

Bilal, E. & Erol, M. (2012). Effect of teaching via modeling on achievement and conceptual understanding concerning electricity. *Journal of Baltic Science Education, 11(3),* 236-247.

Bishaw, A. Lasser, J. (2012). Education in Ethiopia: Past, Present and Future Prospects *African Nebula*, Issue 5.

Blakely, E., & Spence, S. (1990). Thinking for the future. *Emergency Librarian, 17*(5), 11-14.

Blank, L.M. (2000). A Metacognitive Learning Cycle: A Better Warranty for Student Understanding? In P.W. Hewson (Ed), Learning (pp.486–506). Missoula: John Wiley & Sons, Inc.

Boekaerts, M., Pintrich, P. R., & Zeidner, M. (Eds.). (2000). *Handbook of self-regulation*. San Diego: Academic Press.

Boopathiraj, C. and Chellamani, K. (2013). Analysis of Test Items on Difficulty Level and Discrimination Index in the Test for Research in Education. *International Journal of Social Science & Interdisciplinary Research, 2 (2)*, 189-193

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How people learn: brain, mind, experience, and school*. Washington, DC: National Academy Press.

Brent R. & Felder R. M. (2011). Random Thoughts . . . How Learning Works. *Chemical Engineering Education, 45(4), 257-258.*

Britner, S. L. (2008). Motivation in high school science students: A comparison of gender differences in life, physical, and earth science classes. *Journal of Research in Science Teaching, 45* (8), 955-970.

Britner, S. L., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching, 43* (5), 485-499.

Brown, A. L. (1987). *Metacognition, executive control, self-regulation, and other more mysterious mechanisms*. Hillsdale, NJ: Lawrence Erlbaum.

Bruner, J. S. (1960). *The process of education*. New York: Vintage Books.

Bryan, R. R. Glynn, S. M. Kittleson, J. M. (2011). Motivation, Achievement, and Advanced Placement Intent of High School Students Learning Science. *Wiley Online Library (wileyonlinelibrary.com). DOI 10.1002/sce.20462.*

Bulbul, Y. (2010). Effects of 7E learning cycle model accompanied with computer animations on understanding of diffusion and osmosis concepts. Unpublished Doctoral Dissertation, Middle East Technical University, Ankara, Turkey.

Bulu, S., & Pedersen, S. (2010). Scaffolding middle school students' content knowledge and ill-structured problem solving in a problem-based hypermedia learning environment. *Educational Technology Research and Development, 58(5),* 507-529.

Burke, J. D. (1983). Teaching styles in college geography. *Journal of Geography*, 82(6), 255-256.

Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research, 65*(3), 245-281.

Bybee, R.W. & Landes, N. M. (1990). Science for life and living: An elementary school science program from the Biological Sciences Curriculum Study. *The American Biology Teacher, 52(2),* 92-98.

Bybee, W. Rodger, Joseph A. Taylor, April Gardner, Pamela Van Scotter, Janet Carlson Powell, Anne Westbrook, & Nancy Landes, (2006). The BSCS 5E Instructional Model: Origins, Effectiveness, and Applications. Colorado Springs, CO: BSCS.

Cakiroglu, J. (2006). The effect of learning cycle approach on students' achievement in science ögrenme evreleri yaklasiminin ögrencilerin fen basarisina etkisi. *Eurasian Journal of Educational Research, 22*, 61-73.

Camahalan, F. M. G. (2006). Effects of self regulated learning on mathematics achievement on selected Southeast Asian children. *Journal of Instructional Psychology, 33*(3), 194-205.

Campbell, D.T., & Stanley, J.C. (1963). *Experimental and quasi experimental designs for research.* New York: American Educational Research Association.

Caravita, S., & Falchetti, E. (2005). Are bones alive? *Journal of Biological Education, 39*(4), 163-170.

Caraway, K., Tucker, C.M., Reinke, W.M., & Hall, C. (2003). Self-efficacy, goal orientation, and fear of failure as predictors of school engagement in high school students. *Psychology in the Schools*, 40(4), 417-427.

Carin, A. A. & Bass, J. E. (2001). *Teaching science as inquiry.* Columbus: Upper Saddle River.

Cavallo, A. M. L., McNeely, J. C., & Marek E. A. (2003). Eliciting students' understandings of chemical reactions using two forms of essay questions during a learning cycle. *International Journal of Science Education, 25(5),* 583-603.

Cavallo, A. M. L., Rozman, M., & Potter, W. H. (2004). Gender differences in learning constructs, shifts in learning constructs, and their relationship to course achievement in a structured inquiry, yearlong college physics course for life science majors. *School Science and Mathematics*, 104, 288-300.

Cavallo, A. M. L., Rozman, M., Blinkenstaff, J., & Walker, N. (2003). Students' learning approaches, reasoning abilities, motivational goals and epistemological beliefs in differing college science courses. *Journal of College Science Teaching, 33*, 18-23.

Cavas, P. (2011). Factor affecting the motivation of turkish primary students for science learning. *Science Education International*, *22(1)*, 31-42.

Ceylan, E & Geban, Ö. (2009). Facilitating conceptual change in understanding state of matter and solubility concepts by using 5E learning cycle model. *Hacettepe University Journal of Education*, *36*, 41-50.

Chan Y. L. & Norlizah C. H (*2017*). Students' Motivation towards Science Learning and Students' Science Achievement. *International Journal of Academic Research in Progressive Education and Development, 6 (4)*, 174-189

Chandrasegaran, A. L. Treagust, D. F. & Mocerino, M. (2007). The development of a two-tier multiple-choice diagnostic instrument for evaluating secondary school students' ability to describe and explain chemical reactions using multiple levels of representation. *Chemistry Education Research and Practice, 8 (3),* 293-307.

Chattopadhyay, A. (2012). Understanding of mitosis and meiosis in higher secondary students of northeast India and the implications for genetics education. *Education, 2*(3), 41-47.

Chauhan, A. & Singh, N. (2014) Metacognition: A Conceptual Framework. *International Journal of Education and Psychological Research*, *3(3),* 21-22.

Chow, S. J., & Yong, B. S. (2013). Secondary School Students' Motivation and Achievement in Combined Science. *US-China Education Review B, 3* (4), 213-228.

Christianson, R. G. & Fisher, K. M. (1999). Comparison of student learning about diffusion and osmosis in constructivist and traditional classrooms. *International Journal of Science Education, 21 (6),* 687– 698.

Chu, H. E., Treagust, D. F., & Chandrasegaran, A. L. (2009). A stratified study of students' understanding of basic optics concepts in different contexts using two-tier multiple-choice items. *Research in Science and Technological Education, 27*(3), 253–265.

Çimer A (2004). A study of Turkish biology teachers' and students' views of effective teaching in schools and teacher education. Unpublished Dissertation, the University of Nottingham, Nottingham, U.K.

Çimer, A. (2012). What makes biology learning difficult and effective: Students' views. *Educational Research and Reviews,* 7(3), 61-71.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). USA: Lawrence Erlbaum Associates, Publishers.

Cohen, L. and Manion, L. (1989) Research Methods in Education. 3rd .. edn. London: Routledge.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education*. New York: Routledge.

Coley J. D. & Tanner K. D. (2012). Approaches to Biology Teaching and Learning, Common Origins of Diverse Misconceptions: Cognitive Principles and the Development of Biology Thinking. *CBE—Life Sciences Education,11*, 209–215.

Collins, J. W., & O'Brien, N. P. (Eds.) (2003). Greenwood Dictionary of Education. Westport, CT: Greenwood. London.

Colliver J. A. (2002). Constructivism: The View of Knowledge That Ended Philosophy or a Theory of Learning and Instruction? *Teaching and Learning in Medicine*, *14*(1), 49–51.

Conner, L., & Gunstone, R. (2004). Conscious knowledge of learning: Accessing learning strategies in a final year high school biology class. *International Journal of Science Education*, 26, 1427–1443.

Connor, J. (2006). Instructional reading strategy: KWL (know, want to know, learned). http://www.indiana.edu/~l517/KWL.htm.

Costa, A. L. (1984). Mediating the metacognitive. *Educational Leadership, 11*, 57-62.

Creswell, J. W. & Plano Clark, V. L., (2011). *Designing and conducting mixed methods research.* California: SAGE Publication Inc.

Creswell, J. W. (1994). *Research design: Qualitative and quantitative approaches*. Thousand Oaks, CA: Sage Publications.

Creswell, J. W. (2009). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. (3rd ed.).Thousand Okas, CA: Sage.

Cross, D. R. and Paris, S. G. (1988). Developmental and instructional analyses of children's metacognition and reading comprehension. *Journal of Educational Psychology, 80*(2), 131-142.

Darling-Hammond, L., & Youngs, P. (2002). Defining "Highly qualified teachers": What does "Scientifically-based research" actually tell us? Educational Researcher, 31(9), 13-25.

Davis, E. A. (2003) Prompting Middle School Science Students for Productive Reflection: Generic and Directed Prompts, *Journal of the Learning Sciences,* 12(1), 91-142

Demetriou, A., & Efklides, A. (1990). The objective and subjective structure of problem-solving abilities: metacognitive awareness from early adolescence to middle age. In H. Mandl, E. de Corte, S. N. Bennett, & H. F. Friedrich (Eds.), *Learning and instruction in an international context* (pp. 161–179). Oxford: Pergamon Press.

Derry, S. J. (1996). Cognitive schema theory in the constructivist debate. *Educational Psychologist, 31*, 163-174.

Devolder, A., Van Braak, J., & Tondeur, J. (2012). Supporting self-regulated learning in computer-based learning environments: Systematic review of effects of scaffolding in the domain of science education. *Journal of Computer Assisted Learning, 28(6),* 557–573.

Dhaaka, A. (2012). Concept Mapping: Effective Tool in Biology Teaching. *VSRD-TNTJ, 3(6), 225-230.*

Dhindsa, H. S. & Treagust, D. F. (2009). Conceptual Understanding of Bruneian Tertiary Students: Chemical Bonding and Structure. *Brunei Int. J. of Sci. and Math. Edu., 1(1)*, 33-51.

Dignath, C. Buettner, G., & Langfeldt, H. (2008). How can primary school students learn self-regulated learning strategies most effectively? A meta-analysis on self-regulation training programmes. *Educational Research Review 3, 101–129*

Dikmenli, M. (2010). Misconceptions of cell division held by student teachers in biology: A drawing analysis. *Scientific Research and Essay, 5(2),* 235-247.

Ding, C. and Sherman, H. (2006). Teaching effectiveness and student achievement: Examining the relationship. *Educational Research Quarterly, 29(4),* 40-51.

Dixon-Krauss,L.A. (1996) . "A Mediation Model for Dynamic Literary Instruction". Journal of Russian and Eastern European Psychology, *1*, 78-85.

Dogru-Atay, P., & Tekkaya, C. (2008). Promoting students' learning in genetics with the learning cycle. *The Journal of Experimental Education*, *76*(3), 259-280.

Donovan, S., & Bransford, J. (2005). *Scientific Inquiry and How People Learn. In: How students learn: History, Mathematics and Science in the classroom*. Washington, DC: The National Academies Press.

Draper, J. D. (2002). School mathematics reform, constructivism, and a literacy: a case for literacy instruction in the reform-oriented math classroom. *Journal of Adolescent & Adult Literacy*, 45, 520–529.

Driscoll, M. C. (1994). *Psychology of learning for instruction.* Needham Heights, MA: Allyn & Bacon.

Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational research, 23*(7), 5 – 12.

Dufera, D. (2006). Tension between Traditional and Modern Teaching-Learning Approaches in Ethiopian Primary Schools. *Journal of International Cooperation in Education,* 9(1), 123-140.

Duit, R. & Treagust, D. F. (2003). Conceptual Change: A powerful framework for improving science teaching and learning. *International Journal of Science Education, 25(6),* 671-688.

Duit, R. & Treagust, D.F. (2003). Conceptual change: a powerful framework for improving science teaching and learning. *International Journal of Science Education*, 25(6), 671–688.

Duit, R. (1991). Students' conceptual frameworks: Consequences for learning science. In S. M. Glynn, R. H. Yeany, & B. K. Brittion (Eds.), *The Psychology of Learning Science* (pp. 65-85). New Jersey: Lawrence Erlbaum Associates, Inc.

Duit, R. (1996). The Constructivist View in Science Education. What it has to offer and what should not be Expected from It. *Investigações em ensino de ciências, 1*, 40-75.

Duit, R., & Treagust, D. F. (1995). Students' conceptions and constructivist teaching approaches. In B. J. Frase & H. J. Walberg (Eds.), *Improving science education* (pp.46-69). Chicago, Illinois: The National Society for the Study of Education.

Ebel, R. L., & Frisbie, D. A. (1986). *Essentials of education measurement.* Englewood Cliffs, NJ: Prentice Hall.

Efklides, A. (2006). Metacognitive and Affect: What Can Metacognitive Experiences Tell Us About the Learning Process. *Educational Research Review, 1*, 1-3.

Efklides, A. (2008). Metacognition: Defining its facets and levels of functioning in relation to self-regulation and co-regulation. *European Psychologist, 13*, 277–287.

Eisenkraft, A. (2003). Expending 5E model: A proposed 7E model emphasizes transfer of learning and importance of eliciting prior understanding. *The Science Teacher, 70(6)*, 56-59.

Emeagwali, G. and Sefa Dei, G. J. (Ed.) (2014). African Indigenous Knowledge and the Disciplines. Netherlands: Sense Publishers.

Engida, T. (2008). Science Education in Context (SEiC) for Africa: The Case of Malawi. In: Contextualizing Science Education in Africa (news letter). *UNESCO IICBA Newsletter, 10(2)*, 2-5.

European Commission (EU) (2007). Science Education Now: A renewed pedagogy for the future of Europe. Brussels. http://ec.europa.eu/research/rtdinfo/indexen.html

Everson, H. T. & Tobias, S. (1998). The ability to estimate knowledge and performance in college: A metacognitive analysis. *Instructional Science, 26*(1-2), 65-79.

Faris S. B. (2008). Recapturing Spiritual and Cultural Values into Science Education: The Case of Ethiopia. In: Contextualizing Science Education in Africa (news letter). *UNESCO IICBA, Newsletter, 10 (2),* 6-8.

Faris S. B. (2012). Restoring Local Spiritual And Cultural Values In Science Education: The Case Of Ethiopia. Dissertation, University of Toronto.

Federal Democratic Republic Government of Ethiopia (1994): Education and Training Policy. Addis Ababa. St. George Printing Press

Federal Democratic Republic of Ethiopia, Ministry of Education (2009). Biology Syllabus, Grades 9 to 12.

Feyzioğlu E. Y. & Ergin Ö. (2012). The Effect of 5E Learning Model Instruction on Seventh Grade Students' Metacognitive Process. *Journal of Turkish Science Education, 9(3), 78-86.*

Filgona, J. & Sababa L. K. (2017). Effect of Gender on Senior Secondary School Students' Academic Achievement in Geography in Ganye Educational Zone, Nigeria. *European Journal of Education Studies, 3(4),* p. 394-410.

Finley, F. N., Stewart, J. & Yarroch, W. L. (1982). Teachers' Perceptions of Important and Difficult Science Content. *Science Education, 66(4),* 531 - 538.

Flavell, J. H. (1979). Metacognition and Cognitive monitoring: A New Area of Cognitive-developmental Inquiry. *American Psychologist, 34(10),* (906-911).

Flavell, J. H. (1981). Monitoring social cognitive enterprises: Something else that may develop in the area of social cognition. In J. H. Flavell & L. Ross (Eds.), *Social cognitive development: Frontiers and possible futures* (pp. 272-287). New York: Cambridge University Press.

Flavell, J. H. (1988). The development of children's knowledge about mind. In J. W. Astington, P. L. Harris, & R. O. Olson (Eds.), *Developing theories of mind* (pp. 21–29). Cambridge, UK: Cambridge University Press.

Fosnot, C.T. (1996). Constructivist: A psychological theory of learning. In C.T. Fosnot (Ed.), *Constructivism: Theory, perspective and Practice.* New York. Teacher College Press.

Fouché, J. & Lamport, M. A. (2011) "Do Metacognitive Strategies Improve Student Achievement in Secondary Science Classrooms?" Christian Perspectives in Education, 4(2). Available at: http://digitalcommons.liberty.edu/cpe/vol4/iss2/

Fuselier, L., & Jackson, J. K. (2010). Perceptions of collaboration, equity, and values in science among female and male college students. *Journal of Baltic Science Education, 9(2),* 109-118.

Ganyaupfu, E. M. (2013).Teaching Methods and Students' Academic Performance. *International Journal of Humanities and Social Science Invention,* 2(9), 29-35

Ganz, M. N., & Ganz, B. C. (1990). Linking metacognition to classroom success. *High School Journal, 73,* 180-185.

Gatlin, L.S. (1998). The effect of pedagogy informed by constructivism: A comparison of student's achievement across constructivist and traditional classroom environment. Unpublished Doctoral Dissertation, University of New Orlan.

Ge, X., & Land, S. M. (2003). Scaffolding students' problem-solving processes in an ill-structured task using question prompts and peer interactions. *Educational Technology Research and Development, 51*(1), 21-38.

Geberew, T. Tigist, T. & J-F, (2018). The Nature of Classroom Assessment in Ethiopian Public Secondary Schools: Subject Teachers' Views. *Journal of Education, Society and Behavioural Science* 26(3): 1-11.

George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference 11.0 update* (4th ed.). Boston: Allyn & Bacon.

Georghiades, P. (2004). Making pupils' conceptions of electricity more durable by means of situated metacognition. *International Journal of Science Education, 26*(1), 85-99.

Georghiades, P. (2004). Making pupils' conceptions of electricity more durable by means of situated metacognition. *International Journal of Science Education, 26(1),* 85-99.

Giertz, K. (2016). Quality education: The case of teacher motivation and attrition in Ethiopia. Master thesis (Unpublished). Linnet University.

Gitari W. (2008). Some Issues of Science Education in Africa. In S. Nombuso Dlamini (Ed) *New Directions in African Education*: *Challenges and Possibilities* (pp. 41- 72). Canada: University of Calgary Press.

Glynn, S. M. Brickman, P. Armstrong, N. & Taasoobshirazi, G. (2011). Science Motivation Questionnaire II: Validation with Science Majors and Non-science Majors. *Journal of Research in Science Teaching, 48(10),* 1159–1176.

Glynn, S. M., Taasoobshirazi, G., & Brickman, P. (2009). Science motivation questionnaire: Construct validation with nonscience majors. *Journal of Research in Science Teaching, 46*, 127-146.

Gök, G. (2014). The effect of 7E learning cycle instruction on 6th grade students' conceptual understanding of human body systems, self-regulation, scientific epistemological beliefs, and science process skills. Unpublished doctoral dissertation, Middle East Technical University, Turkey.

Gonzales, M.L.G. 2013. Learning goals and strategies in self-regulated learning. US-China Educational Review A, 3(1):46–50.

Gonzalez, F. (1997). Diagnosis of Spanish primary school students' common alternative science conceptions. *School Science and Mathematics, 97(2),* 68-74.

Gourgey, A. F. (1998). Metacognition in basic skills instruction. *Instructional Science, 26,* 81–96.

Grayson, J., Anderson, T. R., & Crossley, L. G. (2001). A four-level frame work for identifying and classifying student conceptual and reasoning difficulties. *International Journal of Science Education*, 23 (6), 611-622.

Greene, J. A., Dellinger, K. R., Tüysüzoglu, B. B., & Costa, L.-J. (2013). A two-tiered approach to analyzing self-regulated learning data to inform the design of hypermedia learning environments. In R. Azevedo & V. Aleven (Eds.), *International handbook of metacognition and learning technologies* (pp.117–128). New York: Springer.

Griffard, P. B. & Wandersee, J. H. (2001). The two-tier instrument on photosynthesis: What does it diagnose? *International Journal of Science Education*, *23(10)*, 1039–1052.

Guay, F., Chanal, J., Ratelle, C. F., Marsh, H. W., Larose, S., & Boivin, M. (2010). Intrinsic identified, and controlled types of motivation for school subjects in young elementary school children. *British Journal of Educational Psychology, 80(4),* 711–735.

Guzetti, B, J. (2000). Learning counter intuitive science concepts: what have we learned from over a decade of research? *Reading, Writing, Quarterly, 16*, 89-95.

Habtamu, R. (2017). Quality of Science Teaching in Secondary Schools of North Gondar Zone in Ethiopia, International Journal of Educational Sciences, 16(1-3), 21-35.

Hake, R. R., (1998). Interactive engagement versus traditional methods: A six thousand student survey of mechanics test data for introductory physics courses. *Am. J. Phys. 66*, 64-74.

Haller, E. P., Child, D. A., and Walberg, H. J. (1988). Can comprehension be taught? A quantitative synthesis of metacognitive studies. *Educational Researcher, 17*(9), 5-8.

Hannafin, M., Land, S., & Oliver, K. (1999). Open learning environments: Foundations, methods, and models. In C. Reigeluth (Ed.), *Instructional-Design Theories and Models: A New Paradigm of Instructional Theory* (pp. 115-140). Mahwah, NJ: Lawrence Erlbaum Associates.

Harrison, A. G., & Treagust, D. F. (1996). Secondary students' mental models of atoms and molecules: Implications for teaching chemistry. *Science Education, 80*(5), 509-534.

Hartle, R. T., Baviskar, S. & Smith, R. (2012). A Field Guide to Constructivism in the College Science Classroom: Four Essential Criteria and a Guide to their Usage. *Bioscene, 38(2)*, 31-35.

Hartman, H. J. (2001). Developing students' metacognitive knowledge and strategies. In H. J.Hartman (Ed.), *Metacognition in Learning and Instruction: Theory, Research, and Practice* (pp. 33–68). Netherlands: Kluwer Academic Publishers.

Hasan, S., Bagayoko, D., & Kelley, E.L. (1999). Misconceptions and the certainty of response index (CRI). *Physics Education, 34*(5), 294–299.

Haslam, F. & Treagust, D. F. (1987). Diagnosing secondary students‟ misconceptions of photosynthesis and respiration in plants using a two-tier multiple choice instrument. *J. Biol. Educ. 21(3)* 203–211.

Hayati, A. M. (2001). Self-directed learning. The Educational Resources Information Center. ERIC Digest. www.eric.ed.gov

Hazel, E., & Prosser, M. (1994). First-year university students' understanding of photosynthesis, their study strategies & learning context. *The American Biology Teacher*, 56 (5), 274-279.

Heiman, G. (1999). *Research methods in psychology* (2nd ed.). Boston: Houghton Mifflin Company.

Hejazi, S. (2006). Teaching methods in education (2nd ed). Tehran: Boshra.

Hill J. R. & Hannafin, M. J. (2001).Teaching and Learning in Digital Environments: The Resurgence of Resource-Based Learning. *ETR & D, 49(3)*, 37–52.

Hosseini, S. B. (2012). Asynchronous Computer-Mediated Corrective Feedback and the Correct Use of Prepositions: Is It Really Effective? *Turkish Online Journal of Distance Education*, *13*(4), 95–111.

Hupper, J., Lomask, S. M., & Lazarowitz, R. (2002). Computer simulations in the high school: Students' cognitive stages, science process skills and academic achievement in microbiology. *International Journal of Science Education,* 24, 803-821.

ICSU (2011). Report of the ICSU Ad-hoc Review Panel on Science Education. International Council for Science, Paris.

Imani, Z., Sabetimani, M., Qujurand, K. A., Ardestani, S. S. (2011). The Effect of Teaching Metacognition Strategies on Time Management, *J. Life Sci. Biomed.* 3(3), 221-228,

Jacob, J. E., & Bleeker, M. M. (2004). Girls' and boys' developing interests in math and science: Do parents matter? *New Directions for Child and Adolescent Development*, *106*, 5-21.

Jacobs, J. E. & Paris, S. G. (1987). Children's metacognition about reading: Issues in definition, measurement and instruction. *Educational Psychologist, 22*, 255-278.

Jennison, B. M. & Reiss, M. J. (1991). Does Anyone Know What Energy Is? *Journal of Biological Education*, 25(3), 173 - 174.

Johnson, A. M., Azevedo, R., & D'Mello, S. K. (2011). The temporal and dynamic nature of self-regulatory processes during independent and externally assisted hypermedia learning. *Cognition and Instruction*, *29*(4), 471–504.

Johnstone, A. H. and Mahmoud, N. A. (1980). Isolating Topics of High Perceived Difficulty in School Biology. *Journal of Biological Education,14(2),* 163 - 166.

Jonassan, D. (1991). Evaluating constructivist learning. *Educational technology*, 36(9) 28-33.

Jonassen, D. , Strobel, J. & Gottdenker J.. (2005). Model Building for Conceptual Change. *Interactive Learning Environments*, *13(*1), 15 – 37.

Jonassen, D.H. (2000). Revisiting activity theory as a framework for designing student-centered learning environments. **In**: D.H. Jonassen and S.M. Land (Eds.), *Theoretical Foundations of Learning Environments* (pp.89 –121). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Jones, G. (1991). Gender differences in science competitions. *Science Education*, *75*(2), 159-167.

Kahle, J., & Meece, J. (2004). Research on gender issues in the classroom. In D. L. Gabel (Ed.), *Handbook of research on science teaching and learning: A project of the National Science Teachers Association* (pp. 542-557). New York: Macmillan.

Kaynar, D., Tekkaya, C. Cakiroglu, J. (2009). Effectiveness of 5E Learning Cycle Instruction on Students Achievement in Cell Concept and Scientific Epistemological Beliefs. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *37*, 96-105.

Kennedy, M. M. (1998). Education reform and subject matter knowledge. *Journal of Research in Science Teaching*, *35*(3), 249-263.

Keraro, F. N., Wachanga, S. W., & Orora, W. (2007). Effects of cooperative concept mapping teaching approach on secondary school students' motivation in biology, Gucha District, Kenya. *International Journal of Science and Mathematics Education,* 5, 111-124.

Kim, J. S. (2005). The effects of constructivist teaching approach on student academic achievement, self concept, and learning strategies. *Asia Pasific Education Review, 6*, 7-19.

Kimberlin, C. L. & Winterstein, A. (2008). Validity and reliability of measurement instruments used in research. *Am J Health-Syst Pharm, 65,* 2276-2284.

Kinchin, I., M. (2000). Concept mapping in biology. *Journal of Biological Education, 34*(2), 61-68.

Kindfield, A. C. H. (1991). Confusing chromosome number and structure: a common student error. *Journal of Biological Education, 25*(3), 193-200.

King, A (1991). Effects of training in strategic questioning on children's problem-solving performance. Journal of Educational psychology, 83, 307-317.

King, A. (1994). Guiding knowledge construction in the classroom: Effects of teaching children how to question and how to explain. *American Educational Research Journal, 31,* 338–368.

Koballa, T. B., & Glynn, S. M. (2007). Attitudinal and motivational constructs in science learning. *In S. K. Abell & N.G. Lederman (Orgs), Handbook of Research on Science Education. Part 1. (pp.237-273).* New Jersey, London: Lawrence Erlbaum Associates.

Kothari, C.R. (2004) Research methodology, methods and techniques. New Delhi: New Age International (P) Ltd.

Krajcik, J., Czerniak, C., & Berger, C. (1999). *Teaching children science: A project-based approach.* Boston: McGraw-Hill Companies.

Krüger, D, Fleige, J., & Riemeie,T. (2006). How to foster an understanding of growth and cell division. *Journal of Biology Education*, 40 (3).

Kuhn, D. (2000). Metacognitive development. *Current Directions in Psychological Science, 9* , 178–181.

Kumari V. S.N & Jinto M (2014). Effectiveness of KWL Metacognitive Strategy on Achievement in Social Science and Metacognitive Ability in Relation to Cognitive Styles. *Int. J. Educat. Res. Technol*, 5 (1]) 92-98.

Kunduz, N. & Secken, N. (2013). Development and Applica tion of 7E Learning Model Based Compu ter-Assisted Teaching Materials on Precipitation Titrations. *Journal of Baltic Science Education, 12(6),* 784-792.

Landine, J. and Stewart, J. (1998). Relationship Between Metacognition, Motivation, Locus of Control, Self-Efficacy, and Academic Achievement. Canadian journal of counseling, (32)3, 200-212.

Latchanna, G. and Garkebo B. (2012). Effectiveness of plasma television integration in teaching secondary school biology. *MIER Journal of Educational Studies, Trends & Practices. 2(2), 215-230.*

Lawson, A. E. (2001). Using the learning cycle to teach biology concepts and reasoning patterns. *Journal of Biological Education* 35(4): 165–169.

Lawson, A. E., & Johnson, M. (2002). The validity of Kolb learning styles and neo- Piagetian developmental levels in college biology. *Studies in Higher Education*, *27*(1), 79-90.

Lawson, A. E., Abraham, M. R. , Renner, J. W. (1989). A theory of instruction: Using the learning cycle to teach science concepts and thinking skills. National Association for Research in Science Teaching.

Lawson, A. E., Thompson, L. D. (1988). Formal reasoning ability and misconceptions concerning genetics and natural selection. *Journal of Research in Science Teaching 25(9)*, 733-746.

Lawson, A.E. (2004). The nature and development of scientific reasoning: A synthetic view. *International Journal of Science and Mathematics Education, 2*, 307-338.

Lawson, A.E., Banks, D.L. & Logvin, M. (2006). Self-efficacy, reasoning ability, and achievement in college biology. *Journal of Research in Science Teaching, Published online in Wiley Inter Science.*

Lazarowitz, R. & Penso, S. (1992). High School Students' Difficulties in Leaming Biology Concepts. *Journal of Biological Education, 26(3*), 215-223.

Lee, C. A. (2003). A learning cycle inquiry into plant nutrition. *Am. Biol. Teach. 65(2),* 136–144.

Lee, V. E. & Burkam, D. T. (1996). Gender differences in middle grade science achievement: Subject domain, ability level, and course emphasis. *Science Education, 80* (6), 613-650.

Leech, N. L. Barrett, K. C. & Morgan, G. A. (2005). SPSS for Intermediate Statistics; Use and Interpretation. 2nd Edition. London: Lawrence Erlbaum Associates, Inc.

Lei, S. A. (2010). Intrinsic and Extrinsic Motivation: Evaluating Benefits and Drawbacks from College Instructors' Perspectives. *Journal of Instructional Psychology, 37(2*), 153-160.

Levitt, K. (2002). The nose knows... or does it? Using the learning cycle and questioning in a lesson about the sense of smell. *Electronic Journal of Science Education, 6*(4).

Lewin, K.M. (1992). Science education in developing countries: issues and perspectives for planners. *International institute for educational planning. UNESCO*.

Lewis, J., & Wood-Robinson, C. (2000). Genes, chromosomes, cell division and inheritance: Do students see any relationship? *International Journal of Science Education, 22*, 177-195.

Lin, S. (2004) Development and Application of a Two-Tier Diagnostic Test for High School Students' Understanding of Flowering Plant Growth and Development. *Int J Sci Math Educ*. 2: 175.

Lin, X. (2001). Designing metacognitive activities. *Educational Technology Research and Development*, *49*(2), 23–40.

Lin, X., & Lehman, J. D. (1999). Supporting learning of variable control in a computer-based biology environment: Effects of prompting college students to reflect on their own thinking. *Journal of Research in Science Teaching, 36*(7), 837–858.

Lord, T. R. (2001). 101 reasons for using cooperative learning in biology teaching. *The American Biology Teacher*, *63*(1), 30-38.

Lord, T.R. (1999). A comparison between traditional and constructivist teaching in environmental science. *The Journal of Environmental Education,* 30(3), 22 – 28.

Lucangeli, D., Cornoldi, C., & Tellarini, M. (1998). Metacognitive difficulties in problem solving skills. *Advances in Learning Disabilities, 12*, 219–243

Madu. B.C. (2012). Effect of the four-step learning cycle model on students' understanding of concepts related to simple harmonic motion. *Asia-Pacific Forum on Science Learning and Teaching, 13(1),* 1 -18.

Mahadi, T. S. T. and Jafari S. M. (2012). Motivation, Its Types, and Its Impacts in Language Learning. *International Journal of Business and Social Science, 3(24), 230 -235*.

Mann, M. & Treagust, D. F. (1998). A pencil and paper instrument to diagnose students' conceptions of breathing, gas exchange and respiration. *Australian Science Teachers Journal*, *44*(2), 55-59.

Maqsud, M. (1997). Effects of metacognitive skills and nonverbal ability on academic achievement of high school pupils. *Educational Psychology, 17*(4), 387-397.

Marasigan, A. C. and Espinosa, A. A. (2013). Modified useful-learning approach: Effects on students' achievement and conceptual understanding in chemistry. *Journal of Education Research and Behavioral Sciences, 2(11*), 206-228.

Marek, E. A., Cowan, C. C., & Cavallo, A. M. L. (1994). Students' misconception about diffusion: How can they be eliminated? *American Biology Teacher,* 56, 74-78.

Marek, E. A., Laubach, T. A., & Pedersen, J. (2003). Pre-service elementary school teachers' understandings of theory based science education. *Journal of Science Teacher Education, 14*(3), 147-159.

Marek, E. A., Maier, S. J., & McCann, F. (2008). Assessing understanding of the learning cycle: The ULC. *Journal of Science Teacher Education, 19*(4), 375-389.

Marshall, H. H. (1996). Implications of differentiating and understanding constructivist approaches. *Educational Psychologist*, *31*, 235-240.

Mauricio, L. & Pinto, R. (2008). Glucose as the Sole Metabolic Fuel: A Study on the Possible Influence of Teachers' Knowledge on the Establishment of a Misconception among Brazilian High School Students. *Advances in Physiology Education,* 32 (3), 225-230.

McCombs, B. L.& Whisler, J. (1997).*The learner-centred classroom and school: Strategies for increasing student motivation and achievement*. San Francisco: Jossey-Bass, Inc.

McCormick, C. B. (2003). Metacognition and learning. In W. M. Reynolds & G. E. Miller (Eds.), *Handbook of psychology: Educational psychology* (pp. 79–102). Hoboken: Wiley.

Mecit, Ö. (2006). The effect of 7E learning cycle model on the improvement of fifth grade students' critical thinking skills. Unpublished doctoral dissertation, Middle East Technical University, Turkey.

Meece, J. L. (2003). Applying Learner-Centred Principles to Middle School. Education. *Theory into Practice, 42*(2), 109-116.

Meece, J. L., Glienke, B. B., & Burg, S. (2006). Gender and motivation. *Journal of School Psychology*, *44*, 351-373.

Mikkila, M. (2001). Improving conceptual change concerning photosynthesis through text design, *Learn. Instr.* 11, 241–257.

Miller, M. D, Linn R. L, Gronlund, N. E, (2009). Measurement and assessment in teaching (10th ed.). Upper Saddle River, NJ: Prentice Hall.

Mills, H.R. (1991). Teaching and training. A handbook for instructors (3rd ed.). London: Macmillan.

MoE (2002). The Education and Trainning Policy and Its Implimentation. Adiss Ababa, Ethiopia.

MOE (2005). Education Sector Development Programme III (ESDP III), 2005–2010. Addis Ababa, Ethiopia.

MoE (2008). Annual Intake and Enrollment Growth and Professional Mix of Ethiopian Public Higher Education: Strategy and Conversion Plan, 2001 –2005. Addis Ababa, Ethiopia.

MoE (2010). EMIS, Planning and Resource Mobilization Management Process. Ethiopia Education Statistics Annual Abstract. Addis Ababa, Ethiopia.

Molenaar, I., & Roda, C. (2008). Attention management for dynamic and adaptive scaffolding. *Pragmatics and Cognition, 16*, 224–271.

Mubeen, S., Saeed, S., & Arif, C. (2013). An investigation of the gender difference into the status of intrinsic motivation towards science learning among intermediate science students. *IOSR Journal of Humanities and Social Science (IOSR-JHSS)*, *10*(6)81-85.

Muijs, D. (2004). *Doing Quantitative Research in Education with SPSS*. India: Sage Publications Inc.

Muijs, D., & Reynolds, D. (2001). *Effective teaching. Evidence and practice.* Gateshead: Athenaeum Press.

Muijs, D., & Reynolds, D. (2005*). Effective teaching: Evidence and practice* (2nd ed.). London: Sage Publications.

Mulu, N. (2009). Quality of Pre-university Preparation, English language proficiency and university entrance examination of students enrolling in Higher Education Insitutions. Quality of Higher Education in Ethiopian public Institutions. Addis Ababa: *Forum for Social Science Studies* (FSS), pp. 1-55.

Munck, M. (2007). Science Pedagogy, Teacher Attitudes, and Student Success. *Journal of Elementary Science Education*, 19(2) , pp. 13-24.

Musheno, B.V., & Lawson, A.E. (1999). Effects of learning cycle and traditional text on comprehension of science concepts by students at differing reasoning levels. *Journal of Research in Science Teaching, 36,* 23-37.

Nakhleh, M. B. (1992). Why some students don't learn chemistry. *Journal of Chemical Education, 69(3),* 191-196.

Namasaka, F. W., Mondoh, H. and Keraro, F. N. (2013). Effects of Concept and Vee Mapping Strategy on Students' Motivation in Biology in Secondary Schools in Uasin – Gishu District, Kenya. *International Journal of Current Research in Life Sciences, (1)7, 23-28.*

National Agency for Examinations (NAE) (2010). Ethiopian First National Learning Assessment of Grades 10 and 12 Students. Addis Ababa, Ethiopia

National Educational Assessment and Examinations Agency (NEA and EA) (2013). Ethiopian 4th National Learning Assessment of grades 4 and 8 pupils. Addis Ababa, Ethiopia

National Educational Assessment and Examinations Agency (NEA and EA) (2014). Second National Learning Assessment on Grades 10 and 12 Students. Addis Ababa, Ethiopia

Novak, J. D. (1977). *A theory of education.* Ithaca: NY: Cornell University Press.

Novak, J. D. (1990). Concept mapping: A useful tool for science education. *Journal of Research in Science Teaching, 27*(10), 937-949.

Nückles, M., Hübner, S., & Renkl, A. (2009). Enhancing self-regulated learning by writing learning protocols. *Learning and Instruction, 19*(3), 259–271.

Nuhoglu, H, and Yalcin, N. (2006). The effectiveness of the learning cycle models to increase students achievement in the physics laboratory. *Journal of Turkish Science Education,* 3(2), 28 – 30.

Odom, A.L. & Barrow, L. H. (1995). Development and Application of Two-tier Diagnostic Test measuring College Biology Students' Understanding of Diffusion and Osmosis after a Course of Instruction. *Journal for Research in Science Teaching,* 32 (1), 45–61.

Odom, A.L. & Kelly, P.V. (2001). Integrating Concept Mapping and the Learning Cycle to Teach Diffusion and Osmosis Concepts to High School Biology Students. *Science Education,* 85: 615 – 635.

Ogle, D. (1986). K-W-L: a teaching model that develops active reading of expository text. *The Reading Teacher*, 39(6), 564–570.

Ogle, D. (2005). K-W-L + in action. In: H. Daniels & M. Bizar (Eds.),*Teaching the best practice way: Methods that matter, K-12*. Portland: Stenhouse.

Ogle, D. (2009). Creating contexts for Inquiry: from KWL to PRC2. *Knowledge Quest*, 38(1), 56–61.

Okoro, C. O. and Chukwudi , E. K. *(2011).* Metacognitive Strategies: A Viable Tool for Self – Directed Learning. *Journal of Educational and Social Research Vol. 1 (4).*

Oloyede, O. I. (2010). Comparative effect of the guided discovery and concept mapping teaching strategies on senior secondary school Student' chemistry achievement. *Journal of Humanity and Social Sciences, 5(1),* 1-6.

Oluwajodu, F., Blaauw, D., Greylin, L.& Kleynhans, E. P. J. (2015). Graduate unemployment in South Africa: Perspectives from the banking sector. *SA Journal of Human Resource Management* 13(1), 1-9.

Omolade, O. O. (2008). Effects of Lecture Demonstration and Lecture Teaching Methods on Students' Achievement in Secondary School Chemistry. *Journal of Teacher Education 9(10)*, 175.

Ongowo, R. O., & Hungi, S. K. (2014). Motivational Beliefs and Self-Regulation in Biology Learning: Influence of Ethnicity, Gender and Grade Level in Kenya. *Creative Education, 5,* 218-227.

Orji, A. B. C. and Ebele, F. U. (2006). Personalised System of Instruction and students' Academic Performance. *Sokoto Educational Review*. 8(2), 149-156

Osborne, J. F., and Dillon, J. (2008). *Science Education in Europe: Critical Reflections*. Nuffield Foundation, London.

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching, 41*(10), 994-1020.

Osborne, J., Simon, S. & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *Intern J. Sci. Educ*, 25, 1049-1079.

Ozkan, G dan Selcuk, G. S. (2015). The Effectiveness of Conceptual Change Texts and Context-Based Learning on Students' Conceptual Achievement. Journal of Baltic Science Education, Vol. 14, No. 6, 753-763.

Pallant, J. (2001). Spss Survival Manual : A Step by Step Guide to Data Analysis Using Spss for Windows (Version 10), St Leonards, NSW: Allen & Unwin.

Pallant, J. (2005). SPSS Survival Manual: A step by step guide to data analysis using SPSS for Windows (Version 12). Australia, NSW: Allen & Unwin.

Pallant, J. (2007). SPSS Survival Manual:spep by step guide to data analysis using SPSS for windows(3rd ed.). New York, NY: McGraw Hill Open University Press.

Palmer, D. H. (2003). Investigating the relationship between refutational text and conceptual change. *Science Education, 87*, 663-684.

Palmer, D. H. 1998. Measuring contextual error in the diagnosis of alternative conceptions in science. *Issues in Educational Research 8*(1), 65–76.

Paris, S. G., & Winograd, P. (1990). How metacognition can promote academic learning and instruction. In B. F. Jones & L. Idol (Eds.), *Dimensions of thinking and cognitive instruction* (pp. 15-51). Hillsdale, NJ: Lawrence Erlbaum Associates.

Patrick, A. O. (2013). Which way do we go in the teaching of biology? Concept mapping, cooperative learning or learning cycle? International Journal of Science and Technology Education Research, 4(2), 18 – 29.

Pearsall, N. R., Skipper, J. E. J., & Mintzes, J. J. (1997). Knowledge restructuring in the life sciences: A longitudinal study of conceptual change in biology. *Science Education, 81*(2), 193-215.

Perrier, F., & Nsengiyumva, J. B. (2003). Active science as a contribution to the trauma recovery process. Preliminary indications with orphans for the 1994 genocide in Rwanda. *International Journal of Science Education, 25*, 1111-1128.

Pesman, H., & Eryilmaz, A. (2010). Development of a three-tier test to assess misconceptions about simple electric circuits. *The Journal of Educational Research, 103*, 208–222.

Phillips, D. C., (1995). The good, the bad, and the ugly: The many faces of constructivism. *Educational Researcher, 24*(7), 5-12.

Piaget, J. (1953). Origins of intelligence in the child. London: Routledge & Kegan Paul.

Piaget, J. (1970). Science of education and the psychology of the child. London: Longman.

Piaget, J. (1976). Piaget sampler: an introduction to Jean Piaget through his own words. New York: Wiley.

Pintrich, P. R, & Schunk, D. H. (2002). Motivation in Education: Theory, Research, and Applications. New Jersey: Merrill Prentice Hall.

Pintrich, P. R., Marx, R. W., & Boyle, R. A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research, 63*(2), 167-199.

Pintrich, P.R., & Schunk, D.H. (2002). *Motivation in education: Theory, research, and applications (2nd ed.)*. upper Saddle River: NJ: Prentice Hall.

Polit, D. F., and Beck, C. T. (2004). *Nursing research: Appraising evidence for nursing practice (7th ed.)*. Philadelphia: Wolters Klower/Lippincott Williams and Wilkins.

Polyiem, T. Nuangchalerm, P. & Wongchantra, P. (2011) Learning Achievement, Science Process Skills, and Moral Reasoning of Ninth Grade Students Learned by 7E Learning Cycle and Socioscientific Issue-based Learning. *Australian Journal of Basic and Applied Sciences, 5(10)*, 257-564

Posner, G. J., Strike, K. A., Hewson, P.W. & Gertzog, W. A. (1982) Accommodation of a scientific conception: toward a theory of conceptual change. *Science Education, 66*, 211-227.

Posner, George, J., Strike, K. A., Hewson, P. W., & Gertzog, W. A., (1982). Accommodation of Scientific Conception: Towards a Theory of Conceptual Change. *Science Education*, 66(2), 211-227.

Pressley, M., & Harris, K. R. (2006). Cognitive strategy instruction: From basic research to classroom instruction. In P. Alexander & P. Winne (Eds.), *Handbook of educational psychology* (pp. 265–286). San Diego: Academic.

Puntambekar, S., & Hubscher, R. (2005). Tools for scaffolding students in a complex learning environment: What have we gained and what have we missed? *Educational Psychologist, 40(1)*, 1–12.

Rahman, F., Jumani, N., Chaudry, M., Chisti, S., & Fahim, A. (2010). Impact Of Metacognitive Awareness On Performance Of Students In Chemistry. *Contemporary Issues in Education Research, 3*(10), 39-44.

Ratner, C. (1991). *Vygotsky's sociohistorical psychology and its contemporary applications.* New York: Plenum Press.

Ray, A. M., & Beardsley, P. M. (2008). Overcoming student misconceptions about photosynthesis: a model- and inquiry-based approach using aquatic plants. *Science Activities: Classroom Projects and Curriculum Ideas, 45(1)*, 13-22.

Rehman, A. & Haider, K.. (2013). The Impact of Motivation on Learning of Secondary School Students in Karachi: An Analytical Study. *Educational Research International, 2(2)*, 139-147.

Richardson, V. (1997). Constructivist pedagogy. *Teachers College Record*, 105 (9), 1623–1640.

Richardson, V. (2003). Constructivist Pedagogy, *Teachers College Record 105*(9) 1623-1640, Columbia University.

Richmond, G. Merritt, B., Urban-Lurain, M. & Parker, J. (2010). The Development of a Conceptual Framework and Tools to Assess Undergraduates' Principled Use of Models in Cellular Biology. *CBE—Life Sciences Education*, 9, 441–452.

Saavedra, A. R. and Opfer, V. D. (2012). Teaching and learning 21st century skills: Lessons from the Learning Sciences. RAND Corporation, Asia Society partnership for global learning. pp.35

Sablonniere, R., Taylor, D. M. & Sadykova, N. (2009). Challenges of applying a student-centered approach to learning in the context of education in Kyrgyzstan. *Int. J. Educ. Dev.* 29, 628–634

Sadi, Ö. & Çakiroğlu, J. (2010). Effects of 5E Learning Cycle on Students' Human Circulatory System Achievement. *Journal of Applied Biological Sciences 4 (3), 63-67.*

Sakiyo, J. & Waziri, K. (2015). Concept mapping strategy: An effective tool for improving students' academic achievement in biology. *Journal of Education in Science, Environment and Health (JESEH), 1*(1), 56-62.

Sanders, M. (1993). Erroneous ideas about respiration: the teacher factor, *Journal of Research in Science Teaching*, 30, 919–934.

Santrock, J. W. (2001). *Educational psychology: International edition*. New York: McGraw-Hill Companies, Inc.

Saye, J. W., & Brush, T. (2002). Scaffolding critical reasoning about history and social issues in Multimedia-supported learning environments. *Educational Technology Research and Development, 50(3),* 77-96.

Schiller, S. (2009). Practicing Learner-Centred Teaching: Pedagogical Design and Assessment of a Second Life Project. *Journal of Information Systems Education, 20(3),* 369-381.

Schmidt H.J., Baumgartner T. and Eybe H., (2003), Changing ideas about the periodic table of elements and studentsí alternative concepts of isotopes and allotropes, Journal of Research in Science Teaching, 31, 621-637.

Schmidt, H. (1997). Students' misconceptions - Looking for a pattern. *Science Education, 81(2)*, 123-135.

Schoenfeld, A. H. (2001). Mathematics education in the 20th century. In L. Corno (Ed.), *Education across a century: The centennial volume (100th yearbook of the national society for the study of education)* (pp. 239-278). Chicago, IL: National Society for the Study of Education.

Schraw, G. & Dennison, R. S. (1994). Assessing Metacognitive Awareness. *Cotemporary educational psychology, 19,* 460-475.

Schraw, G. (1998). Promoting general metacognitive awareness. *International Science*, *26*, 113-125.

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review, 7*, 351-373

Schraw, G., Crippen, K. J., & Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in Science Education, 36,* 111-139.

Schwarz, N. (2013). Metacognition. In: E. Borgida and J. A. Bargh (Eds.), APA Handbook of Personality and Social Psychology: Attitudes and Social Cognition. Washington, DC: APA.

Sedgley, J., (2015)."Video Prompts for Self-Regulated Learning: Metacognition and Reflection Activity" *Theses, Dissertations, Professional Papers.*

Sesli, E., & Kara, Y. (2012). Development and application of a two-tier multiple choice diagnostic test for high school students' understanding of cell division and reproduction. *Journal of Biological Education, 46*(4), 214-225.

Seymour, J. & Longdon, B. (1991). Respiration- That's Breathing isn't it? *Journal of Biological Education*, 23(3), 177-184.

Shadish, W., Cook, T., & Campbell, D. (2002). Experimental and quasi-experimental designs for generalized causal inference. Boston: Houghton Mifflin Company.

Shaheen, M.N.K. & Kayani, M. M. (2015). Improving Students' Achievement in Biology using 7E Instructional Model: An Experimental Study. *Mediterranean Journal of Social Sciences, 6(4), 471-481.*

Shannon, S. V. (2008). Using Metacognitive Strategies and Learning Styles to Create Self-Directed Learners. *Journal of Institute for Learning Styles,* 1.

Shihusa, H. & Keraro, F. N. (2009). Using Advance Organizers to Enhance Students' Motivation in Learning Biology. *Eurasia Journal of Mathematics, Science & Technology Education, 5(4),* 413-420.

Smith, M. U. (1991). Teaching Cell Division: Student Difficulties and Teaching Recommendations. *Journal of College Science Teaching,* (21), 28-33.

Sornsakda, S., Suksringarm, P. & Singseewo, A. (2009). Effect of learning environmental education using 7E learning cycle with metacognitive techniques and teachers hand book approaches on learning achievement, integrated science process skills and critical thinking of Mathayomsuksa 5 students with different learning achievement. *Pakistan journal of social science,* 6(5), 297-303.

Special Education Support Service (SESS) (2009). Metacognition for the classroom and beyond: Differentiation and support for learners.

Sperling, R. A., Howard, B. H., Staley, R., & DuBois, N. F. (2004). Metacognition and self regulated learning constructs. *Educational Research and Evaluation*, *10*(2), 117-139.

Stavy, R. (1991). Using analogy to overcome misconceptions about conservation of matter. *Journal of Research in Science Teaching, 28(4),* 305-313.

Stewart, C., Bachman, C., & Johnson, R. (2010). Students' characteristics and motivation orientations for online and traditional degree programs. *Journal of Online Learning and Teaching, 6(2),* 367-379.

Stewart, J., Hafner, B., & Dale, M. (1990). Students' alternate views of Meiosis. *The American Biology Teacher, 52*(4), 228-232.

Stipek, D. J. (1996). *Motivation and instruction*. In D. C. Berliner & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 85–113). New York: Macmillan.

Sungur, S. and Tekkaya C. (2003). Students Achievement in Human Circulatory System Unit: The Effect of Reasoning Ability and Gender. Journal of Science Education and Technology, 12(7), 58-64.

Sungur, S., Tekkaya, C., & Geban , Ö. (2001). The contribution of conceptual change texts accompanied by concept mapping instruction to students‘understanding of the human circulatory system. *School Science and Mathematics. 101*(*2*), 91-101.

Swan, K. (2005). A constructivist model for thinking about learning online. In: J. Bourne & J. C. Moore (Eds), *Elements of Quality Online Education: Engaging Communities*. Needham, MA: Sloan-C.

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Boston, MA: Allyn and Bacon.

Taber, K. S. (2001). Shifting sands: A case study of conceptual development as competition between alternative conceptions. *International Journal of Science Education, 23(7),* 731-754.

Tamir, P. (1971). An alternative approach to the construction of multiple-choice test items. Journal of Biological Education, 5, 305-307.

Tan, K. C. D., Goh, N. K., Chia, L. S., & Treagust, D. F. (2002). Development and application of a two-tier multiple choice diagnostic instrument to assess high school students' understanding of inorganic chemistry qualitative analysis. *Journal of Research in Science Teaching, 39*, 283–301.

Tandel, S. H. (2013). Development of Metacognitive Skills in Science Student-Teachers Through Constructivist Approach. *Educational Quest, 4(3),* 199-206.

Tanner, K. & Allen, D. (2005). Approaches to Biology Teaching and Learning: Understanding the Wrong Answers—Teaching toward Conceptual Change. *Cell Biology Education, 4:*112–117.

Tanner, K., Chatman, L. S., & Allen, D. (2003). Approaches to cell biology teaching: cooperative learning in the science classroom—beyond students working in groups. *Cell Biology Education*, *2*(1), 1-5.

Tanner. K. D. (2012). *Approaches to Biology Teaching and Learning:* Promoting Student Metacognition. *CBE—Life Sciences Education, 11*:113–120.

Tarakci M, Hatipoglu S, Tekkaya C & Ozden M Y (1999). Across - Age Study of High School Students' Understanding of Diffusion and Osmosis. *Journal of Education,* 15, 84-93

Tebabal, A. & Kahssay, G. (2011). The Effects of Student-Centered Approach in Improving Students' Graphical Interpretation Skills and Conceptual Understanding of Kinematical Motion. *Lat. Am. J. Phys. Educ. 5(2), 373-381.*

Teichert, M. A. & Stacy, A. M. (2002). Promoting understanding of chemical bonding and spontaneity through student explanation and integration of ideas. *Journal of Research in Science Teaching, 39(6),* 464-496.

Teixeria, A, F. (2000). What happens to the food we eat? Children‟s conceptions of the structure and function of the digestive system. *International Journal of Science Education, 22*, 507–520.

Tekkaya, C., Özkan, Ö. & Sungur, S. (2001). Biology Concepts Perceived as Difficult By Turkish High School Students. *Journal of Hacettepe University Education Faculty*, 21, 145-150.

Teshome, A. (2012). Teachers' Perceptions and Practices of Active Learning in Haramaya University, Eastern Ethiopia: The Case of Faculty of Education. Sci. Technol. Arts Res. J., 1(4):74-83

Thompson, J., & Soyibo, K. (2002). Effects of lecture, teacher demonstrations, discussion and practical work on 10th graders' attitudes to chemistry and understanding of electrolysis. *Research in Science and Technological Education*, 20, 25-37.

Tosun, C. Taşkesenligil, Y. (2012). The Effect of Problem Based Learning on Student Motivation Towards Chemistry Classes and on Learning Strategies. Journal of turkish science education, *9(1),104-125*.

Treagust DF (1995). Diagnostic assessment of students' science knowledge. In: Glynn SM, Duit R (Eds.), *Learning science in the schools: Research reforming practice* (pp. 327-346). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Treagust, D. F. (1988). Development and use of diagnostic tests to evaluate students' misconceptions in science. *International Journal of Science Education, 10(2)*, 159-169.

Treagust, D. F. (2006). *Diagnostic assessment in science as a means to improving teaching, learning and retention*. Unit Serve Science Assessment Symposium Proceedings, Invited presentation.

Tsui, C.-Y., & Treagust, D. F. (2004). Conceptual change in learning genetics: An ontological perspective. *Research in Science and Technological Education*, 22, 185-202.

Tuan, H. L., Chin, C., C. & Shieh, S. H. (2005). The development of a questionanaire to measure students' motivation towards science learning. *Internal Journal of Science Education*, 27 (6), 639-654.

Tuan, H-L, Chin, C-C. TSAI, C-C & Shieh, S-H. (2005). Investigating the effectiveness of inquiry instruction on the motivation of different learning styles students. *International Journal of Science and Mathematics Education, 3,* 541–566.

Turk, F., & Calik, M. (2008). Using different conceptual change methods embedded within 5E model: A sample teaching of Endothermic – Exothermic reaction. *Asia-Pacific Forum on Science Learning and Teaching, 9* (1), 1-10.

Tynjälä, P. (1999). Towards expert knowledge? A comparison between a constructivist and a traditional learning environment in the university. *Int. J. Educ. Res. 3, 357-442.*

Ugwu, O., & Soyibo, K. (2004). The effects of concept and vee mappings under three learning modes on Jamaican eighth graders‟ knowledge of nutrition and plant reproduction. *Research in Science and Technological Education, 22,* 41–57.

Umar, A. A. (2011). Effects of biology practical activities on students' process skill acquisition in Minna, Niger State, Nigeria. *JOSTMED, 7*(2), 118–126.

UNESCO (2008). *Science education policy-making: Eleven emerging issues*. UNESCO, Paris.

UNICEF (2010). Child-Friendly Schools: Ethiopia Case Study. Addis Ababa, Ethiopia.

Uzuntiryaki, E. & Capa Aydin, Y. (2008). Development and validation of chemistry self-efficacy scale for college students. *Res. Sci. Educ*, 39, 539-551.

Uzuntiryaki, E., & Geban, Ö. (2005). Effect of conceptual change approach accompanied with concept mapping on understanding of solution concepts. *Instructional Science, 33*(4), 311-339.

Veenman, M.V.J., Wilhelm, P. & Beishuizen, J.J. (2004). The relation between intellectual and metacognitive skills from a developmental perspective. *Learning and Instruction, 14*, 89-109.

Venville, G. J., & Treagust, D. F. (1998). Exploring conceptual change in genetics using a multidimensional interpretive framework. *Journal of Research in science teaching*, *35*(9), 1031-1055.

Vighnarajah, Luan, & Bakar **(**2008). The Shift in the Role of Teachers in the Learning Process. *European Journal of Social Sciences,* 7(2), 33-36.

Vitharana, P. R. K. A. (2015). Student misconceptions about plant transport – a Sri Lankan example. *European Journal of Science and Mathematics Education*. *3(3),* 275-288

Von Glasersfeld, E. (1984). An introduction to radical constructivism. In: P Watzlawick (Ed.): *The Invented Reality*. Norton: New York, pp. 17-40.

Von Glasersfeld, E. (1992). *A constructivist view of teaching and learning. Research in Physics Learning. Theoretical and Issues and Empirical Studies.* IPN, Kiel, Germany, 29-39.

Vygotsky, L. (1962). Thought and langua. Cambridge, MA: MIT Press.

Vygotsky, L. S. (1986). Thought and language (Translation newly rev. and edited/Kozulin, Alex ed.). Cambridge, Mass.: MIT Press.

Wachanga, S. and Mwangi, J. G. (2004). Effects of the cooperative class experiment teaching method on secondary school students' chemistry achievement in Kenya's Nakuru District. *International Education Journal, 5* (1).

Wallace, J. D., & Mintzes, J. J. (1990). The concept map as a research tool: Exploring conceptual change in biology. *Journal of Research in Science Teaching, 27*(10), 1033-1052.

Wandersee, J. H., Mintzes, J. J. , Novak, J. D. (1994). Research on alternative conceptions in science. Handbook of research on science teaching and learning.

Wandersee, J.H., Fisher, K.M., & Moody, D.E. (2000). The nature of biology knowledge. *In mapping biology knowledge*, (pp. 25–37). Norwell, MA: Kluwer.

Wang J R (2004). Development and Validation of a Two-Tier Instrumentto Examine Understanding of Internal Transport in Plants and theHuman Circulatory System. *Int. J. Sci. Math. Edu. 2*, 131-157.

Wang, J. R. (2004). Development and validation of a two-tier instrument to examine understanding of internal transport in plants and the human circulatory system. *International Journal of Science and Mathematics Education*, *2*, 131–157.

Warliani, R., Muslim and Setiawan W. (2016). Implementation Of 7E Learning Cycle Model Using Technology Based Constructivist Teaching (TBCT) Approach To Improve Students' Understanding Achievement In Mechanical Wave Material. *Mathematics, Science, and Computer Science Education (MSCEIS),* AIP Conf. Proc. 1848, 050005-1–050005-5; doi: 10.1063/1.4983961. p 1-5.

Way, J., & Rowe, L. (2008). The role of scaffolding in the design of multimedia learning object. Paper presented at 11th International Congress on Mathematical Education, Mexico.

Weaver, C. (1994). Reading process and practice: From socio-psycholinguistics to whole language. Portsmouth, NH: Heinemann.

Weimer, M. (2002). Learner-Centered Teaching: Five Key Changes to Practice. San Francisco, CA: Jossey-Bass.

Wieman, C. E. and Perkins K. K. (2006). A powerful tool for teaching science. *Commentary. Nature physics*, 2.

Wigfield, A., Eccles, J. S., & Rodriguez, D. (1998). The development of children's motivation in school contexts. In P. D. Pearson and A. Iran-Nejad (Eds.), *Review of research in education*, Vol.23 (pp. 73-118). Washington, DC: American Educational Research Association.

Wiggins, G., and McTighe, J. (1998). Understanding by Design. Alexandria, VA: Association for Supervision and Curriculum Development.

Wilder, M., & Shuttleworth, P. (2005). Cell inquiry: A 5E learning cycle lesson. *Science Activities, 41*(4), 37-43.

Williams, K., & Williams, C. (2011). Five key ingredients for improving motivation. *Research in Higher Education Journal*, 11. http://aabri.com/manuscripts/11834.pdf

Williams, M., DeBarger, A.H., Montgomery, B.L., Zhou, X., Tate, E. (2012). Exploring middle school students' conceptions of the relationship between genetic inheritance and cell division. *Science Education, 96*(1), 78–103.

Wilson, J. (1999). *Defining Metacognition: A Step Towards Recognizing Metacognitionas a Worthwhile Part of the Curriculum.* Paper presented at the AARE Conference, Melbourne.

Wiseman, D.C. (1999). *Research strategies for education.* New York: Wadsworth Publishing Company.

Wood, D., Bruner, J., & Ross, G. (1976). The role of tutoring in problem solving. Journal of Child Psychology and Psychiatry, 17, 89–100.

Xie, K., & Bradshaw, A. C. (2008). Using question prompts to support ill-structured problem solving in online peer collaborations. *International Journal of Technology in Teaching and Learning, 4(2)*, 148–165.

Yager, R. E. (1991). The constructivist learning model. *The Science Teacher, 56*(6), 52-57.

Yalew Endaweke (2004). Teachers‘ Beliefs, knowledge and practice of learner- centered Approach in school of Ethiopia. The Ethiopian Journal of education, 24(2) 17-42.

Yerdelen-Damar, S. & Eryilmaz, A. (2016). The Impact of The Metacognitive 7E Learning Cycle on Students' Epistemological Understandings. *Kastamonu Education Journal, 24(2)*, 603-618.

Yilmaz, D., Tekkaya, C., & Sungur, S. (2011). The comparative effects of prediction/discussion_based learning cycle, conceptual change text, and traditional instructions on student understanding of genetics. *International Journal of Science Education*, *33*(5), 607-628.

Yin, R. K. (2003). *Case Study Research: Design and Methods,* 3rd edition, Beverly Hills, CA: Sage.

Young, D. J., & Fraser, B. J. (1994). Gender differences in science achievement: Do school effects make a difference? *Journal of Research in Science Teaching, 31*, 857–871.

Zakaria, E. and 1ksan, Z. (2007).*Promoting Cooperative Learning in Science and Mathematics Education. A Malaysian Perspective. Eurasia journal of Mathematics, Science and Technology, 3*, 35-39.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. Theory into Practice, 41(2), 64-70.

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal*, *45*(1), 166–183.

Zimmerman, B. J., & Martinez-Pons, M. (1986). Development of a structured interview for assessing student use of self-regulated learning strategies. *American Educational Research Journal*, *23*, 614-628.

Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. J*ournal of Research in Science Teaching*, *39*(1), 35-62.

Zumbrunn, S., Tadlock, J. and Roberts, E. D. (2011). Encouraging Self - Regulated Learning in the Classroom: A Review of the Literature. Metropolitan Educational Research Consortium (MERC), Virginia Commonwealth University.

Appendices

Appendix 1. Human Biology Achievement Test

Addis Ababa University

College of Education and Behavioral Studies

Department of Science and Mathematics Education

The main objective of this test is to gather data with regards to grade 9 students' biology achievement in the school. The items are from grade 9 human biology topics. Your correct and complete answer to the following questions will have great value for this study. Therefore, you are kindly requested to answer all the questions after reading thoroughly.

Thank You in Advance for Your Cooperation!

Direction: - 1. Do not write your name

2. Make a circle on your response

3. Respond all questions

Section 1:- Background Information

1.1. Name of school____

1.2. **Student's code** ___________________

1.2. **Sex**: Put a tick mark (✓) Age ___________

Male ☐ Female ☐

1.3 Grade _________ section _______

Section 2:- Test Items

Instruction: This test consists of 40 multiple choice questions from grade 9 human biology topics. Choose the best answer and **circle** your letter of choice.

1. Which of the following substance is used as a source of nutrients and energy for the body?
   A. Vitamins C. Food

B. Minerals
D. Water

2. Which of the following carbohydrates is mainly found in milk sugar?
   A. Sucrose
   B. Lactose
   C. Glucose
   D. Maltose
3. Which of the following is true about balanced diet?
   A. Taking only very few foods is enough in order to get a balanced diet.
   B. Getting enough amounts from all nutrients is required in order to get a balanced diet.
   C. Eating only fruits is sufficient in order to get a balanced diet.
   D. Eating injera every day is enough in order to get a balanced diet.
4. Assume that you have four test tubes A, B, C and D which contains equal amount of unknown food solutions. You added equal amount of ethanol and shook the tubes. Then you poured the contents in to other tubes, a white cloudy layer formed only in test tube "C". What will be the food solution in test tube "C"?
   A. Vitamin C
   B. Protein
   C. Lipid
   D. Starch
5. Suppose you are asked to determine Biuret test for a certain food. Which of the following is correct about your test? If the food has:
   A. Protein, purple colour will develop
   B. Protein, orange red colour will develop
   C. Sugar, purple coloour will develop
   D. Sugar orange colour will develop
6. Which of the following nutrients serve as structural components of cell membrane?
   A. Lipids
   B. Minerals
   C. Carbohydrates
   D. Vitamins
7. In which part of the alimentary canal the reaction Lipids $\xrightarrow{\text{Bile}}$ Fat droplets does takes place?
   A. Ileum
   B. Mouth
   C. Duodenum
   D. Stomach
8. Which of the following is a function of bile? It:
   A. Kills bacteria
   C. Facilitates protein digestion

B. Emulsifies fat D. Facilitates carbohydrates digestion

9. What is the importance of mechanical digestion?
   A. Minimize the effect of microbes on the food we eat
   B. Initiate the release of digestive enzymes from their glands
   C. Increase the surface area of the food for enzyme action
   D. Change large and insoluble molecules to smaller and soluble one
10. Which of the following statement is correct about absorption of the smaller food molecules from the digestive system?
   A. The smaller food molecules are directly absorbed by the body cells
   B. Fatty acid and glycerol move directly in to the blood
   C. Glucose and glycerol move directly in to the blood
   D. The smaller food molecules leave the digestive system by diffusion
11. Which of the following section of the gut produces enzyme that digests all the three food types?
   A. Oesophagus C. Stomach
   B. Small intestine D. Mouth
12. What do we call the reaction that breaks down carbohydrates, proteins and fats in to their monomer units during digestion?
   A. Dehydration C. Condensation
   B. Mastication D. Hydrolysis
13. Which of the following actions increase the volume of the chest cavity?
   A. Lowering of the rib cage
   B. Relaxation of the diaphragm
   C. Contraction of the diaphragm
   D. Relaxation of intercostals muscles
14. Tidal volume of air is the air which:
   A. Is exchanged during a normal breath
   B. Remains in the lungs after forced exhalation
   C. Is inhaled after forced exhalation
   D. Is forcibly exhaled after normal inhalation

15. In which structure of the lungs does exchange of gases with blood takes place?

A. Capillaries
B. Bronchioles
C. Alveoli
D. Bronchi

16. How high altitudes affect our breathing system? At high altitude the:

A. Number of red blood cells increase, as available oxygen increases
B. Number of red blood cells decrease as available oxygen decreases.
C. The amount of oxygen is low, as a result our breathing rate increases
D. The amount of oxygen is high, as our breathing rate increases

17. The first step during artificial respiration is:

A. Opening of the air way
B. Checking for breathing
C. Calling for help loudly
D. Checking the causality is conscious

18. This item is based on the following table which compares the percentage of atmospheric gases breathed in and out of the lungs.

No	Atmospheric gas	Air breathed in	Air breathed out
1	Oxygen	23%	16%
2	Nitrogen	About 80%	About 80%
3	Carbon dioxide	4%	0.04%

Which of the following comparison is/are correct?

A. 2 and 3
B. 2
C. 1
D. 1 and 2

19. In the activity to demonstrate the tar in cigarette smoke, the white cotton wool plugged in the smoking machine changes to brown colour as a result of tar accumulation. Where does such effect observed in the smokers body? In the:

A. Brain
B. Lungs
C. Heart
D. Kidneys

20. Which of the following happens during breathing air into the lungs? The:

A. Diaphragm become dome shaped
B. Ribs move down and inwards
C. Pressure inside the chest cavity is higher than outside

D. Volume of the chest cavity increases

21. How does body exercise affect the breathing rate? When the body:

A. Begins exercise, the breathing rate increases

B. Gets rest, breathing is totally lost

C. Begins exercise, the breathing rate decreases

D. Gets rest, breathing rate increases

22. Which of the following breathing structure separates human thorax and abdomen?

A. Trachea

B. Diaphragm

C. Bronchus

D. Ribs

23. Which of the following are the products of anaerobic respiration?

A. Lactic acid and ethanol

B. Oxygen and lactic acid

C. Ethanol and water

D. Water and carbon dioxide

24. Which of the following comparisons about aerobic and anaerobic respiration is correct?

A. The waste product of anaerobic respiration are CO_2 and H_2O while that of aerobic respiration is lactic acid

B. Energy produced by aerobic respiration is much higher than that produced by anaerobic respiration

C. Aerobic respiration occurs in the cytoplasm while anaerobic respiration occurs in the mitochondria.

D. Aerobic respiration occurs in animal cells while anaerobic respiration occurs in plant cells

25. What is the importance of ATP in the human body? It helps to carry out:

A. Diffusion process

B. Osmosis process

C. Passive transport process

D. Metabolism

26. Substance required to produce ATP during aerobic respiration are

A. Glucose and carbohydrate

B. Water and carbon dioxide

C. Glucose and oxygen

D. Water and glucose

27. Which of the following valve structures prevent the back flow of blood in to the right ventricle?

A. Bicuspid
B. Mitral
C. Tricuspid
D. Semi-lunar

28. Which of the following parts of the heart pumps blood relatively long distance? The

A. Right side of the heart
B. Right ventricle of the heart
C. Left side of the heart
D. Middle part of the heart

29. What are antigens? They are proteins which:

A. Allow red blood cells to accommodate more oxygen
B. Destroy foreign cells to the body
C. Play regulatory role in cells
D. Allow cells to recognize each other and cells from different organisms

30. Which of the following is the correct path of blood flow in the heart?

A. Right atrium → the body → right ventricle → lungs → left ventricle → left atrium
B. Right ventricle → right atrium → lung → left atrium → the body → left ventricle
C. The body → right atrium → right ventricle → left atrium → left ventricle → lungs
D. Right atrium → right ventricle → lungs → left atrium → left ventricle → the body

31. Which of the following functions of blood vessels is true?

A. Veins always carry blood towards the heart
B. Arteries always carry oxygenated blood
C. Pulmonary vein carries deoxygenated blood from lungs to the heart
D. Capillaries are thicker than veins

32. If someone with blood group “A” has got a car accident and lost a lot of blood. Therefore, he needs blood transfusion. Which of the following blood group is used during the transfusion?

A. OB
B. AB
C. B
D. O

33. Which of the following structures of the human heart is correctly matched with its function

A. Right ventricle → pumps deoxygenated blood to the body

B. Left atrium → receives oxygenated blood from the lungs

C. Left ventricle → pumps deoxygenated blood to the lungs

D. Right atrium → receives oxygenated blood from the lungs

34. Which of the following statement is true about hypertension? It

A. Is due to the presence of few red blood cell to carry hemoglobin

B. Can be reduced during higher age and over weight of the body

C. Is a deficiency disease caused by lack of iron

D. Can be managed by reducing salt and fats in the diet

35. If the pulse rate of an adult man at rest is 18 times in 15 seconds. What is the pulse rate of this man per minute?

A. 54

B. 90

C. 108

D. 72

Appendix 2. Propositional Knowledge Statements

Propositional knowledge statements identified for the target concepts of food and nutrition, digestive system, respiratory system, cellular respiration and circulatory system

1. Organisms need energy and nutrients to survive and they obtain these from the food.
2. Human being uses food in three ways: to provide energy for our cells, to provide new materials to grow and repair and replace damaged and worn out cells, to provide the resource needed to fight disease and maintain a healthy body
3. Carbohydrates provide energy when it is broken down to form glucose, which is used in cellular respiration to produce energy in a form used in all cells.
4. Based on their complexity, there are three types of carbohydrate namely simple sugar (glucose), double sugar(sucrose) and complex sugar(starch)
5. There are a number of chemical tests that you can carry out to test the presence of carbohydrate an example is to test glucose using Benedict's test and the result is the blue solution changes to orange red colour if glucose is present because it reduces copper II to copper I.

1. Proteins are used for body building up and their presence can be tested using Biuret test which results purple colour if protein is present.
2. Formation of carbohydrates from simple sugar and protein from amino acids call condensation and the reverse process is hydrolysis.
3. Lipids are extremely important group of chemicals as an important source of energy and the most effective energy store in your body and this is why your body converts spare food in to lipid for use at a later date.

The digestive system

1. The human body needs small soluble molecules to use in all the reactions of metabolism such as releasing energy and making large molecules
2. The main job of the digestive system is to breakdown the food we eat in to smaller, soluble molecules so as to be absorbed in to the blood stream and used by our body.
3. There are physical or mechanical breakdown and the chemical breakdown of food
4. Mechanical digestion physically breaks food in to smaller pieces by biting and chewing and muscular structure of the gut.
5. Chemical digestion breaks large insoluble food in to small soluble molecules by hydrolysis so that they can be absorbed in to our body and controlled by enzymes.
6. The breaking and building of new materials takes place in a rapid and controlled manner by biological catalyst known as enzymes.
7. Enzymes are made up of proteins and are not affected by the reaction they speed up, so they can be used many times.
8. Enzymes are very specific in that each type of reaction that takes place in our body is controlled by specific enzymes that do not catalyze any other type of reaction.
9. The digestive system of human body involves structure such as mouth, tongue, salivary gland, esophagus (gullet), stomach, liver, gallbladder, pancreas, small intestine (duodenum, ileum), large intestine (colon and rectum) and anus.
10. Food digestion begins in mouth with the help of teeth and enzymes like amylase for carbohydrate digestion and the partially digested food moves along the digestive system by the help of muscular contraction known as peristalsis.

11. The stomach digests protein by the help of the enzyme protease mainly pepsin and produces hydrochloric acid to kill bacteria and help digestion because pepsin works at acidic environment.
12. In the first parts of the small intestine (duodenum), the acidic nature of the food is neutralized and the fats break down(emulsified) by bile which is produced in liver and stored in gall balder.
13. In the second parts of the small intestine (ileum), complete digestion of carbohydrates, proteins and fats occur by the help of enzymes such as carbohydrase, protease and lipase from pancreas and ileum.
14. Once the food molecules have been digested giving glucose, amino acids, fatty acids and glycerol, they are absorbed in to the blood stream by diffusion in small intestine which is assisted by villi to increase surface area of the small intestine.
15. After absorption of food molecules in the blood, undigested food (mainly cellulose), bile pigments, dead cells and mucus are moved in to the large intestine and finally removed to external environment in the form of faeces through rectum and anus.

The respiratory system

1. In human beings, breathing brings oxygen in to their body and removes the waste carbon dioxide produced by their cells as they work.
2. The human breathing system/respiratory system involve the structures such as nose, nasal passage, epiglottis, larynx (voice box), trachea, bronchus, lung, bronchiole and alveoli. It is assisted by intercostals muscles and diaphragm.
3. Air that enters in to the breathing system is filtered in the nasal cavity by hairs and mucus to remove dust and small particles such as bacteria and pollen.
4. The movement of air in to the lung and out of the lung brought about by the movement of ribcage and diaphragm change the pressure in the chest cavity.
5. When we breathe in (inhalation), our ribs move up and out, the muscles of the diaphragm contracts, the intercostals muscles between the ribs contracts, the volume of the chest cavity increases, the pressure inside the chest cavity decreases
6. This results in air to move in to the lung and the volume of the lung increases.

7. When we breathe out our ribs move down and in, the muscles of the diaphragm relaxes, the intercostals muscles between the ribs relaxes, the volume of the chest cavity decreases, the pressure inside the chest cavity increases
8. This results in air to move out of the lung and the volume of the lung decreases.
9. Exchange of oxygen and waste carbon dioxide occurs at alveoli in the lung by diffusion along concentration gradient.
10. The mechanism of gas exchange in the alveoli depends on a large surface area, moist surfaces, short diffusion distance and a rich blood supply maintaining a steep concentration gradient.
11. The air breathed in contains 80% nitrogen, 21%oxygen and 0.04% carbon dioxide.
12. Whereas the air we breathe out contains 80% nitrogen, 16%oxygen and 4% carbon dioxide.
13. The average resting breathing rate for an adult human being is around 12-14 breaths per minute.
14. When you are breathing normally at rest, you take about 500 cm3 of air in and out each time you breathe. This is known as your tidal volume of air
15. The vital capacity of your lungs is the absolute maximum amount of air you can take in to or breathe out of your lungs
16. Anything that increases the oxygen requirement of our body such as exercise, anxiety, drugs, altitude, weight and smoking affects the breathing rate.

Cellular respiration

1. During the process of cellular respiration, glucose reacts with oxygen to release energy that can be used by the cell and produce carbon dioxide and water as waste products.
2. ATP (adenosine triphosphate) is the energy currency of the cell that is used by cells released from food we eat by cellular respiration.
3. Aerobic respiration takes place in mitochondria of the cell.
4. The reaction is glucose + oxygen $\longrightarrow$ carbon dioxide + water + energy (ATP), this reaction is called aerobic respiration.
5. anaerobic respiration takes place in cytoplasm of the cell
6. The reaction is glucose $\longrightarrow$ lactic acid + energy (ATP), this is called anaerobic respiration.

7. Aerobic respiration is more efficient than anaerobic respiration because it breaks glucose completely using oxygen.
8. ATP is used for metabolism reaction, muscles contraction, body temperature control and material transport
9. All of your cells need energy to carry out the reaction of life, and respiration provides this energy.

The circulatory system

1. The human transport system to transport materials such as food and oxygen is the blood circulation system.
2. Pulmonary circulation carrying blood from the heart to the lung and back again to exchange oxygen and carbon dioxide with the air.
3. Systemic circulation carrying blood all around the rest of the body and back again.
4. In human body we have three main types of blood vessels: arteries, veins and capillaries.
5. Arteries carry oxygenated blood away from the heart so they have to be able to withstand the pumping of the heart forcing the blood out in to the circulation.
6. Arteries have thick walls that contain muscles and elastic fibers, so that they can stretch as the blood is forced through them and go back in to shape afterwards.
7. The Veins carry deoxygenated blood towards your heart and they have much thinner walls than arteries and the blood in them is under low pressure.
8. The capillaries link the other two types of blood vessels and serve as a site of the exchange of substances within the body.
9. The heart consists of four chambers: two atria (right and left) and two ventricles (right and left).
10. The walls of the atria are relatively thin so they can stretch to contain a lot of blood whereas the walls of the ventricles are much thicker as they have to pump the blood out through the major blood vessels.
11. The muscles walls of the left side of the heart are thicker than on the right because the left side pump blood around the whole body whilst the right side pump blood only to the lung.
12. Deoxygenated blood which has supplied oxygen to the cells of the body and is loaded with carbon dioxide, comes in to the right atrium of the heart from the veins of the body.
13. Oxygenated blood returns back to the heart from the lung and fills up left atrium.

14. The right atrium contracts and forces blood in to the right ventricle whereas the right ventricle contracts and forces blood out of the heart and in to the lungs where it is oxygenated-it picks up oxygen
15. The left atrium contracts and forces blood in to the left ventricle whereas the left ventricle contracts and forces oxygenated blood out of the heart and around the body.
16. Antigens are special proteins found on all cells that allow cells to recognize each other and cells from different organisms.
17. If the cells of the immune system recognize a foreign antigen on a cell in our body, they will produce antibodies that join on to the antigen and destroy the foreign cells.
18. Based on the type of antigen found on blood cells, there are four blood groups.
19. In this system there are two possible antigens on the red blood cells: antigen A and antigen B
20. There are also two possible antibodies in the plasma: antibody a, and antibody b.
21. Blood group A has antigen A and antibody b and can receives blood from blood group A and O
22. Blood group B has antigen B and antibody a and can receives blood from blood group B and O
23. Blood group AB has antigen AB and has no antibody and can receives blood from all blood group –universal recipient
24. Blood group O has no antigen and has antibody ab and can receive blood from O blood group and give to all blood group–universal donors.
25. If someone loses a lot f blood, transfusion of blood possible after the two persons blood type known to avoid blood coagulation.

Appendix 3. Human Biology Conceptual Understanding Test

Addis Ababa University

College of Education and Behavioral Studies

Department of Science and Mathematics Education

The main objective of this test is to gather data with regards to "students' understanding and misconception about human biology'' in the School. Your correct and complete answer to the following questions will have great value for this study. Therefore, you are kindly requested to answer all the questions after reading thoroughly.

Thank You in Advance for Your Cooperation!

Direction: - 1. Do not write your name

2. Respond all questions precisely, clearly and genuinely.
3. Make a **Circle** on your choice
4. Write any different reasons other than listed on the space provided.

Section 1:- Background information

1.1. Name of school ____

1.2. **Student's code** ______________________

1.2. Sex: Put a tick mark (✓) Age _______________

Male ☐ Female ☐

1.3 Grade _____________ section ______________

Section 2:- Test Items

Instruction: This test consists of 20 pairs of questions from grade 9 human biology topics. Each question has two parts. The first part is a multiple choice response. The second part is a multiple choice reason. Choose the best answer from both response and reason parts and make a **Circle** on your letter of choice.

1. To which of the following substance that the excess food in our body converted for later use?

   A. Protein B. Lipid C. Carbohydrate

   The reason for my answer is:

   1. It is an important source of energy and the most effective energy store in our body.
   2. It is an important source of vitamins in our body.
   3. Used as sources of energy when there is lack of oxygen in our body.
   4. It is an important immediate source of energy for cellular activities.
   5. Other reason: ____.

2. A grade 9 student conducted an experiment in biology laboratory. First she put a sample of glucose powder and water in to a test tube. Then she added a few drops of Benedict's solution

in to the test tube and placed it in boiling water. What was the most probable colour she observed within the test tube?

A. Blue B. Purple C. Black D. Orangey-red

The reason for my answer is:

1. Copper(II) in the Benedict's solution is reduced to copper(I)
2. Copper(I) in the Benedict's solution is oxidized to copper(II)
3. Monosaccharide is reduced in the reaction to disaccharides
4. When water boils it changes its colour
5. Other reason:____.

3. In human digestive system, where does absorption of food take place? In the:

A. Mouth B. Large intestine C. Stomach D. Small intestine

The reason for my answer is:

1. Digestion is completed there and contains villi for diffusion to occur rapidly.
2. Absorption of water completed there and contains villi for diffusion to occur rapidly.
3. It contains bacteria to digest minerals and nutrients and villi for diffusion to occur rapidly.
4. It involves the process of peristalsis to move smaller substance through villi in to blood stream.
5. It contains hydrochloric acid that facilitate diffusion of molecules in to the blood stream.
6. Other reason:____.

4. Mechanical digestion breaks down large food substance in to smaller and soluble molecules?

A. True B. False

The reason for my answer is:

1. It releases enzymes from glands and breaks food substance in to small and soluble molecules.
2. It breaks down food in to smaller pieces and increases the surface area for enzyme action.
3. It breaks down food substance in to small and soluble molecules through hydrolysis reaction.
4. It changes large and insoluble molecules to smaller and soluble one through the action of enzymes.
5. Other reason:____.

5. During chemical digestion, enzymes bind with the food substance to catalyze a reaction but released at the end of a reaction without any change on their nature.

A. True B. False

The reason for my answer is:

1. Enzymes take part in the reaction and broken down in to smaller components at the end.
2. Enzymes do not take part in the reaction and not affected by the reaction they catalyze.
3. Enzymes take part in the reaction and affected by the reaction they catalyze.
4. Enzymes are proteins. They are broken down in to amino acids when they catalyze a reaction.
5. Other reason: ____.

6. All the oxygen we inhale (breathe in) is taken into the blood and then to the body's cells where it is used up. As a result of it being used up, no oxygen is breathed out when we exhale.

A. True B. False

The reason for my answer is:

1. All the oxygen breathed in is absorbed and it is all used in the process of respiration.
2. Not all of the oxygen inhaled is absorbed and so there is some left in the lungs that will be breathed out with the carbon dioxide.
3. We absorb all of the oxygen we inhale because we need it. We only remove materials that are dangerous to the body. Since carbon dioxide is poisonous to us we breathe it out.
4. The diaphragm pulls all of the oxygen into the body and only pushes the carbon dioxide out.
5. If oxygen is not absorbed straight away, it is stored in the alveoli for use later and it is not exhaled. It is needed too much by the body to be breathed out.
6. Other reason:____.

7. Each lung is a large hollow sack that is like a balloon that expands and contracts to get air into and out of the lung.

A. True B. False

The reason for my answer is:

1. There is a model that shows the lungs as two balloons in a cavity. The balloons expand to let air into them and get smaller to push air out of them.

2. The lungs are composed of lots of little sacks and the air entering them makes them expand.
3. The lungs are made up of a lot of tiny sacks and the lungs expand and contract as the thoracic (chest) cavity changes its volume.
4. The lungs are two hollow bags and their volume changes because the diaphragm pushes and pulls on them.
5. Other reason:____.

8. Breathing is the same as respiration.

A. True B. False

The reason for my answer is:

1. Both of these processes involve getting oxygen into the body and carbon dioxide out of the body so they are the same.
2. Breathing is getting oxygen into the body and carbon dioxide out; while respiration is the process involved in moving these gases around the body in the blood.
3. Breathing is the process of getting oxygen into the lungs from the atmosphere (inhaling) and carbon dioxide out of the body (exhaling). Respiration is the process of getting oxygen from the lungs to the body and carbon dioxide from the body into the lungs.
4. Breathing is the process of getting oxygen from the atmosphere into the cells and carbon dioxide out of the cells and into the atmosphere. Respiration is the process in which the cells produce energy and carbon dioxide.
5. Breathing occurs in the lungs while respiration occurs elsewhere in the body but not in or near the lungs. Apart from where they occur they are the same thing.
6. Other reason:____.

9. When we breathe in, the lungs expand in volume because the thoracic (chest) cavity expands.

A. True B. False

The reason for my answer is:

1. Air moving into the lungs forces them to expand to let the air in and as the air moves out the lungs decrease in volume because there is less air to fill them.
2. Because of surface tension between the thoracic (chest) cavity, the pleura and the lungs, as the thoracic cavity increases in volume (size) the lungs increase in volume as well.

3. The lungs change in volume and this causes the thoracic cavity to change in volume to accommodate the lungs' new volume.
4. The lungs actively expand so we can breathe in (inhale) and they contract so we can breathe out (exhale).
5. Other reason:____.

10. When we breathe deeply, the diaphragm contracts strongly and pulls harder on the lungs and this increases the volume of the lungs. The diaphragm relaxes extra hard and it pushes on the lungs to force air out.

A. True B. False

The reason for my answer is:

1. The diaphragm and intercostal muscles contract. It is these two sets of muscles contracting that leads to an increase in the volume of the thoracic (chest) cavity.
2. When we exercise, we make more carbon dioxide which gets into the lungs and makes them expand more. When the carbon dioxide moves out of the body, it reduces the volume needed by the lungs.
3. The air moving into the lungs during exercise causes the lungs to expand as the air needs more space than when we breathe normally and this pushes out the diaphragm and ribs and so we get an increase in thoracic (chest) cavity size.
4. When we exercise we need more oxygen and this extra oxygen moving into the lungs makes them bigger. As we absorb the oxygen there is less volume of air left and so the lungs' volume decreases.
5. Other reason:____

11. Which of the following is true?

Energy release during respiration occurs:

A. Only in the lungs.
B. Only in the stomach.
C. In all cells of the body.
D. Only in small intestine.

The reason for my answer is:

1. All cells have an energy requirement and must respire.

2. The lungs are the place where oxygen is taken into the body.
3. The stomach is the place where food is digested.
4. Small intestine is the place where energy is released.
5. Other reason:____.

12. Which of the following is true about respiration?

A. It involves the oxidation of food and release of energy.
B. It involves the extraction of energy from oxygen.
C. Energy is used to oxidize food.
D. It involves extraction of oxygen from food.

The reason for my answer is:

1. Food cannot be used by the body unless energy is used to break it down.
2. Food contains chemical energy which can only be released by using oxygen to break it down.
3. Oxygen contains chemical energy which can only be released by breaking it down.
4. Respiration is a process of taking and releasing energy and oxygen.
5. Other reason:____.

13. Anaerobic respiration is less efficient than aerobic respiration.

A. True B. False

The reason for my answer is:

1. In aerobic respiration there is metabolism but in anaerobic respiration there is no metabolism.
2. Anaerobic respiration use oxygen but aerobic respiration does not use oxygen.
3. Aerobic respiration breaks food molecules completely and releases high energy
4. Anaerobic respiration breaks food molecules completely and releases high energy.
5. Anaerobic respiration breaks food molecules partially and releases less energy.
6. Other reason:____.

14. Which part of the heart has thicker muscles wall?

A. The left side of the heart B. The right side of the heart

The reason for my answer is

1. It protects the heart from external damage.
2. It pumps blood to a relatively long distance.

3. It pumps blood to a relatively short distance.
4. It receives much of the digested food to build them.
5. The heart is found in the left of the chest.
6. Other reason:____.

15. If someone with blood group "A" has got a car accident and lost a lot of blood. Therefore, he needs blood transfusion. Which of the following blood group is used during the transfusion?

A. B   B. AB   C. O

The reason for my answer is because:

1. It has no antibody that reacts with antigen of the red blood cells of the person.
2. It has antigen AB that do not react with antibody in the red blood cells of the person.
3. It has no antigen that reacts with antibody of the red blood cells of the person.
4. It has no antigen and antibody that reacts with the red bloods of the person.
5. Other reason:____.

16. Which of the following is correct about blood vessels?

A. Veins have thick and elastic walls
B. Arteries have thick and elastic walls
C. Capillaries have thick and elastic walls

The reason for my answers is:

1. They stretch as blood forced in to them and pump long distance.
2. They pump blood under high pressure to the nearest body parts.
3. They prevent heat loss as blood travels through them.
4. Maintain high blood pressure in human body.
5. Other reason: ____.

17. Systemic circulation in human being transports both oxygenated and deoxygenated blood.

A. True   B. False

The reason for my answers is:

1. Pulmonary circulation transports deoxygenated blood and systemic circulation transports oxygenated blood throughout the body.
2. Systemic circulation transports deoxygenated blood from different part of the body to the heart and oxygenated blood from the heart to different parts of our body.

3. Pulmonary circulation transports deoxygenated blood from different part of the body to the heart and oxygenated blood from the heart to different parts of our body.
4. Systemic circulation transports deoxygenated blood to the lung and oxygenated blood to the heart.
5. Other reason____.

18. When the right and left ventricle contracts:

A. Both oxygen-rich and oxygen poor blood leaves the heart.
B. Blood from one side of the heart goes to the right side of the body and blood from the other side of the heart goes to left side of the body.
C. Oxygen-rich and oxygen poor blood enters the right ventricles of the heart.
D. Blood enters into the heart from lower side of the body and blood leaves the heart and goes to the upper part of the body.

The reason for my answer is:

1. Blood from the right side of the heart goes to lung and blood from the left side of the heart goes to our body.
2. Blood from the left side of the heart goes to the lung and blood from the right side of the heart goes to the body.
3. The right side of the heart pumps blood to the right side of the body where as the left side pump blood to left side of the body.
4. Only oxygenated blood enters the heart because the heart needs pure blood.
5. The right side of the heart pumps blood to the lower parts of the body where as the left side pump blood to upper part of the body.
6. Other reason____.

Appendix 4. Science Motivation Questionnaire

4.1 Amharic Version

አ□ስ አበባ ዩኒቨርሲቲ

□ስነት/ትና ባህሪ ጥናት ኮልጅ

የሳይንስና ሂሳብ ት/ት ክፍል

ለስነ-ህይወት ት/ት ያለንን ተነሳሽነት የሚመለከት መ□□ቅ

ው□ ተማሪ- ች:

በዚህ ሰዓት □□ህረ ምረቃ (□ኤችዲ) መመረቂያ ጥናትና ምርምር በማካሄ□ ላ□ እ□ኛለሁ:: በመሆኑም የዚህ መጠይቅ ዋና ዓላማ የ9ኛ ክ□ል ተማሪ- ች ስነ-ህይወትን በተመለከተ ምን እንደሚያስቡና እንዴት እንደሚሰማቸ□ መረ□ ለመሰብሰብ ነዉ:: ከ□ህ መ□□ቅ □ሚ□ኘ□ መረ□ ስነ-ህይወት ትምህርትን የመማርያ ዘዴዎችን ለማጎልበት የሚረዱ ግብአቶችን ለመ□ቆም □ረ□ል:: □ህ መ□□ቅ ሃ□ አራት ጥያቄዎችን □ዟል:: ስለ□ህ ለቀረቡላችሁ መ□□ቆች ትክክለኛዉን መልስ በቅንነት እንድትመልሱ በታላቅ ትህትና እ□□ቃለሁ:: ከ□ህ መ□□ቅ □ሚ□ኘዉ መረጃ በሚስጥር የሚያዝ ይሆናል::

በመ□□ቁ ላ□ ስምህ መጻ□ አ□ስ□ል□ም::

ስለትብብራችሁ በቅ□ሚ□ አመሰግናለሁ::

ክ□ል 1

□ራዊ መረ□

1. **የት/ት በቱ ስም ____**
2. **□ተማሪ□ /ዥ መለ□ ኮ□_____________________**
3. **ጾታ: □ህን ምልክት ይጠቀሙ(✓) እ□ሜ ________**
   ወንድ ☐ ሴት ☐
4. **□ክ□ል □ረ□ _______ ሴክሽን _________**

ክ□ል 2

□ር□ር □□ቂ- ች

መመሪ□:- ከ□ህ በታች ያለ□ ሰ□ረ□ □ር□ር □□ቄ- ች □ዟል:: ለ□ያቄ- ቹ ትክክለኛ ወ□ም □ተሳሳተ መልስ □ለም:: ለናንተ ትክክል መስሎ □ተሰማችሁን መልሱ:: ስለ□ህ ስለት/ት ቤታችሁ□□ስነ-ህይወት ትምህርት ምን እን□ምታስብ/ቢ እና እንዴት እን□ሚሰማህ/ሽ ለመረዳት ይቻል ዘንድ ለጥያቄ- ቹን በጥንቃቄ በማንበብ ከተሰጡት አማራ□ ልኬቶች □ስ□ "ት/ት ቤት እያለሁ ...." ከሚል እሳቤ በትክክል □ሚ□ልጽህን/ሽን □(✓) ምልክት በመ□ቀም መልስ/ሽ::

አማራ□ ልኬቶች:- 0 = በ□ፁም 1 = አል□ አል□ 2 = አንዳንድ ጊዜ
3 = አብ□ኛዉን ጊዜ 4 = ሁልጊዜ

No	ጥያቄዎች:	አማራ□ ልኬቶች				
	ትምህርት ቤት እ□ለሁ:	0	1	2	3	4
01	እን□መራመር □ሚ□□ር□ኝን የስነ-ህይወት ትምህርት እወ□ዋለሁ::					
02	□ስነ-ህይወት ፈተናን ከሌሎች ተማሪዎች የተሻለ መስራት እ□ል□ለሁ::					
03	ስነ-ህይወትን መማር አስ□ሳች ሆኖ አ□ኘቼዋለሁ::					
04	ስነ-ህይወት ጥሩ ዉጤት ማግኘት ለእኔ አስ□ላ□ ነ□ ::					
05	ስነ-ህይወትን ለመማር በቂ ጥረት አ□ር□ለሁ::					
06	በ ስነ-ህይወት ትምህርት ከሌሎች ተማሪ- ች እኩል ወ□ም □ተሻለ እን□ምሰራ እ□ብቃለሁ::					
07	ስነ-ህይወትን በሚገባ መረዳት የዉጤታማነት ስሜት ይሰማኛል::					
08	በስነ-ህይወት እ□□ በ□ም □ሩ ዉጤት ማምጣት ለእኔ አስ□ላ□ ነ□ ::					
09	በስነ-ህይወት ፈተና ጥሩ ዉጤት እን□ማመ□ እተማመናለሁ::					
10	ከስነ-ህይወት የፈተና ከማ□ኘዉ ዉጤት የበለጠ የምማረዉ ትምህርት ለእኔ አስ□ላ□ ነ□ ::					
11	ስነ-ህይወትን ለመማር ብዙ ጊዜ አ□□ለሁ::					
12	ስነ-ህይወትን መማሬ ሕይወቴን እጅግ ትርጉም ያለዉ እንዲሆን					

	□□ርዋል::					
13	ስነ-ህይወትን ስማር የሚያስቸ□ር ነ□ር ሲ□□□መኝ ም□ን□ቱን ለማወቅ እሞ□ራለሁ::					
14	በስነ-ህይወት ቤተሙከራና ፕሮጀክት ሥራ- ች ላ□ □ሩ መስራት እን□ምችል እተማመናለሁ::					
15	በስነ-ህይወት ትምህርት በቂ ዕዉቀትና ክህሎት መጨበ□ እን□ምችል አምናለሁ::					
16	ለስነ-ህይወት ፈተናና ቤተሙከራሥራ በቂ ዝግጅት አ□ር□ለሁ::					
17	□ስነ-ህይወት አ□□ስ □ምርምር □ኙቶችን ለማወቅ በ□ም እጓጓለሁ::					
18	በስነ-ህይወት ትምህርት በጣም ከፍተኛ ዉጤት ማምጣት እን□ምችል አምናለሁ::					
19	ስነ-ህይወትን መማር ያስደስተኛል::					
20	በስነ-ህይወት ስለማገኘዉ ዉጤት በቅድሚያ አስባለሁ::					
21	ስነ-ህይወት ትምህርት መረዳት እን□ምችል እር□□ኛ ነኝ::					
22	ስነ-ህይወትን ለመማር በ□ም አ□ናለሁ::					
23	ስነ-ህይወትን በ□ሩ ሀኔታ□ለመማር □ሚ□ስችሉ ስልቶችን እ□ቀማለሁ::					
24	በስነ-ህይወት ፈተናና ቤተሙከራ ሥራ ከፍተኛ ዉጤት ማምጣት ለኔ ትርጉም አለ□ ::					

4.2 English Version

Addis Ababa University

College of Education and Behavioral Studies

Department of Science and Mathematics Education

Biology Motivation Questionnaire

Dear students,

I am conducting a PhD dissertation research. Thus, the purpose of this questionnaire is to collect data from grade 9 students on what they think and how they feel about biology. The information obtained from this questionnaire will serves as an input in enhancing students' biology learning. The questionnaire consists of 24 statements. Therefore, you are kindly requested to give genuine response to the questions. The responses to the questions will be kept confidential.

Do not write your name.

Thank You for Your Cooperation

Section A

Background Information

1. Name of School ____
2. Gender: Put a tick mark (✓)
   Male ☐ Female ☐
3. Grade Level ______________ Section ___________

Section B: Items

Instruction: The following table contains list of statements. There is no right or wrong answers to the statements. It is simply what is true for you. Therefore, in order to better understand what you think and how you feel about your school biology courses, please read every statements carefully and respond to each of the statements by putting a tick mark (√) using the scale below from the perspective of ''When I am in a school. . …….''

Scales: 0 = Never 1 = Rarely 2 = Sometimes 3 = Usually 4 = Always

No	Statements (Items) When I am in a school:	**0**	**1**	**2**	**3**	**4**
01	I like biology that challenges me.					
02	I like to do better than other students on biology tests.					
03	I find learning the biology interesting.					

04	Getting a good biology grade is important to me.					
05	I put enough effort into learning the biology.					
06	I expect to do as well as or better than other students in the biology course.					
07	Understanding the biology gives me a sense of accomplishment.					
08	It is important that I get an "A" in biology.					
09	I am confident I will do well on the biology tests.					
10	The biology I learn is more important to me than the grade I receive.					
11	I spend a lot of time learning biology.					
12	Learning biology makes my life more meaningful.					
13	If I am having trouble learning the biology, I try to figure out why.					
14	I am confident I will do well on the biology labs and projects.					
15	I believe I can master the knowledge and skills in the biology course.					
16	I prepare well for the biology tests and labs.					
17	I am curious about discoveries in biology.					
18	I believe I can earn a grade of “A” in the biology course.					
19	I enjoy learning the biology.					
20	I think about the grade I will get in biology.					
21	I am sure I can understand biology.					
22	I study hard to learn biology.					
23	I use strategies that ensure I learn the biology well.					
24	Scoring high on biology tests and labs matters to me.					

Appendix 5. Metacognitive Awareness Inventory Test

5.1 Amharic Version

አ□ስ አበባ ዩኒቨርሲቲ

□ስነት/ትና ባህሪ ጥናት ኮልጅ

የሳይንስና ሂሳብ ት/ት ክፍል

ስለራሳችን አስተሳሰብ ያለንን ግንዛቤ የሚመለከት መ□□ቅ

ው□ ተማሪ- ች:

እኔ □□ህረ ምረቃ (□ኤችዲ) መመረቂያ ጥናትና ምርምር በማካሄ□ ላ□ እ□ኛለሁ፡፡ □□ህ መጠይቅ ዋና ዓላማ የ9ኛ ክ□ል ተማሪ- ች □ስነ-ህይወት ትምህርትን በሚማሩበት ወቅት ስለሚ□ከናዉኗቸ□ ተግባራት ያላቸዉን ግንዛቤ በተመለከተ መረ□ ለማሰባሰብ ነዉ፡፡ ከመ□□ቁ □ሚ□ኘ□ መረ□ □ስነ-ህይወት ትምህርትን የመማርያ ዘዴዎችን ለማጎልበት □ሚረ□ □ብአቶችን ለመጠቆም ይረዳል፡ መጠይቁ ሃያ ጥያቄዎችን □ዟል፡፡ ስለ□ህ ለቀረቡላችሁ መ□□ቆች ትክክለኛዉን መልስ በቅንነት እንድትመልሱ በታላቅ ትህትና እ□□ቃለሁ፡፡ ከ□ህ መ□□ቅ □ሚ□ኘዉ መረጃ በሚስጥር የሚያዝ ይሆናል፡፡

በመ□□ቁ ላ□ ስም መጻ□ አ□ስ□ል□ም፡፡

ስለትብብራችሁ በቅ□ሚ□ አመሰግናለሁ፡፡

ክ□ል 1

□ራዊ መረ□

1. **የት/ት በቱ ስም** ____
2. **□ተማሪ□ /ዥ መለ□ ኮ□**____________________
3. **ጾታ:** □(✓) ምልክት አስቀም□ **እ□ሜ** ________
   ወንድ [ ] **ሴት**[ ]
4. **□ክ□ል □ረ□** _______ **ሴክሽን** _________

ክ□ል 2

□ር□ር □□ቄ- ች

መመሪ□፡- ከ□ህ በታች ያለ□ ሰ□ረ□ □ር□ር □ያቄዎችን □ዟል፡፡ ለ□ያቄ- ቹ ትክክለኛ ወ□ም □ተሳሳተ መልስ □ለም፡፡ ለናንተ ትክክል መስሎ □ተሰማችሁን መልሱ፡፡ ስለ□ህ

□ያቄ- ቹን በጥንቃቄ በማንበብ ስነ-ህይወት ትምህርትን ስትማሩ ስለምታደርጉት ነ□ር ከተሰጡት አማራጭ ልኬቶች □ስ□ በትክክል □ሚ□ልጽህን/ሽን የ(✓) ምልክት በመጠቀም መልስ/ሽ::

አማራጭ ልኬቶች: **1 = በ□ም አልስማማም** **2 = አልስማማም**

3 = ለመወሰን ያስቸ□ረኛል **4 = እስማማለሁ** **5 = በ□ም እስማማለሁ**

No	□ር□ር □□ቄ- ች	አማራጭ ልኬቶች				
		1	**2**	**3**	**4**	**5**
01	ዓላማዬን ማሳካቴን ሁል ጊዜ ራሴን እ□□ቃለሁ::					
02	በምማርበት ጊዜ በቂ ጊዜ እንዲኖረኝ □□ዬን መጥኜ እ□ቀማለሁ::					
03	□□ቄ ከመመለሴ በፊት የተለያዩ አማራጮችን ግምት ዉስጥ አስ□ባለሁ::					
04	አንድን ሥራ ከመጀመሬ በፊት በትክክል ምን መማር እንደምፈልግ አስባለሁ::					
05	□ተና ከፊ ረስኩ በኋላ ምን ያክል በ□ሩ ሁኔታ እንደሰራሁ አ□ ቃለሁ::					
06	አንድን ሥራ ከመጀመሬ በፊት ዝርዝር ግቦችን/ዓላማዎችን አስቀም□ለሁ::					
07	ጥያቄዎችን/መልመጃዎችን ከመስራቴ በፊት የተለያዩ አማራጮችን ግምት ዉስጥ ማስገባቴን ራሴን እ□□ቃለሁ::					
08	አንድን ሥራከፊ ረስኩ በኋላ ሌላ ቀላል መንገድ መኖሩን ራሴን እ□□ቃለሁ::					
09	ጠቃሚ ዝምድና ያላቸዉን ነገሮች ለመገዘብ እንዲረዳኝ ሁል □□ □□ሜ እመለከታቸዋለሁ::					
10	አንድ ነገር ከመጀመሬ በፊት ስለቁሱ/ጉዳዩ ራሴን እ□□ቃለሁ::					
11	□□ለ □□□, ካለቀ በኋላ ምን የተማርኩትን እከልሳለሁ::					
12	አንድን ጥያቄ ለመስራት ብዙ መንገዶች እንዳሉ ተገንዘቤ					

	□ተሻለዉን እመር□ለሁ::					
13	በማጠናበት ጊዜ የተለያዩ ዘዴዎች ያላቸዉን ጠቀሜታ እገነዘባለሁ::					
14	ሥራዬን ከፊ ረስኩ በኋላ ዓላማዬን ምን ያክል በ□ሩ ሁኔታ እንዳንሳካሁ□ራሴን እ□□ቃለሁ::					
15	ምን የህል እንደተገነዘብኩ ለማረጋገጥ ሁል ጊዜ ራሴን እፈትሻለሁ::					
16	ጥያቄዎችን/ መልመጃዎችን ከሰራሁ በኋላ ሁሉንም አማራጮች መጠቀሜን ራሴን እ□□ቃለሁ::					
17	አንድን ሥራ ከመጀመሬ በፊት መመሪያዎንች በጥንቃቄ አነባለሁ::					
18	አዲስ ነገር በምማርበት ወቅት ምን ያክል በ□ሩ ሁኔታ እ□ሰራሁ አንደሆነ ራሴን እ□□ቃለሁ::					
19	ዓላማዬን በጥሩ ሁኔታ ለማሳካት ጊዜዬን ባግባቡ እ□ቀማለሁ::					
20	አንድን ሥራ ከፊ ረስኩ በኋላ ምን ያክል መማር እንደነበረብኝ ራሴን እ□□ቃለሁ::					

5.2 English Version

Addis Ababa University
College of Education and Behavioral Studies

Department of Science and Mathematics Education

Metacognition Awareness Inventory Test

Dear students,

I am conducting a PhD dissertation research. Thus, the purpose of this questionnaire is to collect data from grade 9 students about what they do when they learn biology. The information obtained from this questionnaire will serves as an input in enhancing students' biology learning. The questionnaire consists of 20 statements. Therefore, you are kindly requested to give genuine response to the statements. The responses to the questions will be kept confidential.

Do not write your name.

Thank You for Your Cooperation

Section A

Background Information

1. Name of School ____
2. Gender: Put a tick mark (✓)

   Male ☐ Female ☐
3. Grade Level ____________ Section __________

Section B: Items

Instruction: The following table contains list of statements. There is no right or wrong answers to the statements. It is simply what is true for you. Therefore, read every statements carefully and choose the one that best describes you about what you do when you learn biology and putt a tick mark (√) in the table using the scale below.

Scale : 1 = Strongly Disagree 2 = Disagree 3 = Neutral

4 = Agree 5 = Strongly Agree

No	Items	**5**	**4**	**3**	**2**	**1**
1	I ask myself periodically if I am meeting my goals.					
2	I pace myself while learning in order to have enough time.					
3	I consider several alternatives to a problem before I answer.					
4	I think about what I really need to learn before I begin a task.					
5	I know how well I did once I finish a test.					

6	I set specific goals before I begin a task.					
7	I ask myself if I have considered all options when solving a problem.					
8	I ask myself if there was an easier way to do things after I finish a task.					
9	I periodically review to help me understand important relationships.					
10	I ask myself questions about the material before I begin.					
11	I summarize what I've learned after I finish.					
12	I think of several ways to solve a problem and choose the best one.					
13	I find myself analyzing the usefulness of strategies while I study.					
14	I ask myself how well I accomplish my goals once I'm finished					
15	I find myself pausing regularly to check my comprehension.					
16	I ask myself if I have considered all options after I solve a problem.					
17	I read instructions carefully before I begin a task.					
18	I ask myself questions about how well I am doing while learning something new.					
19	I organize my time to best accomplish my goals.					
20	I ask myself if I learned as much as I could have once I finish a task.					

Appendix 6. Interview Questions

Addis Ababa University

College of Education and Behavioral Studies

Department of Science and Mathematics Education

The main objective of this question is to gatherer data with regards to students' understanding of human biology concepts and misconceptions in the School. Your correct and complete answer to the following questions will have great value for this study. Therefore, you are kindly requested to answer all the questions when you are asked.

Biology Conceptual Understanding Interview Questions

1. What are the different types of food? Describe how you can test the presence of glucose in a solution. What do you observe? Why?
2. What is Digestion? Explain the type and process digestion. Where does absorption of food take place? Why? What happens to excess food in our body? Why?
3. What is the function of enzymes? What happens to enzymes during reaction?
4. What is breathing? Explain the process of breathing. What happens to lung, volume of chest, diaphragm, ribs and intercostals muscles when we breathe in and out?
5. What is respiration? Where it occurs? Why? Explain the difference between aerobic and an aerobic respiration. Which one is more efficient? Why?
6. What is blood circulation? Trace the path of blood in our body. Explain the difference between systemic and pulmonary circulation?
7. What is the difference between the right side and left side of the heart? Why?
8. How many types of blood groups we have? What is blood transfusion? Can anybody transfer blood to any one? Why?
9. What are blood vessels? What is the difference between blood vessels? Why?
10. What happens when the right and left ventricle contracts and relaxes?

Appendix 7. Classroom Observation Check List

Classroom Observation Protocol

School ____ date ______________________

Teacher ______________________________ grade level __________ subject _____________

observer ___________________ Lesson topic _______________________ Duration of observation ___________________

No	Statements Does the teacher:	Rating scale			Comments
		Yes	No	Partly	
1	Prepare a lesson plan in line with 7E instructional model lesson plan format				
2	Activate students' prior knowledge?				
3	Explore misconceptions?				
4	Stimulate students' curiosity/interest to learn the subject?				
5	Perform activities to improve the learner's motivation?				
6	Provide opportunities for students to become aware of the topic?				
7	Prepare activities in which students use prior knowledge to create new thoughts via activities (experiments, concept maps, questions, etc.).				
8	encourages learners to interact in the classroom				
9	Observes learners' study habits and directs them when needed.				
10	Queries students when needed to direct, provide tips, and encourage thinking.				
11	Leads learners to question their misconceptions and incomplete information/ knowledge.				
12	Guides students to access alternative / supplemental resources.				
13	allows learners to compare information				
14	Has the teacher created environments in which students can present their work				
15	Explain new vocabularies, information and concepts about the subject?				
16	Has the teacher establishes a connection with learners' previous knowledge.				
17	Removes misconceptions to ensure students are learning new concepts.				
18	Helps learners to correct and complete missing information.				
19	Deepen and consolidate students understanding through alternative activities in their real lives.				
20	Directs learners to question their knowledge of new situations and to share this with classmates.				

21	Evaluate learners' gained knowledge and skills.				
22	Gives opportunities to learners for self-evaluation.				
23	Gives opportunities to learners for peer-assessment.				
24	Provides models/exemplars/teal life situations for transfer of learning in new or different context				
25	Guide students to associate existing concepts with other areas or the other concepts/topics				
26	Encourage students to apply the concepts and skills they learned to new situations and create the necessary environment?				
27	Give the opportunity to think about their own plan (goal, strategies)				
28	Give the opportunity to check/ monitor their own progress?				
29	Give the opportunity to assess their own learning, goal, strategies?				

Appendix 8. Lesson Plan Format

Lesson Plan

Lesson Plan Sample

Teacher's name: ______________________ **School** ______________________

Subject ________________ **Date of lesson** ______________ **Time** ________

Grade _____ Unit _______Title _______________________________

Lesson topic _____________________

Lesson Objectives

At the end of this session students will be able to:

____

____

____

____

Phases	Guiding questions / ideas	Materials needed	Teacher's activities	Students' activities	Time
Elicit					
Engage					
Explore					
Explain					
Elaborate					
Evaluate					
Extend					

Appendix 9. Permission Letters

A. From the Department

አዲስ አበባ ዩኒቨርስቲ
ሥነ-ትምህርትና ጠባይ ጥናት ኮሌጅ
የሳይንስና ሒሳብ ትምህርት ክፍል
አዲስ አበባ፣ኢትዮጵያ

Addis Ababa University
College of Education and Behavioral Studies
Department of Science & Mathematics Education
Addis Ababa, Ethiopia

Date: October 02, 2017
Ref. No.: SMED/010/2010-17

To: Addis Ababa City Administration Education Bureau
Addis Ababa

Subject: Requesting Permission for Research Work

Mr. Habtamu Wodaj is a PhD candidate at the department of science and mathematics education. He has requested the department to write him an official letter to get your permission.

The department has approved his research proposal entitled "***Learning Human biology through 7E instructional model with metacognitive scaffolding*** " which will be conducted in some selected secondary schools in Addis Ababa. This is therefore; to kindly request your usual cooperation for Mr. Habtamu Wodaj in permitting him to conduct his research in the schools and other necessary support during conducting the research.

With Regards,

Kassa Micheal (PhD)
Chairman, Department of Science and Mathematics Education

☎ 011 1 22 07 67

✉ 1176

B. From City Government of Addis Ababa Education Bureau

የአዲስ አበባ ከተማ አስተዳደር
ትምህርት ቢሮ

CITY GOVERNMENT OF ADDIS
ABABA EDUCATION BUREAU

ቁጥር 824/1651/1838-40/35
REF.NO

ቀን 25/01/2010
DATE

ለጉለሌ ክ/ከተማ ትም/ጽ/ቤት

ለየካ ክ/ከተማ ትም/ጽ/ቤት

ለቂርቆስ ክ/ከተማ ትም/ጽ/ቤት

ለአራዳ ክ/ከተማ ትም/ጽ/ቤት

አዲስ አበባ

ጉዳዩ፡- ትብብር ስለመጠየቅ

አቶ ሀብታሙ ወዳጅ የተባሉት በሂሳብ፣ በሳይንስና ባይዮሎጂ ትምህርት ላይ ለሚያካሂዱት ጥናት መረጃ ለመሰብሰብ ትብብር እንዲደረግላቸው በቁጥር SMED/010/2010-17 በቀን October 02/2017 ዓ.ም በተፃፈ ደብዳቤ ጠይቀዋል፡፡

በዚህ መሰረት በክ/ከተማችሁ የሚገኙ ት/ቤቶች ላይ በሚያካሂዱት ጥናት መረጃ ለመሰብሰብ ተገቢውን ትብብር እንዲደረግላቸው እንጠይቃለን፡፡

ከሠላምታ ጋር

25/1/2010

መረጋ አብርሃ በርሄ
የትምህርት ምርምር ምዘናና ፈተና ዝግጅት
ዋና የሥራ ሂደት መሪ

ግልባጭ

- ለት/ኢ/ኮ/ቴ/ል/ም/ቢሮ ኃላፊ
- የፈተና ዝግጅትና አስተዳደር ዳይሬክቶሬት

ት/ቢሮ

መለስ ዜናዊ፤ ለህዝብ የተፈጠረ፤ለህዝብ የኖረ፤ለህዝብ የተሰዋ ታላቅ መሪ!!
ሌጋሲህ ይቀጥላል ራዕይህም በትውልዶች ቅብብሎሽ ይሳካል!!
"ለትምህርት ጥራትና መስፋፋት በወቅቱ የሚከፍሉት ግብር ዓይነተኛ መሣሪያ ነው፡፡"
"ለአዲስ ለውጥ ! በአዲስ መንፈስ"

+251111-223884/91 FAX +251111-223888 Website WWW.aaceb.gov.et E-mail aa.cgeb@telecom.net.et ✉744
አዲስ አበባ ኢትዮጵያ Addis Ababa – Ethiopia
ማሳሰቢያ ሁልጊዜ የማገናዘቢያ ቁጥሮችን የጉዳዩን ርዕስና የሚመለከተውን ክፍል ይጥቀሱ
REMINDER: PLEASE ALWAYS PROVIDE REF. NO SUBJECT AND ATTENTION TO

Appendix 10. Participant Consents

A. With school principals

አ□ስ አበባ ዩኒቨርሲቲ
□ስነት/ትና ባህሪ ጥናት ኮልጅ
የሳይንስና ሂሳብ ት/ት ክፍል

<u>በት/ት ቤት የምርምር ስምምነት ቅፅ</u>

ውድ የት/ርት ቤቱ ር/መምህር:

እኔ □□ህረ ምረቃ (3ኛ ዲግሪ) መመረቂያ ጥናትና ምርምር በማካሄ□ ላ□ እ□ኛለሁ:: □□ህ ጥናት ዋና ዓላማ የ9ኛ ክ□ል ተማሪ- ች □ስነ-ህይወት ትምህርትን ውጤት የተለያዩ ዘዴዎችን በመ□ቀም ለማሻሻል ነዉ:: □ህ ቅፅ ምርምሩ እንዲካሄድ □ቃ□ ለመ□□ቅ □ተ□□ ነ□ :: የጥናቱ ርዕስ** Learning Human Biology through 7E Instructional Model with Metacognitive Scaffolding **ነዉ:: ጥናቱ በትምህርት ቤቱ የትምህርት ፕሮግራም መሰረት የሚካሄ□ ነ□ :: ነገር ግን የማስተማሪያ ዘዴን መጠቀም፤ አንዳድ ጊዜ ቪ□□ መቅረፅ ፤□□ል ምልከታ ማድረግ፤ ፈተናዎች መፈተን እና መ□□ቆች በመረጃ በመሰብሰብ ሂደት ዉስጥ ይኖራሉ:: በጥናቱ ጊዜ የሚሰበሰቡ መረጃዎች ሚስ□ራዊነታቸዉ የተጠበቀ ይሆናል:: ጥናቱ የት/ርት ቤቱ ላ□ □ሚ□ስከትለዉ ወጪና ጉዳት የለም:: ነገር ግን ተማሪዎች እንዴት መማር እንዳለባቸ□ እንዲያዉቁና በስነ-ህይወት ትምህርት** (Biology) **□ሩ ውጤት እንዲያመጡ □ር□ቸዋል ተብሎ ይጠበቃል:: ስለጥናቱ ጥያቄ ካለዎት በማንኛ□ ም □□ መ□□ቅ □ችላሉ::□

ስለ ትብብርዎ በቅድሚያ አመሰግናለሁ::

ሀብታሙ ዉ□□

ከላ□ □ተ□ለፀዉን አንብቤና የጥናቱን ዓላማ ተረድቼ ጥናቱ እንዲካሄድ ተስማምቻለሁ::

ስም ____

□ርማ ____

ቀን ____

B. Consent with Biology Teachers

አ□ስ አበባ ዩኒቨርሲቲ

□ስነት/ትና ባህሪ ጥናት ኮልጅ

የሳይንስና ሂሳብ ት/ት ክፍል

<u>በት/ት ቤት የምርምር ስምምነት ቅፅ</u>

ዉ□ መምህር:

እኔ □□ህረ ምረቃ (3ኛ ዲግሪ) መመረቂያ ጥናትና ምርምር በማካሄ□ ላ□ እ□ኛለሁ:: □□ህ ጥናት ዋና ዓላማ የ9ኛ ክ□ል ተማሪ- ች □ስነ-ህይወት ትምህርትን ውጤት የተለያዩ ዘዴዎችን በመ□ቀም ለማሻሻል ነው:: □ህ ቅፅ በምርምር ለመሳተ□ □ቃ□ኝነትን ለመ□□ቅ □ተ□□□ ነዉ:: የጥናቱ ርዕስ *Learning Human Biology through 7E Instructional Model with Metacognitive Scaffolding* ነዉ:: ጥናቱ በትምህርት ቤቱ የትምህርት ፕሮግራም መሰረት □ሚካሄ□ ነ□ :: ነገር ግን የማስተማሪያ ዘዴን መጠቀም፣ አንዳድ ጊዜ ቪ□□ መቅረፅ ፣□□ል ምልከታ ማድረግ፣ ፈተናዎች መፈተን እና መ□□ቆች በመረጃ መሰብሰብ ሂደት ዉስጥ □ኖራሉ:: ጥናቱ በፈቃደኝነት ላይ የተመሰረተነዉ:: በጥናቱ ጊዜም ይሁን ዉጤቱ ሲገለፅ ስም- አ□□ለፅም፣ በኮ□ ነዉ የሚሰራዉ:: በዚህ ጥናት የሚሰበሰቡ መረጃዎች ሚስ□ራዊነታቸዉ የተጠበቀ ይሆቲናል:: ጥናቱ በርስዎ ላይ የሚያስከትለዉ ወጪና ጉዳት □ለም:: ነገር ግን ተማሪዎች እንዴት መማር እንዳለባች□ እንዲያዉቁና በስነ-ህይወት ትምህርት (Biology) □ሩ ውጤት እንዲያመጡ □ር□ቸዋል ተብሎ ይጠበቃል:: ስለጥናቱ □□ቄ ካለዎት በማንኛ□ ም □□ መ□□ቅ □ችላሉ::
ስለ ትብብርዎ በቅድሚያ አመሰግናለሁ
ሀብታሙ ወ□□
ከላ□ □ተ□ለፀዉን አንብቤና የጥናቱን ዓላማ ተረድቼ በጥናቱ ለመሳተፍ ተስማምቻልሁ::
ስም ____
□ርማ ______________________________________
ቀን ____

C. Consent with School Students

አ□ስ አበባ ዩኒቨርሲቲ

□ስነት/ትና ባህሪ ጥናት ኮልጅ

የሳይንስና ሂሳብ ት/ት ክፍል

<u>በት/ት ቤት የምርምር ስምምነት ቅፅ</u>

ውድ ተማሪ- ች:

እኔ □□ህረ ምረቃ (3ኛ *ዲግሪ*) *መመረቂያ ጥናትና ምርምር በማካሄ□ ላ□ እ□ኛለሁ:: □□ህ ጥናት ዋና ዓላማ የ9ኛ ክ□ል ተማሪ- ች □ስነ-ህይወት ትምህርትን ውጤት የተለያዩ ዘዴዎችን በመ□ቀም ለማሻሻል ነዉ:: □ህ ቅፅ በምርምር ለመሳተ□ □ቃ□ኝነትን ለመ□□ቅ □ተ□□□ ነዉ:: የጥናቱ ርዕስ Learning Human Biology through 7E Instructional Model with Metacognitive Scaffolding ነዉ:: ጥናቱ በትምህርት ቤቱ የትምህርት ፕሮ□ራም መሰረት □ሚካሄ□ ነ□ :: ነገር ግን የማስተማሪያ ዘዴን መጠቀም፤ አንዳድ ጊዜ ቪ□□ መቅረፅ ፤□□ል ምልከታ ማድረግ፤ ፈተናዎች መፈተን እና መ□□ቆች በመረጃ መሰብሰብ ሂደት ዉስጥ □ኖራሉ:: ጥናቱ በፈቃደኝነት ላይ የተመሰረተነዉ:: በጥናቱ ጊዜም ይሁን ዉጤቱ ሲገለፅ ሰማችሁ አ□□ለፅም፤ በኮ□ ነ□ □ሚሰራ□ :: ከናንተ የሚሰበሰቡ መረጃዎች ሚስ□ራዊነታቸዉ የተጠበቀ ይሆናል:: ጥናቱ በናንተ ላይ የሚያስከትለዉ ወጪና ጉዳት □ለም:: ነገር ግን እንዴት መማር እንዳለባችሁ እንድታቁና በስነ-ህይወት ትምህርት* (Biology) *□ሩ ውጤት እንድታመ□- □ር□ችኋል ተብሎ ይጠበቃል:: ስለጥናቱ ጥያቄ ካላችሁ በማንኛዉም ጊዜ መጠየቅ ትችላላችሁ::□*

ስለ ትብብራችሁ በቅ□ሚ□ አመሰግናለሁ

ሀብታሙ ዉ□□

ከላ□ □ተ□ለፀዉን አንብቤና የጥናቱን ዓላማ ተረድቼ በጥናቱ ለመሳተ□ ተስማምቻለሁ::

ተ.ቁ	ስም	□ርማ

Appendix 11. Items with Misconceptions

Items			EG1	EG2	EG3	CG
1	To which of the following substance that the excess food in our body converted for later use?					
	A	Protein	17.08	31.47	39.17	33.38
	B	Lipid*	48.34	50.53	39.92	42.76
	C	Carbohydrate	34.54	18.05	40.91	23.86
	The reason for my answer is					
	1	It is an important source of energy and the most effective energy store in our body.*	28.86*	26.85*	18.99*	30.86*
	2	It is an important source of vitamins in our body	4.88	5.26	9.3	7.14
	3	Used as sources of energy when there is lack of oxygen in our body.	9.76	13.16	9.3	4.76
	4	It is an important immediate source of energy for cellular activities.	4.88	5.26	2.33	
	5	Other reason: ___________	0	0		2.38
2	A grade 9 student conducted an experiment in biology laboratory. First she put a sample of glucose powder and water in to a test tube. Then she added a few drops of Benedict's solution in to the test tube and placed it in boiling water. What was the most probable colour she observed within the test tube?					
	A	Blue	29.27	26.56	42.14	29.66
	B	Purple	30.73	23.84	11.62	27.28
	C	Black	7.32	5.26	2.33	7.14
	D	Orangey-red*	33.74	45.27	44.47	47.5
	reason					
	1	Copper(II) in the Benedict's solution is reduced to copper(I)*	26.42	40.01	18.99	26.1
	2	Copper(I) in the Benedict's solution is oxidized to copper(II)	2.44	5.26	2.33	7.14
	3	Monosaccharide is reduced in the reaction to disaccharides	0	0	9.3	11.93
	4	When water boils it changes its colour	4.88	0	13.95	2.38
	5	Other reason:	0	0		0
3	In human digestive system, where does absorption of food take place? In the:					
	A	Mouth	21.22	17.67	27.52	7.04

	B	Large intestine	8.8	18.42	25.28	21.56
	C	Stomach	12.2	26.52	9.34	27.75
	D	Small intestine*	58.13	37.38	37.59	42.76
	The reason for my answer is					
	1	Digestion is completed there and contains villi for diffusion to occur rapidly*.	21.54	29.49	28.29	23.72
	2	Absorption of water completed there and contains villi for diffusion to occur rapidly.	2.44	0	4.65	
	3	It contains bacteria to digest minerals and nutrients and villi for diffusion to occur rapidly.	2.44	7.89		
	4	It involves the process of peristalsis to move smaller substance through villi in to blood stream.	26.83	0	4.65	7.14
	5	It contains hydrochloric acid that facilitate diffusion of molecules in to the blood stream.	4.88	0	9.3	7.14
	6	Other reason:				4.76
4	Mechanical digestion breaks down large food substance in to smaller and soluble molecules?					
	A	True	58.15	52.05	48.8	54.67
	B	False*	41.05	47.9	51.76	45.2
	The reason for my answer is					
	1	It releases enzymes from glands and breaks food substance in to small and soluble molecules.	2.44	0	11.63	0
	2	It breaks down food in to smaller pieces and increases the surface area for enzyme action.*	33.73	40.01	28.29	26.1
	3	It breaks down food substance in to small and soluble molecules through hydrolysis reaction.	2.44		2.33	4.76
	4	It changes large and insoluble molecules to smaller and soluble one through the action of enzymes.	2.44	7.89	11.63	11.93
	5	Other reason:	0	0	0	2.38
5	During chemical digestion, enzymes bind with the food substance to catalyze a reaction but released at the end of a reaction without any change on their					

	nature.					
	A	True*	65.45	76.85	72.48	53.7
	B	False	34.55	23.15	27.52	46.3
	The reason for my answer is					
	1	Enzymes take part in the reaction and broken down in to smaller components at the end.	7.32	15.79	6.98	9.52
	2	Enzymes do not take part in the reaction and not affected by the reaction they catalyze.*	28.86	40.01	35.26	26.1
	3	Enzymes take part in the reaction and affected by the reaction they catalyze.	9.76	5.26	23.26	4.76
	4	Enzymes are proteins. They are broken down in to amino acids when they catalyze a reaction.	19.51	13.16	6.98	9.52
	5	Other reason:		2.63		3.8
6	All the oxygen we inhale (breathe in) is taken into the blood and then to the body's cells where it is used up. As a result of it being used up, no oxygen is breathed out when we exhale.					
	A	True	19.85	33.8	29.94	19.09
	B	False *	80.05	66.36	70.06	80.87
	The reason for my answer is					
	1	All the oxygen breathed in is absorbed and it is all used in the process of respiration.	14.6	2.63	4.65	14.29
	2	Not all of the oxygen inhaled is absorbed and so there is some left in the lungs that will be breathed out with the carbon dioxide.*	50.81	42.64	46.89	42.77
	3	We absorb all of the oxygen we inhale because we need it. We only remove materials that are dangerous to the body. Since carbon dioxide is poisonous to us we breathe it out.	9.76	5.26	11.63	14.29
	4	The diaphragm pulls all of the oxygen into the body and only pushes the carbon dioxide out	4.88	2.63	6.89	2.38
	5	If oxygen is not absorbed straight away, it is stored in the alveoli for use later and it is not exhaled. It is needed too much by		13.16		7.14

		the body to be breathed out.				
	6	Other reason:				
7	Each lung is a large hollow sack that is like a balloon that expands and contracts to get air into and out of the lung.					
	A	True	63.86	37.3	48.49	57.24
	B	False *	36.14	62.74	51.51	42.76
	reason					
	1	There is a model that shows the lungs as two balloons in a cavity. The balloons expand to let air into them and get smaller to push air out of them.		13.16	11.6	7.14
	2	The lungs are composed of lots of little sacks and the air entering them makes them expand.	14.6	15.59	18.6	11.9
	3	The lungs are made up of a lot of tiny sacks and the lungs expand and contract as the thorasic (chest) cavity changes its volume.*	21.54	26.1	21.31	18.96
	4	The lungs are two hollow bags and their volume changes because the diaphragm pushes and pulls on them.		7.89		4.76
	5	Other reason:				
8	Breathing is the same as respiration.					
	A	True	36.51	10.53	39.49	A
	B	False*	63.04	90.01	60.42	B
	The reason for my answer is					reason
	1	Both of these processes involve getting oxygen into the body and carbon dioxide out of the body so they are the same.	4.88	5.26	4.66	1
	2	Breathing is getting oxygen into the body and carbon dioxide out; while respiration is the process involved in moving these gases around the body in the blood.	14.63	2.63	16.28	2
	3	Breathing is the process of getting oxygen into the lungs from the atmosphere (inhaling) and carbon dioxide out of the body (exhaling). Respiration is the process of getting oxygen from the lungs to the body and carbon dioxide from the body	14.63	10.53	11.63	3

		into the lungs.				
	4	Breathing is the process of getting oxygen from the atmosphere into the cells and carbon dioxide out of the cells and into the atmosphere. Respiration is the process in which the cells produce energy and carbon dioxide.*	28.86	66.33	28.29	4
	5	Breathing occurs in the lungs while respiration occurs elsewhere in the body but not in or near the lungs. Apart from where they occur they are the same thing.		5.26		5
	6	Other reason:				6
9	When we breathe in, the lungs expand in volume because the thorasic (chest) cavity expands.					
	A	True*	96.12	89.06	74.8	90.44
	B	False	4.34	11.16	25.54	9.52
	The reason for my answer is					
	1	Air moving into the lungs forces them to expand to let the air in and as the air moves out the lungs decrease in volume because there is less air to fill them.	12.2	13.16	11.63	19.05
	2	Because of surface tension between the thorasic (chest) cavity, the pleura and the lungs, as the thorasic cavity increases in volume (size) the lungs increase in volume as well.*	57.58	55.5	25.96	40.09
	3	The lungs change in volume and this causes the thorasic cavity to change in volume to accommodate the lungs' new volume.	12.2	10.53	27.91	16.67
	4	The lungs actively expand so we can breathe in (inhale) and they contract so we can breathe out (exhale).	14.63	10.53	9.3	14.29
	5	Other reason:				
10	When we breathe deeply, the diaphragm contracts strongly and pulls harder on the lungs and this increases the volume of the lungs. The diaphragm relaxes extra hard and it pushes on the lungs to force air out.					
	A	True *	89.63	66.16	74.76	74.12

	B	False	10.52	33.84	25.21	25.87
	The reason for my answer is					
	1	The diaphragm and intercostal muscles contract. It is these two sets of muscles contracting that leads to an increase in the volume of the thorasic (chest) cavity.*	50.81	40.01	35.26	28.88
	2	When we exercise, we make more carbon dioxide which gets into the lungs and makes them expand more. When the carbon dioxide moves out of the body, it reduces the volume needed by the lungs.	14.6	15.79	18.6	14.29
	3	The air moving into the lungs during exercise causes the lungs to expand as the air needs more space than when we breathe normally and this pushes out the diaphragm and ribs and so we get an increase in thorasic (chest) cavity size.	12.07	15.79	11.63	4.76
	4	When we exercise, we need more oxygen and this extra oxygen moving into the lungs makes them bigger. As we absorb the oxygen there is less volume of air left and so the lungs' volume decreases.	12.2	10.53	9.3	26.19
	5	Other reason:				
11	Which of the following is true? Energy release during respiration occurs:					
	A	Only in the lungs.	10.07	10.53	7.02	4.76
	B	Only in the stomach.	4.88	5.26	18.6	9.52
	C	In all cells of the body.*	80.08	82.11	53.87	69.05
	D	Only in small intestine.	4.88	2.63	21.29	4.76
	The reason for my answer is					
	1	All cells have an energy requirement and must respire.*	70.32	74.22	35.26	59.14
	2	The lungs are the place where oxygen is taken into the body.			6.98	9.52
	3	The stomach is the place where food is digested.	7.32	5.26	9.3	14.29
	4	Small intestine is the place where energy is released.	2.44	2.63	2.33	4.76
	5	Other reason:				
12	Which of the following is true about respiration?					

	A	It involves the oxidation of food and release of energy.*	48.37	68.96	56.19	58.46
	B	It involves the extraction of energy from oxygen.	26.71	13.42	11.63	32.1
	C	Energy is used to oxidize food.	19.5	15.77	30.04	2.38
	D	It involves extraction of oxygen from food.	4.86	2.63	2.33	7.12
	The reason for my answer is					
	1	Food cannot be used by the body unless energy is used to break it down.	2.44	13.16	16.28	7.14
	2	Food contains chemical energy which can only be released by using oxygen to break it down.*	31.29	50.54	30.61	23.72
	3	Oxygen contains chemical energy which can only be released by breaking it down.	4.88	2.63	4.65	11.93
	4	Respiration is a process of taking and releasing energy and oxygen.	9.76	2.63	4.65	16.67
	5	Other reason:				
13	Anaerobic respiration is less efficient than aerobic respiration.					
	A	True*	75.17	92.84	84.04	85.5
	B	False	24.84	7.09	15.86	14.5
	reason					
	1	In aerobic respiration there is metabolism but in anaerobic respiration there is no metabolism.	14.6	18.42	13.95	7.14
	2	Anaerobic respiration does not use oxygen but aerobic respiration uses oxygen.	12.2	10.53	18.6	21.43
	3	Aerobic respiration breaks food molecules completely and releases high energy	7.32	7.89	11.63	9.52
	4	Anaerobic respiration breaks food molecules completely and releases high energy.	7.32		13.95	14.29
	5	Anaerobic respiration breaks food molecules partially and releases less energy. *	31.29	55.8	25.96	33.25
	6	Other reason:	2.44			
14	Which part of the heart has thicker muscles wall?					
	A	The left side of the heart *	79.16	71.59	70.13	65.76
	B	The right side of the heart	20.84	28.41	29.87	34.31

	The reason for my answer is					
	1	It protects the heart from external damage.	2.44	2.63		4.76
	2	It pumps blood to a relatively long distance.*	54.76	42.64	30.61	30.86
	3	It pumps blood to a relatively short distance.	7.32	13.16	13.95	11.9
	4	It receives much of the digested food to build them.		10.53	13.95	11.9
	5	The heart is found in the left of the chest.	12.2	2.63	11.63	4.76
	6	Other reason:	2.44			2.38
15	If someone with blood group “A” has got a car accident and lost a lot of blood. Therefore, he needs blood transfusion. Which of the following blood group is used during the transfusion?					
	A	B	7.32	2.63	13.57	4.76
	B	AB	24.4	36.32	9.3	47.72
	C	O*	67.89	61.06	77.13	47.52
	The reason for my answer is					
	1	It has no antibody that reacts with antigen of the red blood cells of the person.	9.76	7.89	11.63	4.76
	2	It has antigen AB that do not react with antibody in the red blood cells of the person.	9.76		13.95	11.9
	3	It has no antigen that reacts with antibody of the red blood cells of the person.*	36.17	53.17	39.92	26.1
	4	It has no antigen and antibody that reacts with the red bloods of the person.	12.2		11.63	4.76
	5	Other reason:				
16	Which of the following is correct about blood vessels?					
	A	Veins have thick and elastic walls	32.03	13.16	11.63	23.62
	B	Arteries have thick and elastic walls*	55.7	79.49	70.17	50.04
	C	Capillaries have thick and elastic walls	12.2	7.89	18.2	26.4
	The reason for my answer is					
	1	They stretch as blood forced in to them and pump long distance. *	28.86	32.12	39.92	23.72
	2	They pump blood under high pressure to the nearest body parts.	12.2	18.42	11.63	9.52
	3	They prevent heat loss as blood travels through them.	9.76	13.16	13.95	7.14

	4	Maintain high blood pressure in human body.	4.88	15.79	4.65	9.52
	5	Other reason:				
17	Systemic circulation in human being transports both oxygenated and deoxygenated blood.					
	A	True*	87.81	87.32	74.8	83.28
	B	False	12.2	13.16	25.26	16.8
	The reason for my answer is					
	1	Pulmonary circulation transports deoxygenated blood and systemic circulation transports oxygenated blood throughout the body.	9.76	26.32	9.3	11.9
	2	Systemic circulation transports deoxygenated blood from different part of the body to the heart and oxygenated blood from the heart to different parts of our body.*	45.93	45.28	46.89	28.48
	3	Pulmonary circulation transports deoxygenated blood from different part of the body to the heart and oxygenated blood from the heart to different parts of our body.	14.63	2.63	16.28	19.05
	4	Systemic circulation transports deoxygenated blood to the lung and oxygenated blood to the heart.	17.07	10.53	2.33	23.81
	5	Other reason		2.63		
18	When the right and left ventricle contracts:					
	A	Both oxygen-rich and oxygen poor blood leaves the heart*.	33.24	43.27	35.37	54.7
	B	Blood from one side of the heart goes to the right side of the body and blood from the other side of the heart goes to left side of the body.	28.35	38.37	36.86	16.76
	C	Oxygen-rich and oxygen poor blood enters the right ventricles of the heart.	30.72	7.89	16.28	14.29
	D	Blood enters into the heart from lower side of the body and blood leaves the heart and goes to the upper part of the body.	7.32	10.5	11.63	14.29
	The reason for my answer is					
	1	Blood from the right side of the heart goes	19.1	32.12	25.96	28.48

		to lung and blood from the left side of the heart goes to our body.*				
	2	Blood from the left side of the heart goes to the lung and blood from the right side of the heart goes to the body.	2.44	7.89	6.98	4.76
	3	The right side of the heart pumps blood to the right side of the body where as the left side pump blood to left side of the body.	12.2			11.9
	4	Only oxygenated blood enters the heart because the heart needs pure blood.		2.63		9.52
	5	The right side of the heart pumps blood to the lower parts of the body where as the left side pump blood to upper part of the body.		2.63	2.33	
	6	Other reason				

NB: Percentages under reasons are those with correct first choice only.

Appendix 12. Misconceptions Identified

			Groups			
no	item	Misconceptions	TG1	TG2	TG3	CG
1	1	It is an important source of vitamins in our body	4.88	5.26	11.63	7.14
2	1	Used as sources of energy when there is lack of oxygen in our body.	9.76	13.16	9.3	4.76
3	2	When water boils it changes its colour	4.88	0	13.95	2.38
4	3	It involves the process of peristalsis to move smaller substance through villi in to blood stream.	26.83	0	4.65	7.14
5	3	It contains hydrochloric acid that facilitate diffusion of molecules in to the blood stream.	4.88	0	9.3	7.14
6	4	It releases enzymes from glands and breaks food substance in to small and soluble molecules.	2.44		11.63	
7	4	It changes large and insoluble molecules to smaller and soluble one through the action of enzymes.	2.44	7.89	11.63	9.52
8	5	Enzymes take part in the reaction and broken down in to smaller components at the end.	7.32	15.79	6.98	9.52
9	5	Enzymes take part in the reaction and affected by the reaction they catalyze.	9.76	5.26	23.26	4.76
10	5	Enzymes are proteins. They are broken down in to amino acids when they catalyze a reaction.	19.51	13.16	6.98	9.52

11	6	All the oxygen breathed in is absorbed and it is all used in the process of respiration.	14.6	2.63	4.65	14.29
12	6	We absorb all of the oxygen we inhale because we need it. We only remove materials that are dangerous to the body. Since carbon dioxide is poisonous to us we breathe it out.	9.76	5.26	11.63	14.29
l13	6	If oxygen is not absorbed straight away, it is stored in the alveoli for use later and it is not exhaled. It is needed too much by the body to be breathed out.		13.16		7.14
14	7	There is a model that shows the lungs as two balloons in a cavity. The balloons expand to let air into them and get smaller to push air out of them.		13.16	11.6	7.14
15	7	The lungs are composed of lots of little sacks and the air entering them makes them expand.	14.6	15.59	18.6	11.9
16	8	Breathing is getting oxygen into the body and carbon dioxide out; while respiration is the process involved in moving these gases around the body in the blood.	14.6	2.63	16.28	11.9
17	8	Breathing is the process of getting oxygen into the lungs from the atmosphere (inhaling) and carbon dioxide out of the body (exhaling). Respiration is the process of getting oxygen from the lungs to the body and carbon dioxide from the body into the lungs.	14.63	10.53	11.63	7.14
18	9	Air moving into the lungs forces them to expand to let the air in and as the air moves out the lungs decrease in volume because there is less air to fill them.	12.2	13.16	11.63	19.05
19	9	The lungs change in volume and this causes the thorasic cavity to change in volume to accommodate the lungs' new volume.	9.76	10.53	27.91	16.67
20	9	The lungs actively expand so we can breathe in (inhale) and they contract so we can breathe out (exhale).	14.63	10.53	9.3	14.29
21	10	When we exercise, we make more carbon dioxide which gets into the lungs and makes them expand more. When the carbon dioxide moves out of the body, it reduces the volume needed by the lungs.	19.5	15.79	18.6	14.29
22	10	The air moving into the lungs during exercise causes the lungs to expand as the air needs more space than when we breathe normally and this pushes out the diaphragm and ribs and so we get an increase in	17.07	15.79	11.63	4.76

		thorasic (chest) cavity size.				
23	10	When we exercise, we need more oxygen and this extra oxygen moving into the lungs makes them bigger. As we absorb the oxygen there is less volume of air left and so the lungs' volume decreases.	12.2	10.53	9.3	26.19
24	11	The stomach is the place where food is digested.	7.32	5.26	9.3	14.29
25	12	Food cannot be used by the body unless energy is used to break it down.	2.44	13.16	16.28	7.14
26	12	Oxygen contains chemical energy which can only be released by breaking it down.	4.88	2.63	4.65	9.52
27	12	Respiration is a process of taking and releasing energy and oxygen.	9.76	2.63	4.65	16.67
28	13	In aerobic respiration there is metabolism but in anaerobic respiration there is no metabolism.	14.6	18.42	13.95	7.14
29	13	Anaerobic respiration use oxygen but aerobic respiration does not use oxygen.	12.2	10.53	18.6	21.43
30	13					
31	13	Anaerobic respiration breaks food molecules completely and releases high energy.	7.32	5.26	13.95	14.29
32	14	It pumps blood to a relatively short distance.	7.32	13.16	13.95	11.9
33	14	It receives much of the digested food to build them.		10.53	13.95	11.9
34	14	The heart is found in the left of the chest.	12.2	2.63	11.63	4.76
35	15	It has no antibody that reacts with antigen of the red blood cells of the person.	9.76	7.89	11.63	4.76
36	15	It has antigen AB that do not react with antibody in the red blood cells of the person.	9.76		13.95	11.9
37	15	It has no antigen and antibody that reacts with the red bloods of the person.	12.2		11.63	4.76
38	16	They pump blood under high pressure to the nearest body parts.	12.2	18.42	11.63	9.52
39	16	They prevent heat loss as blood travels through them.	9.76	13.16	13.95	7.14
40	16	Maintain high blood pressure in human body.	4.88	15.79	4.65	9.52
41	17	Pulmonary circulation transports deoxygenated blood and systemic circulation transports oxygenated blood throughout the body.	9.76	26.32	9.3	11.9
42	17					
43	17	Pulmonary circulation transports deoxygenated blood from different part of the body to the heart and oxygenated blood from the heart to different parts of our body.	14.63	2.63	16.28	19.05

44	17	Systemic circulation transports deoxygenated blood to the lung and oxygenated blood to the heart.	17.07	10.53	2.33	23.81
45	18	The right side of the heart pumps blood to the right side of the body where as the left side pump blood to left side of the body.	12.2			11.9
46	18	Only oxygenated blood enters the heart because the heart needs pure blood.		2.63		9.52

NB percentage under reasons are those only with correct first choice