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

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

GÜLSÜM GÖK

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
THE DEPARTMENT OF ELEMENTARY EDUCATION

AUGUST 2014

Approval of the Graduate School of Social Sciences

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ABSTRACT

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

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August 2014, 570 pages

The purpose of the current study is to investigate the relative effect of 7E learning cycle (7E-LCI) instruction and curriculum oriented science instruction (COSI) on middle school students' conceptual understanding of human body systems, self-regulation, scientific epistemological beliefs, and science process skills.

The sample consisted of 185 sixth grade students from six intact classes. Among them, three classes were randomly assigned as experimental group and other three as comparison group. The experimental group students were learned the skeletal system, circulatory system and respiratory systems topic through 7E-LCI while the comparison group students instructed with COSI.

Skeletal System Conceptual Inventory, Circulatory System Conceptual Inventory, and Respiratory System Conceptual Inventory were administered to the participants as pretests, posttests, and follow-up tests at before, after and one-month later of related topic instruction. Moreover, Motivated Strategies for Learning Questionnaire, Epistemological Beliefs Questionnaire, and Science Process Skills Test were administered to participants as pretest and posttest at the beginning and at the end of the study.

Mixed between within subjects ANOVAs and mixed between within subjects MANOVAs were conducted to compare the effectiveness of two instructions on collective variables as well as to investigate the relative effect of two instructions on development of collective variables. The results of the study showed that 7E-LCI is more effective than curriculum oriented science instruction in terms of acquiring conceptual understanding, retaining acquired knowledge, and promoting self-regulation. On the other hand, two instructions did not indicate a striking effect on students' scientific epistemological beliefs and science process skills.

Keywords: 7E Learning Cycle, Science Education, Human Body Systems, Conceptual Understanding, Self-Regulation

ÖZ

7E ÖĞRENME DÖNGÜSÜ MODELİNİN 6. SINIF ÖĞRENCİLERİNİN VÜCUDUMUZDA SİSTEMLER KONUSUNU ANLAMALARINA, ÖZ-DÜZENLEME BECERİLERİNE, BİLİMSEL EPİSTEMOLOJİK İNANÇLARINA VE BİLİMSEL SÜREÇ BECERİLERİNE ETKİSİ

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Ağustos 2014, 570 sayfa

Bu çalışmanın amacı, 7E öğrenme döngüsünü modeli ile müfredat tabanlı fen öğretiminin altıncı sınıf öğrencilerinin vücudumuzda sistemler konusunu kavramsal anlama, öz-düzenleme becerileri, bilimsel epistemolojik inançları ve bilimsel süreç becerileri üzerindeki etkinliğinin karşılaştırmalı olarak araştırılmasıdır.

Çalışmanın örneklemi, altı farklı sınıfta eğitim gören 185 altıncı sınıf öğrencisinden oluşmaktadır. Sınıflardan üç tanesi deney grubu olarak, üç tanesi de karşılaştırma grubu olarak rasgele atanmıştır. Deney grubundaki öğrenciler Destek ve Hareket Sistemi, Dolaşım Sistemi ve Solunum Sistemi konularını 7E öğrenme döngüsü yöntemi ile öğrenirken, karşılaştırma grubu aynı konuları müfredat tabanlı fen öğretimi yöntemi ile öğrenmiştir.

Öğrencilerin kavram anlamaları Destek ve Hareket Sistemi Kavram Testi, Dolaşım Sistemi Kavram Testi ve Solunum Sistemi Kavram Testi ile ölçülmüş, her bir test, ilgili konunun başında, sonunda ve tamamlanmasından bir ay sonra ön test, son test ve takip testi olarak uygulanmıştır. Ayrıca Öğrenmede Güdüsel Stratejiler Anketi, Epistemolojik İnançlar Anketi ve Bilimsel Süreç Becerileri Testi çalışmanın öncesinde ve sonrasında ön test ve son test olarak uygulanmıştır.

Öğretim yöntemlerinin ölçülen değişkenler üzerindeki etkisini karşılaştırmak amacıyla karışık faktörlü varyans analizi (Mixed-ANOVA) ve karışık faktörlü çoklu varyans analizi (Mixed-MANOVA) uygulanmıştır. Bulgular 7E öğrenme döngüsü modelinin müfredat tabanlı fen öğretimine göre öğrencilerin kavram anlamaları, kavramların kalıcılığı ve öz-düzenleme becerileri açısından daha etkin olduğunu göstermiştir. Öte yandan bilimsel epistemolojik inançlar ve bilimsel süreç becerileri açısından her iki öğretim yönteminin birbirlerine göre bir fark ortaya çıkartmadığı gözlenmiştir.

Anahtar Kelimeler: 7E Öğrenme Döngüsü Modeli, Fen Eğitimi, Vücudumuzda Sistemler, Kavramsal Anlama, Öz-Düzenleme

To my beautifiul daughter Zeynep Defne Gök

&

To my husband Ali Gök

ACKNOWLEDGEMENT

The completion of my doctoral degree and this dissertation would have been impossible without the assistance of countless people to whom I am very thankful. Assoc. Prof. Dr. Semra Sungur, my advisor, must be gratefully acknowledged firstly as she agreed to shepherd my progress from the beginning to the final defense. She is an extraordinary scholar who provides all guidance, support, feedbacks and care to achieve the highest quality work from her students. I will always be indebted for the opportunity to have been her student. I am also grateful to my co-advisor Prof. Dr. Ceren Öztekin for her guidance, encouragement and feedbacks. It was a pleasure to benefit from her expertise and wisdom. I would like to thank my dissertation committee of Prof. Dr. Jale Cakiroglu, and Assoc. Prof. Dr. Ömer Faruk Özdemir for their contributions in turning a research idea to a completed study. I am also thankful to Assoc. Prof. Dr. Özgül Yılmaz Tüzün and Assist. Prof. Dr. Eren Ceylan for participating in my committee members and for their valuable comments and recommendations.

Members of my family were very much part of this journey. Special heartfelt thanks to my husband Ali Gök, for his patience, help, encouragement and undying support during all steps of my PhD. I have to thank my daughter Zeynep Defne for being such a warmhearted, patient and sensitive kid. I am eternally grateful for her presence in my life. She was my comfy place to hide and calm when I am full of stress. I would like to most importantly thank to my mom Gülser Araz. It would not be possible to finish this process without her endless hours of babysitting, help, care, and physical and emotional supports. I am also thankful to my dad Dr. Rifat Araz, my older brothers Kadir Araz and Dr. Kürşad Araz, and his wife Yasemin Araz for their help and moral support. Additionally, I am grateful to my uncle Assoc. Prof. Dr.

Selami Serhatlıoğlu to share his medical expertise, and my friend Füsun Aykanat to share her science teacher expertise for reviewing all my conceptual test items.

A special thank goes to my beloved friend and my officemate Dr. Sündüs Yerdelen for all our shared memories, for her effort to motivate me to study, and for patiently serving as a self-regulation literature database and dissertation manual during my dissertation writing. My special thanks also go to Dr. Mustafa Cansız and Dr. Nurdane Aydemir who shared all academic sources they have and their final dissertations before opening to public access, which made the process absolutely easier for me. I acknowledge my friend and officemate Muhammet Ali Karaduman for all his help in this process. I was also surrounded by a host of friends that have shared their love, support and encouragement along the way: Dr. Aslıhan Osmanoğlu, Dr. Burcu Şenler, Dr. Asiye Parlak Rakap, Dr. Yasemin Taş, Dr. Esma Hacıeminoğlu, Dr. Zeynep Akdağ, Dr. Hasibe Özlen Bakır, Dr. Ayşe Yenilmez Türkoğlu, Dr. Murat Aydemir, Dr. Buket Bezgin Çarbaş, and Tuğçe Karaduman. I am thankful to all of them. I also acknowledge my friend Filiz Bezci who simplified the completion of this dissertation. My additional thanks go to Dr. Gürcan Çetin for selflessly teaching me how to use reference function of the Office Word and Şahin Tanrıverdi, security guard, for sharing his food and coffee while I study late times in my office.

My sincere appreciation to 6^{th} grade students of Talia Yaşar Bakdur İlköğretim Okulu who participated in this study and also their science teachers who agreed to apply my instructional materials fastidiously. I would also express my sincere appreciation to administrators and all teachers worked in this school for their acceptance and facilitation. Sincere gratitude is extended to Faculty Development Program (OYP) for providing an opportunity to have my education in a valuable academic and social environment. I also extend my gratitude to TUBITAK for providing financial support in this process by National Scholarship Programme for PhD Students. I am sincerely grateful to YÖK for the scholarship that allowed me to visit UCLA for one year and Prof. Dr. Willam Sandoval for his acceptance, guidance, creative ideas and support during my visiting time at UCLA.

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LIST OF ABBREVIATIONS

7E-LCI: 7E Learning Cycle Instruction

AAAS: American Association for the Advancement of Science

CG: Comparison Group

CLB: Control of Learning Beliefs

COSI: Curriculum Oriented Science Instruction

CSCI: Circulatory System Conceptual Inventory

CT: Critical Thinking

E: Elaboration

EBQ: Epistemological Beliefs Questionnaire

EG: Experimental Group

EGO: Extrinsic Goal Orientation

ER: Effort Regulation

HS: Help Seeking

IGO: Intrinsic Goal Orientation

Mixed-ANOVA: Mixed Between Within Analysis of Variance

Mixed-MANOVA: Mixed Between Within Multivariate Analysis of Variance

MoNE: Ministry of National Education

MSLQ: Motivated Strategies for Learning Questionnaire

O: Organization

PL: Peer Learning

R: Rehearsal

RSCI: Respiratory System Conceptual Inventory

SE: Self-Efficacy

SPST: Science Process Skills Test

SR: Metacognitive Self-Regulation

SSCI: Skeletal System Conceptual Inventory

TA: Test Anxiety

TSE: Time and Study Environment

TV: Task Value

CHAPTER I

INTRODUCTION

Comprehensive international studies such as Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) clearly demonstrated that Turkish students were below the international average on the science achievement tests and ranked in the lower-performing group of the countries in these exams for years. Actually, classroom practices that students encounter in their schools appeared to be one of the most influential factors of student performances in these internationally administered examinations (Aypar, Erdogan & Sozer, 2007; Ozdemir, 2003). This situation indicates the need for improvement in science education through classroom practices that promote conceptual understanding, the motivation and skills in students to learn by themselves, inquiry and understanding the natural world, and keeping up with the rapid changes in the science and technology. 7E learning cycle is a promising instructional model to achieve this purpose. 7E learning cycle is an inquiry based teaching approach which ground on the theory of constructivism.

The current reforms in both national and international science education were developed from the perspective of constructivism. Constructivist perspective views learning as an active knowledge construction process in the mind of the learner instead of the acquisition from outsiders in an already organized form (Rowlands & Carson, 2001; Eggen & Kauchak, 1994). The ideas of Piaget were accepted as the core of the constructivism theory. According to Piaget, knowledge is constructed by learners in a continuous self-construction process including three basic concepts assimilation, accommodation and equilibration (Pulaski, 1980). Assimilation occurs if the new experiences fit the existing cognitive structure. Accommodation, on the other hand, occurs if students' existing structure is inadequate to interpret the new experience. At this moment, disequilibrium arises because of the cognitive conflict between the new information and substantial conception. In order to reach equilibrium, individual transforms or extends the current conceptions to balance with the newly comprehended one. Equilibration is the name of this process of transformation from disequilibrium to equilibrium to reach the stability on mental structure (Wadsworth, 1971). As clearly seen in the process, the most influential factor is emphasized as the existing knowledge of the students. As driven from the Ausubel's ideas that the existing knowledge assists or interferes the further learning, the constructivist educators take these knowledge into account to promote learning in the classroom (Duit & Tregaust, 1998). Moreover, influencing from the Vygotsky's arguments, constructivism considers the support of social interactions between the learner and the other individuals of the learning environment in the course of learning process. Various learning approaches were generated in the basis of these principles of the constructivism such as cooperative learning (Soyibo & Evans, 2002) anchored instruction (Bransford, Sherwood, Hasselbring, Kinzer & Williams, 1990), inquiry-based learning, problem-based learning, and experiential learning (Kirschner, Sweller & Clark, 2006), and exploratory learning (Rieman, 1996). Among these approaches inquiry-based learning is that comprises learning cycle model (Abraham, 1989).

Learning cycle model was originated from Piaget's mental functioning model. The first version of the model included three phases initially called preliminary exploration, invention and discovery (Karplus & Their, 1969) but they were revised to exploration, concept introduction and concept application to increase the expressiveness (Hanley, 1997). The developers of the model suggested that students' substantial knowledge impacts their learning and also they need to be allowed to explore the phenomena on their own prior to the introduction of new terms associated with the scientific concepts. Another requirement was about the necessity of application of the initial experiences and learning in new situations following to the term introduction. This sequence was proposed as necessary to develop better understanding and interest towards the science concepts. As the learning cycle started to be implemented and investigated over years, the model was modified regardless this conceptual foundation of the approach (Bybee, Taylor, Gardner, Scotter, Powell, Westbrook & Landes, 2006). Educators and researches extended the phases of model to increase the emphasis on some issues and different versions of the model were emerged as 3E, 4E, 5E and 7E. Among them, 7E learning cycle instruction is the broad one encompassing seven phases each starting with the same letter; Elicit, Engagement, Exploration, Explanation, Elaboration, Evaluation, and Extension. In line with the development theory of Piaget, knowledge construction in learning cycle instruction can be explained as following in the light of related literature (Abraham & Renner, 1986; Marek, Eubanks & Gallaher, 1990; Balci, Cakiroglu & Tekkaya, 2005). The first phase of the cycle, *elicit phase*, activates students existing knowledge and prepare students to construct connected knowledge structures. Following step is *engagement phase* which creates interest in the topic, captivates students' attention and promotes curiosity to focus on the content. Students assimilate the new concept in the *exploration phase* in addition to reevaluate their existing conceptions to be able to interpret the new phenomena. The cognitive conflict rose in students' existing mental structures and new situation causes disequilibrium which the individual avoid to stay. To be able to reach equilibrium, they accommodate the concept in an environment that they are allowed to explain and discuss their ideas in the *explanation phase* based on the data obtained from the exploratory activities. This phase is the essential to allow students to accommodate through the discussion and interpretation of data. In *the elaboration phase*, both assimilation and accommodation occur since the students organize, apply and relate the newly developed concept to prior concepts or daily life applications. *Evaluation phase* make students to realize the change in their knowledge and assess their own conceptions to make necessary arrangements. Finally *extension phase* prepare student to connect the acquired knowledge to following new phenomena.

Considering these characteristics of 7E learning cycle instruction, the higher acquisition and retention of science concepts are anticipated. A large body of research investigating the learning cycle approaches also evidenced its effectiveness on conceptual understanding (Lawson, 1995; Musheno & Lawson, 1999; Ates, 2005; Yilmaz, Tekkaya & Sungur, 2011), likewise on the other significant learning outcomes such as self-regulation (Yilmaz, 2007; Akar, 2005; Boddy et al., 2003; Tinnin, 2001; Ebrahim, 2004; Aydemir, 2012), epistemological beliefs, (Kaynar, Tekkaya & Cakiroglu, 2009) and science process skills (Lavoie, 1999; Anagun & Yasar, 2009). These studies confirmed the superiority of learning cycle over the traditional teaching approaches in terms of promoting scientific knowledge as well as skills and abilities related to learning, and beliefs about learning and knowledge. Actually, the phases of the cycle provides opportunity to students to focus on and become interested in the subject, actively engage in the process, use their prior knowledge and construct new knowledge by the help of previous experiences, explore the scientific phenomena and comprehend the nature of scientific knowledge, and develop inquiry skills and self-evaluation. In this manner, 7E learning cycle instruction is promising to develop self-regulated learning in the students.

The importance of self-regulated learning in the development of conceptual understanding and learning skills was stressed by Zimmermann (2005). Self-regulation defined by Pintrich (2005) as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constructed by their goals and the contextual features in the environment." (p.453). Pintrich's model of self-regulation falls into four areas as regulations of cognition, motivation, behavior, and context through various strategies. There is an extensive research in the literature evidenced the fact that all areas of self-regulation closely related with academic performance while they also interplay with each other (Pintrich, 1989; Pintrich & De Groot, 1990; Pintrich & Garcia, 1991; Yumusak, Sungur & Cakiroglu, 2007). Having both the motivation to learn science and the profession to use self-learning strategies brings academic achievement while in turn the accomplishments enhance the motivation and learning strategy use. Additionally, there is also a reciprocal relation between motivational constructs and learning strategies. Considering the importance of these constructs, the researchers investigated the promising learning environments to improve self-regulation and concluded to various characteristics such as providing students the sense of independence in class, engagement with challenging, interesting and useful activities, recognition of effort and accomplishments, and collaborative work in small groups (Epstein, as cited in Pintrich & Shunk, 2002; Eshal & Koavi, 2003; Pintrich, 2005; Meyer & Turner, 2002; Paris & Paris, 2001). 7E learning cycle is an instructional model that enables to embed the abovementioned characteristics of an effective learning environment in the class. The preliminary phases of learning cycle intend to capture students' attention, to raise their curiosity and interest, and to engage them in real life situations which are suggested to develop mastery goals and task value in students (Pintrich & Shunk, 2002). The middle phases of learning cycle provide active participation of students which provides opportunity to implement and develop various self-regulatory strategies and to explore their belief systems (Odom & Kelly, 2001). The hands-on activities in these phases may lead to positive motivational outcomes such as task value and self-efficacy (Renner, Abraham, & Birnie, 1985; Thompson & Soyibo, 2002). Moreover, collaborative or individual engagement of students in the activities together with the role teacher as facilitator/assistance may enhance students' strategy use and motivation (Slavin, 1996). Concluding phases of learning cycle provides transfer of knowledge in new situations and student questioning on their own conceptions (Boddy et al., 2003) which provide self-evaluation of the process, knowledge and effort.

Besides self-regulation, developing a sophisticated belief towards knowledge is necessary in science classes. Hofer (2001) states that sophisticated epistemological beliefs are crucial to learn science. Similarly, Bath and Smith (2009) argue the role of epistemological belief as the keystone of learning since the certain view or belief of a learner towards the knowledge motives them to engage in discovery the new knowledge and association with the existing one. Epistemological beliefs were originated from the work of Perry (1968) and they are defined as the theories people hold about knowing and nature of knowledge (Hofer, 2000). Perry revealed that students' perspective of knowledge ranges from dualistic thinker, who believe the knowledge as right or wrong, towards realistic thinker, who believe the multiple perspectives and the truth is relative the context (Hofer, 2000; Buehl & Alexander, 2001). In later years, Shommer (1990) proposed that epistemological beliefs are not unidimensional rather it is a system of multidimensional beliefs which are possible to range from independently each other. The five dimensions explained by Shommer were the beliefs towards the structure, certainty, source, control, and speed of knowledge. Parallel with Shommer's multidimensional belief system, Conley, Pintrich, Vekiri and Harrison (2004) defined four dimensions of epistemological beliefs namely; source (knowledge origins from authority versus from personal observation and reasoning), certainty (single truth and knowledge is certain versus multiple truth and knowledge is complex), development (knowledge has concrete nature versus evolving nature), and justification (experiments and evidences are necessary in justification of knowledge versus not necessary). The influence of these beliefs were investigated in science education extensively and the studies revealed the beliefs generally become more sophisticated over years (Schommer, Calvert, Gariglietti & Bajaj, 1997; Schommer, 1998; Cano, 2005) and the students with more sophisticated beliefs tend to gain higher grades in the school (Walker, 1997; Schommer-Aikins, Mau, Brookhart & Hutter, 2000; Cano, 2005; Hofer, 2000; Conley et al., 2004; Pintrich et al., 2004). The evidences towards the developmental nature of epistemological beliefs and their significant impact on learning gave insight to seek effective teaching approaches to improve sophisticated beliefs towards science knowledge. Smith, Maclin, Houghton and Hennessey (2000) suggest the instructional factors that support development of students' epistemological beliefs as authentic inquiry, generative problems, representing ideas in multiple ways, and collegial learning communities and metacognitive discourse. Providing these factors in a class encourage the students to construct their own knowledge based on their own thinking, judgments and reasoning. Application of these factors in science class as a part of lesson routine endorses students to retain scientific epistemological beliefs in their future learning (Qian & Alvermann, 2000; King & Kitchener, 2002). In this vein, 7E learning cycle is possible to develop sophisticated epistemological beliefs in students since it blends various suggested approaches and strategies such as student-centered learning, inquiry, hands-on activities, collaborative learning, constructing own knowledge from multiple sources, and sharing ideas in multiple ways as well as respecting and judging other ideas. The student-student and teacher-student negotiations are always encouraged in the phases of learning cycle. Students are expected to define their experiences, claim their ideas, and support their claims with evidences especially in the exploration and explanation phases of learning cycle approach.

Another skill necessary in science education is the ability to know and conduct the steps that a scientist follows during the experiments and problem solving. They are named as science process skills and divided in two categories as basic and integrated. Basic science process skills are used to interpret the natural world while the integrated process skills mostly utilize in the process of an experimental situation. In general, basic skills are listed as observing, measuring, inferring, predicting, classifying, and collecting and recording data. In addition, the integrated process skills are identifying variables, identifying and stating hypothesis, operationally defining, designing investigations, and graphing and interpreting the data (Okey et al., 1982). Students mastering these skills would have a vision of a scientist, utilize the scientific methods to solve the problems that they encounter in their daily life, question, investigate, and make the connection between scientific knowledge with their daily life (MoNE, 2006). The studies indicated science process skills can be taught to students through the implementation of appropriate learning approaches (Griffiths & Thomson, 1993; Germann, Aram & Burke, 1996; Dogruöz, 1998; Özdemir, 2004; Anagun & Yasar, 2009). Some of the suggested approaches were hands-on activities, laboratory approaches, inquiry, and guided inquiry. Although the authors suggests several approaches, they all agreed on providing regular practices of science process skills in the classes to improve the proficiency of these skills. Indeed, 7E learning cycle model provides an inquiry environment in which students construct their own learning, pose questions, seek information to find appropriate solutions to the emerged questions, and propose explanations. Whilst all phases of learning cycle are suitable to embed the prompting activities, the strongest ones are exploration and explanation (Settlage & Southerland, 2007). In those phases students may engage with a research question, claim a hypothesis, identify the variables, design an experiment and reach a conclusion based on the collected data.

The challenge for science education is to facilitate learning processes that put into action a blend of these skills and beliefs for engaging with science topics. Considering the suggested learning environments for each aspect, 7E learning cycle instruction is plausible to assert as a teaching approach to display such environment in class. Therefore, in the current study, it was attempted to investigate the comparative effectiveness of the 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' conceptual understanding, self-regulation, scientific epistemological beliefs, and science process skills. The effectiveness of two instructions on development of collective variables was also addressed in the study.

Accordingly, the first aim of the study was to determine the effect of 7E learning cycle on students' conceptual understanding. In this aim, the concept of human body systems was selected on the grounds of the extensively reported difficulty in learning and unscientific ideas of students towards this topic. Through the seven phases of the learning cycle students get the opportunity to actively engage in the learning process, to explore the scientific phenomena, to use their prior knowledge and construct new knowledge by the help of previous experiences, to clarify their own thought process and to correct their unscientific understandings, to put out inquiry, to ask questions and seek scientific explanations and answers, to work collaboratively (Ceylan & Geban, 2009; Balci et al., 2006; Wise, 2006). Therefore, students were expected to develop better understanding of human body systems concepts after receiving 7E learning cycle instruction in comparison to the students receiving curriculum oriented science instruction.

The second aim of the study was to investigate the effect of 7E learning cycle on students' self-regulation. In the present study, self-regulation concept was handled in two main aspects as motivation and learning strategies. Thus, the relative effectiveness of 7E learning cycle instruction and curriculum oriented science instruction was compared in terms of motivation and learning strategy use. Motivation aspect covered intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy, and test anxiety. Additionally, the learning strategies aspect included strategies such as rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment management, effort regulation, peer learning, and help seeking. In this study, the activities in 7E learning cycle was designed to challenge students in an optimum difficulty level and workload, to connect classroom science with daily life, to develop the sense of independence and the perception of control in the classrooms, to have students realize their own learning and progress, to provide opportunity for both collaboration and individual work. The evaluation of the students was based on their progress rather than the comparison with others in the class and teacher provided feedbacks that foster students self-monitoring skills and awareness towards their learning. Implementation of challenging but attainable tasks, evaluation strategies focusing on individual progress, presence of small group works, and autonomy support encourage students to hold intrinsic goals. In the current study, the students in experimental group were asked what they want to learn about the topic at the beginning of learning cycle approach. Students listed the concepts that they wonder to learn more and the teacher concerned these requests to be sure that students learned what they desire to learn in the course of instruction. Moreover, during the engagement and exploration phases students may have the chance to explore the scientific phenomena without given a conceptual knowledge from the teacher. This kind of situations might lead students to show interest in the topics and adopt intrinsic goals such as learning to satisfy the curiosity, the need for challenge or the desire to master the content. Additionally, exploration, explanation, and elaboration phases were prefect resorts to practice the learning strategies such as elaboration, organization and metacognitive self-regulation. The hands-on/minds-on activities presented in these phases and the facilitator role of the teacher encourage students to use and develop adaptive learning strategies to learn. The first phases of learning cycle as well as the elaboration phase engaged students to integrate and connect new knowledge with the previous ones and apply them in a new situation which in turn may develop their critical thinking (Pintrich et al., 1991). Moreover, Mecit (2006) also emphasized the social interaction between students facilitates to learn how to think better, to reason and criticize into subject matter, to be open to alternative views, and to justify their own opinions. Additionally, as argued by Sungur and Tekkaya (2006) small group work on a challenging problem solving task leads students to reflect on their own thinking, revise their ideas and realize the gaps in their thoughts which is a metacognitive process. Furthermore, the tasks given in the phases endorse students to adjust their own study time by scheduling and planning as well as to arrange the study environment well organized and free from distractors and enable to work with peers. Thus, in the current study, it was expected that the students engaged with 7E learning cycle instruction will perceive higher motivation and learning strategy use as well as they develop better motivation and learning strategy use compared to the students instructed with curriculum oriented science instruction.

The third aim of the study was to explore the influence of 7E learning cycle instruction on students' scientific epistemological beliefs dimensions which are source, certainty, development, and justification. As suggested by Saunders, Cavallo and Abraham (1999), development of sophisticated beliefs towards the source of the knowledge can be possible with an attitude of teacher who does not present themselves as an authority who provides knowledge rather allows students to construct their own knowledge. Qian and Alvermann (2000) claim that an approach which attempts to have students to realize how they learn something and the source of their ideas, and then encourages the active construction of deeper theoretical understanding in students' minds promotes sophisticated beliefs. Moreover, the researchers add that the historical stories of well-known scientists may give students ideas about how to construct the scientific knowledge. What is more, it was emphasized by many researchers that sophisticated epistemological beliefs of students can be developed through collaborative work of students, and opportunities to argue about their ideas and reflect on their thinking (Hofer, 2001; Southerland, Sinatra & Matthews, 2001; Smith, Maclin, Houghton & Hennessey, 2000; Conley et al., 2004). In the current study, 7E learning cycle instruction covered some historical stories that emphasized the development and evolvement of scientific knowledge over time, the necessity of experiments on justifying the scientific knowledge, the existence of multiple truths, and the possibility of directing different ideas and conclusions on same subject by different scientists. The exploratory activities also emphasized the subjective nature of knowledge. Actually, 7E learning cycle instruction is an inquiry based approach and various studies revealed the effectiveness of inquiry on student epistemological beliefs. Therefore, in the present study, it was anticipated that the students instructed with 7E learning cycle approach develops more sophisticated beliefs than the students instructed with curriculum oriented science instruction.

The last aim of the study was focused on the relative influence of 7E learning cycle instruction on students' proficiency of science process skills. The concern of the study is integrated science process skills which are identifying variables, identifying and stating hypothesis, operationally defining, designing investigations, and graphing and interpreting the data. According to Wilke and Straits (2005), teaching these skills is crucial since it promotes students' success to use them in scientific inquiries both in and out of school. The research on the instructions to develop science process skills revealed that students need to become an active learner of science who inquire about the scientific phenomena, seek answers through the experiments, and reach conclusions with this process in order to gain mastery of these skills (Griffiths & Thomson, 1993; Germann, Aram & Burke, 1996; Dogruöz, 1998; Özdemir, 2004; Anagun & Yasar, 2009). As proposed by Settlage and Southerland (2007) the practice of these skills is possible with the prompting activities that can be embedded in all phases of learning cycle but mostly to the exploration and explanation phases. In the present study, these two phases covered some activities that required students to develop a research problem, generate a hypothesis, identify the variables, design and conduct the experiment, collect and report data, and finally draw graphs and reach conclusion from the collected data. These activities were intended to practice students in designing a manipulative experiment. Thus, students were expected to report higher proficiency in science process skills after receiving 7E learning cycle instruction in comparison to the students receiving curriculum oriented science instruction.

1.1 Research Questions

This part presents six main research questions and their sub-questions addressed in the study. The first research question aims to describe the sample with respect to collective variables at the beginning of the study. Other five main questions were directed to investigate the effect of treatment on five variables namely, conceptual understanding, motivation, learning strategy use, epistemological beliefs, and science process skills. Each of these five questions detailed to three sub-questions based on investigating the treatment effect at between group level, with-in group level and interaction level. Figures that explain the hierarchy of main and sub-questions were presented at the beginning of all five main questions. Firstly, Figure 1.1 outlines the Main Research Question 1 and its sub-questions.

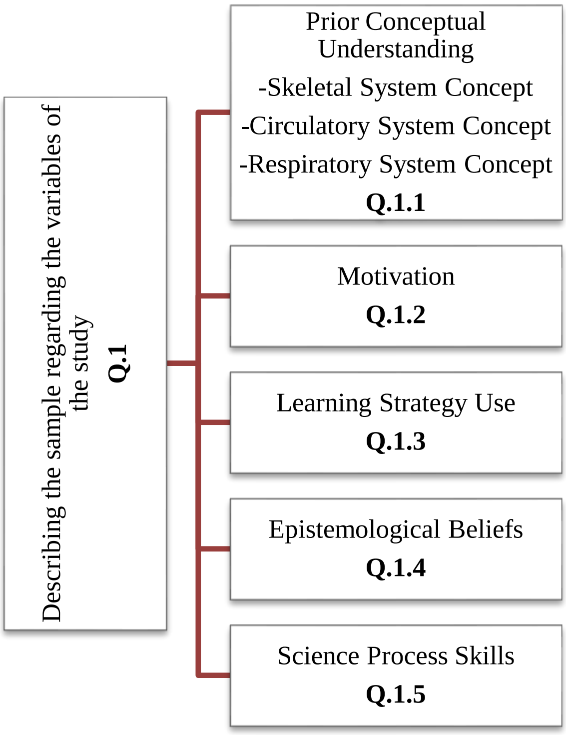

Figure 1.1 Hierarchy of Main Research Question 1 and Sub-questions

Q.1. What are the relevant prior knowledge regarding human body systems, perceived motivation, perceived use of learning strategies, epistemological beliefs and science process skills of 6th grade students?

Q.1.1. What is the relevant prior knowledge of 6th grade students in skeletal system, circulatory system, and respiratory system concepts?

Q.1.2. What are the 6th grade students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Comparison of Learning Beliefs, Self-Efficacy for Learning and Performance, and Test Anxiety)?

Q.1.3. What are the 6th grade students' perceived use of learning strategies (Rehearsal, Elaboration, Organization, Critical Thinking, and Metacognitive Self-Regulation)?

Q.1.4. What are the 6th grade students' perceived epistemological beliefs (Source, Certainty, Development, and Justification)?

Q.1.5. What are the 6th grade students' science process skills?

Figure 1.2 summarizes the Main Research Question 2 and its sub-questions considering the conceptual understanding variable.

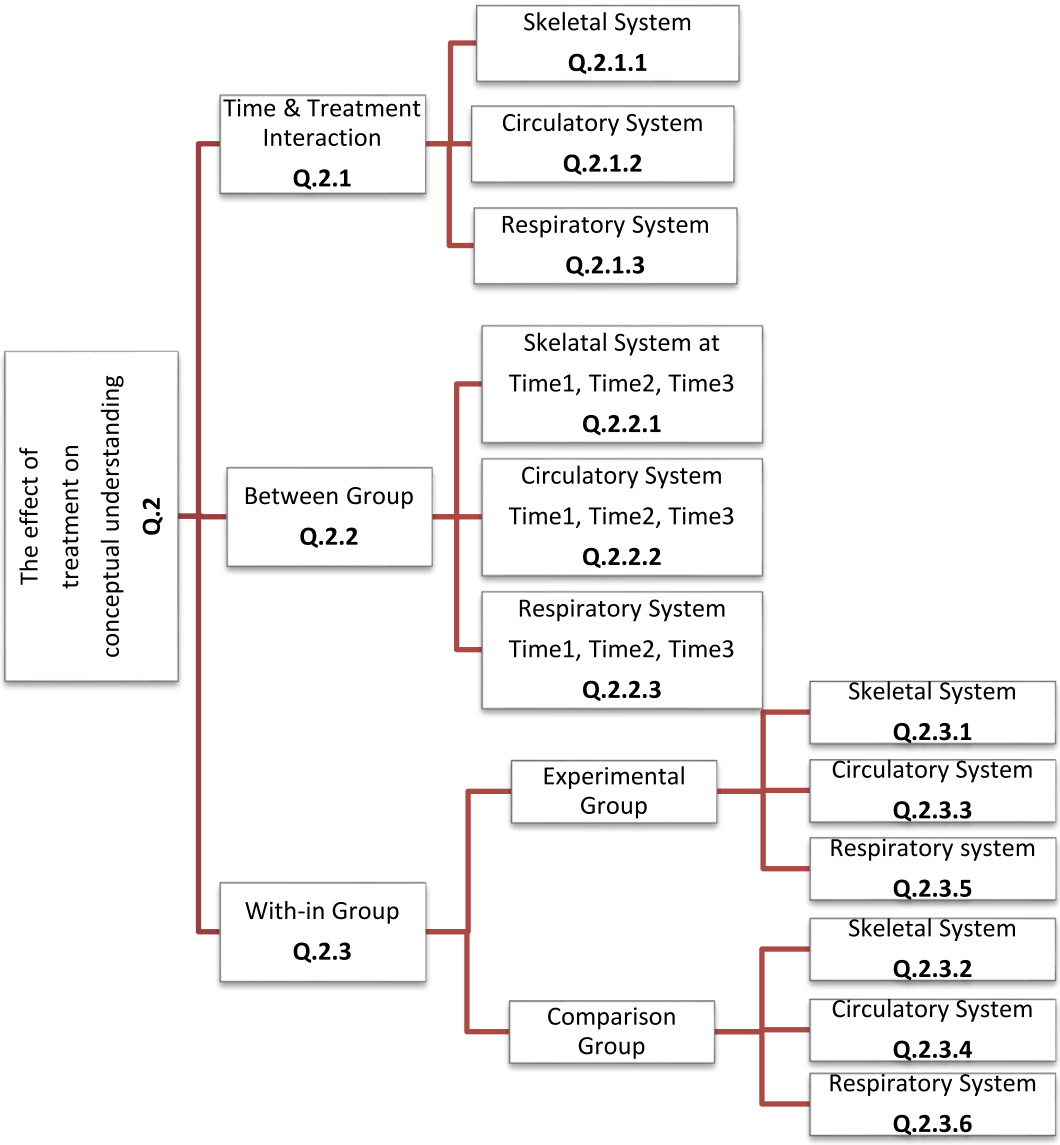

Figure 1.2 Hierarchy of Main Research Question 2 and Sub-questions

Q.2. What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' understanding of human body systems concept?

Q.2.1. Is there a significant interaction between treatment and time with respect to students' conceptual understanding of human body systems concept?

Q.2.1.1. Is there a significant interaction between treatment and time with respect to students' conceptual understanding of skeletal system concepts?

Q.2.1.2. Is there a significant interaction between treatment and time with respect to students' conceptual understanding of circulatory system concepts?

Q.2.1.3. Is there a significant interaction between treatment and time with respect to students' conceptual understanding of respiratory system concepts?

Q.2.2. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' understanding of human body systems concept?

Q.2.2.1. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' understanding of skeletal system concepts at before the treatment (Time1), after the treatment (Time2), and one-month later the treatment (Time3)?

Q.2.2.2. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' understanding of circulatory system concepts at before the treatment (Time1), after the treatment (Time2), and one-month later the treatment (Time3)?

Q.2.2.3. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' understanding of respiratory system concepts at before the treatment (Time1), after the treatment (Time2), and one-month later the treatment (Time3)?

Q.2.3. What is the change in students' understanding of human body systems concept across three time periods?

Q.2.3.1. Is there a significant change in conceptual understanding of experimental group students who exposed to 7E learning cycle instruction with respect to skeletal system concepts across three time periods?

Q.2.3.2. Is there a significant change in conceptual understanding of comparison group students who exposed curriculum oriented science instruction with respect to skeletal system concepts across three time periods?

Q.2.3.3. Is there a significant change in conceptual understanding of experimental group students who exposed to 7E learning cycle instruction with respect to circulatory system concepts across three time periods?

Q.2.3.4. Is there a significant change in conceptual understanding of comparison group students who exposed curriculum oriented science instruction with respect to circulatory system concepts across three time periods?

Q.2.3.5. Is there a significant change in conceptual understanding of experimental group students who exposed to 7E learning cycle instruction with respect to respiratory system concepts across three time periods?

Q.2.3.6. Is there a significant change in conceptual understanding of comparison group students who exposed curriculum oriented science instruction with respect to respiratory system concepts across three time periods?

Main Research Question 3 which addresses the motivation variable and its sub-questions were outlined in Figure 1.3.

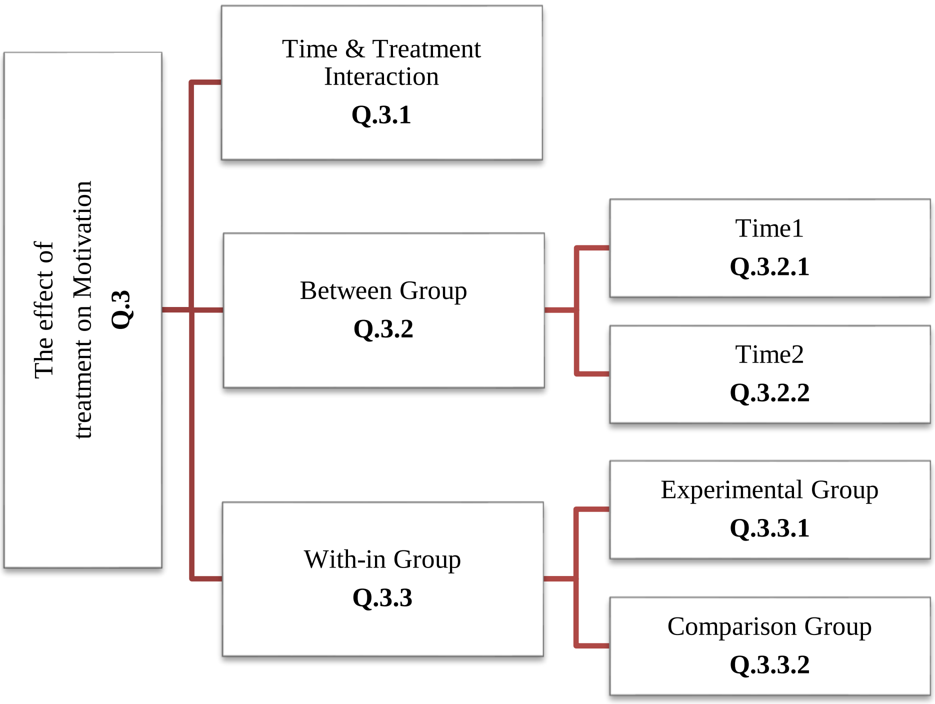

Figure 1.3 Hierarchy of Main Research Question 3 and Sub-questions

Q.3. What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, and Test Anxiety)?

Q.3.1. Is there a significant interaction between treatment and time with respect to students' perceived motivation?

Q.3.2. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived motivation?

Q.3.2.1. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived motivation before the treatment?

Q.3.2.2. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived motivation after the treatment?

Q.3.3. What is the change in students' perceived motivation across two time periods?

Q.3.3.1. Is there a significant change in perceived motivation of experimental group students who exposed to 7E learning cycle instruction.

Q.3.3.2. Is there a significant change in perceived motivation of comparison group students who exposed to curriculum oriented science instruction.

Main Research Question 4 with respect to learning strategy use variable and its sub-questions were summarized in Figure 1.4.

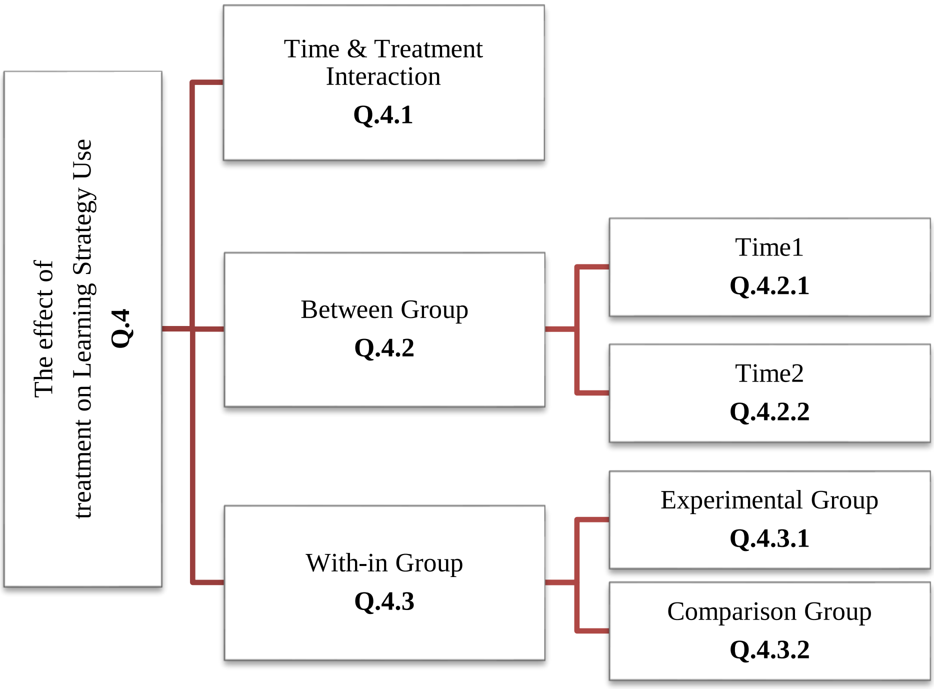

Figure 1.4 Hierarchy of Main Research Question 4 and Sub-questions

Q.4. What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' perceived learning strategies (Rehearsal, Elaboration, Organization, Critical Thinking, and Metacognitive Self-Regulation)?

Q.4.1. Is there a significant interaction between treatment and time with respect to students' perceived learning strategies?

Q.4.2. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived learning strategies?

Q.4.2.1. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived learning strategies before the treatment?

Q.4.2.2. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived learning strategies after the treatment?

Q.4.3 What is the change in students' perceived learning strategies across two time periods?

Q.4.3.1. Is there a significant change in perceived learning strategies of experimental group students who exposed to 7E learning cycle instruction.

Q.4.3.2. Is there a significant change in perceived learning strategies of comparison group students who exposed to curriculum oriented science instruction.

Figure 1.5 summarizes Main Research Question 5 considering scientific epistemological beliefs variable and its sub-questions.

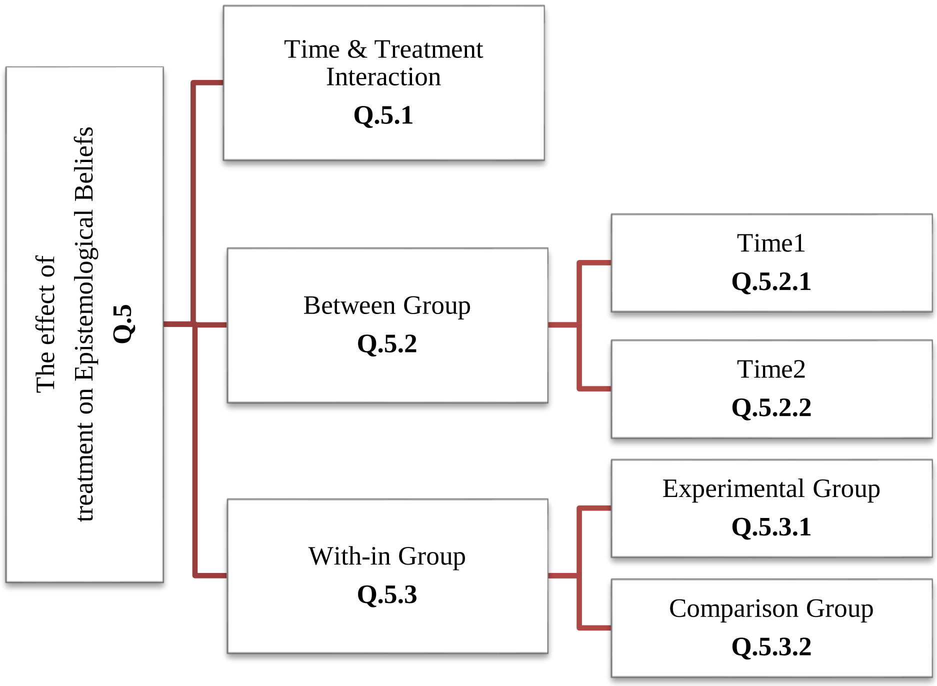

Figure 1.5 Hierarchy of Main Research Question 5 and Sub-questions

Q.5. What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' perceived epistemological beliefs (Source, Certainty, Development, and Justification)?

Q.5.1. Is there a significant interaction between treatment and time with respect to students' perceived epistemological beliefs?

Q.5.2. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived epistemological beliefs?

Q.5.2.1. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived epistemological beliefs before the treatment?

Q.5.2.2. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived epistemological beliefs after the treatment?

Q.5.3. What is the change in students' perceived epistemological beliefs across two time periods?

Q.5.3.1. Is there a significant change in perceived epistemological beliefs of experimental group students who exposed to 7E learning cycle instruction.

Q.5.3.1. Is there a significant change in perceived epistemological beliefs of comparison group students who exposed to curriculum oriented science instruction.

Finally, Figure 1.6 summarizes Main Research Question 6 regarding science process skills variable and its sub-questions.

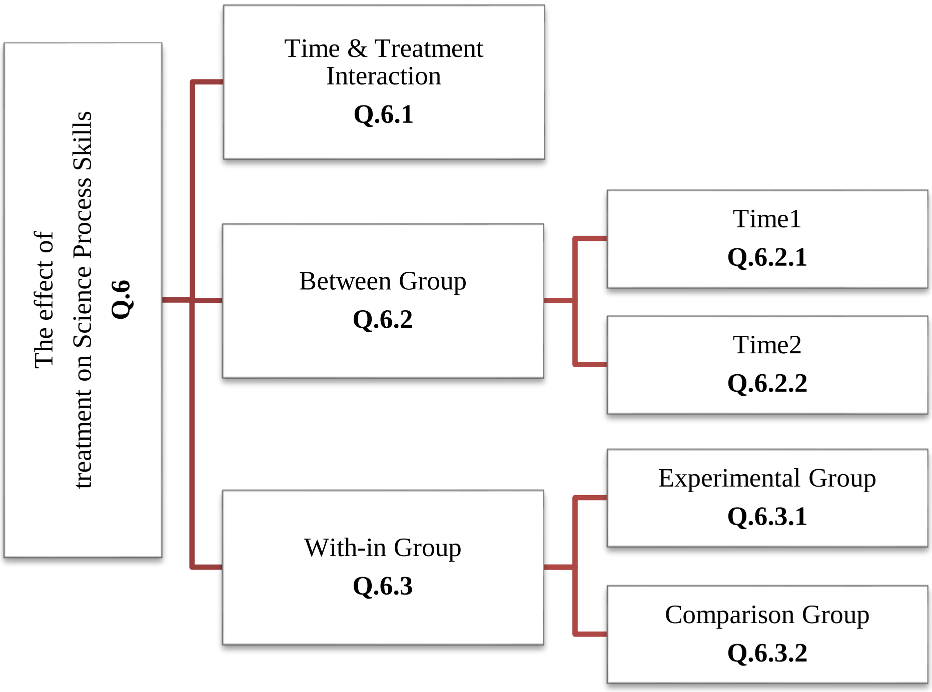

Figure 1.6 Hierarchy of Main Research Question 6 and Sub-questions

Q.6. What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' science process skills?

Q.6.1. Is there a significant interaction between treatment and time with respect to students' science process skills?

Q.6.2. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' science process skills?

Q.6.2.1. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' science process skills before the treatment?

Q.6.2.2. Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' science process skills after the treatment?

Q.6.3. What is the change in students' science process skills across two time periods?

Q.6.3.1. Is there a significant change in science process skills of experimental group students who exposed to 7E learning cycle instruction.

Q.6.3.2. Is there a significant change in science process skills of comparison group students who exposed to curriculum oriented science instruction.

1.2 Definitions of Variables

Conceptual Understanding: Student comprehension towards science concepts. In the current study the concerned science concepts were skeletal, circulatory, and respiratory systems and measured by Skeletal System Conceptual Inventory, Circulatory System Conceptual Inventory, and Respiratory System Conceptual Inventory.

Self-Regulation: The process of learners in which they set goals and then monitor, regulate, and control their cognition, motivation, and behavior, in the guidance of their goals and the contextual features in the environment (Pintrich, 2005). The current study will handle this term in two parts as motivation and learning strategy use which will be measured by the related scales of Motivated Strategies for Learning Questionnaire (Pintrich, Garcia, & McKeachie, 1991).

Motivation: Students' perceptions about their goals and value beliefs for science, their beliefs related with their own skills to achieve science, and their anxiety about tests in science which are measured by related scales of Motivated Strategies for Learning Questionnaire (Pintrich, Garcia, & McKeachie, 1991).

Learning Strategy Use: Students' perceptions about their use of cognitive and metacognitive strategies in science learning which are measured by corresponding scales of Motivated Strategies for Learning Questionnaire (Pintrich, et al., 1991).

Scientific Epistemological Beliefs: The theories students hold about knowing science and nature of scientific knowledge (Hofer, 2000). These beliefs are multidimensional and may range from naïve to sophisticated beliefs. The concern of the study covers four beliefs towards source, certainty, development, and justification of knowledge. In this study scientific epistemological beliefs were measured by using Epistemological Beliefs Questionnaire developed by Conley et al. (2004).

Science Process Skills: The steps that a scientist conducts during the experiments and problem solving. The process skills investigated in the current study are integrated science process skills which utilized in manipulative experiments and they were measured by Science Process Skills Test (SPST) developed by Burns et al. (1985).

Curriculum Oriented Science Instruction: The science instruction based on the Turkish curriculum that carried out in middle schools since 2006. The suggested instruction is based on the constructivist perspective. The teachers were allowed to follow their regular rutine in their lessons. However, the implemented instruction by teachers in this study was mostly based on teacher explanations, demonstrations, question and answering techniques, and the information and activities suggested in the textbook.

7E Learning Cycle Instruction: A constructivist instructional strategy that process through seven phases. Each phases cover hands-on and minds-on activities that respectively aim to elicit prior knowledge and misconceptions, gain students' attention, to let the students explore the concept and realize the insufficient explanations on their minds, to connect students' explanations with scientific clarification, to deepen students' understanding by alternative activities, to evaluate their conception, and finally to transfer the knowledge in new situations.

1.3 Significance of the Study

Science and technology has an important role in the development of countries. Moreover, the necessity of developing lifelong learners is realized by educators in order to follow the improvements in science and technology. The main aim of the science courses must be training students to acquire the required learning skills and beliefs towards learning and scientific knowledge to develop a capacity to think scientifically, to analyze critically, to solve problems in daily life, and to integrate theory and practice. Moreover, science courses must be designed with the consideration that learning consists of iterative interactions that take place between students' existing conceptions and their new experiences. In this respect, the present study may lead to various implications for curriculum developers, educational researchers, and science teachers in terms of effectiveness such learning environments through 7E learning cycle instruction.

For example, the findings of the study may give feedbacks about the curricular implementations. The national elementary science curriculum of Turkey has undergone a revision since 2006. The new curriculum has a vision of developing scientifically literate individuals and adopts a philosophical perspective of constructivism (MoNE, 2006). In theory, the curriculum aims to let students discover the scientific phenomena in student-centered learning environments through hands-on and minds-on activities. Nevertheless, there are studies in the literature reporting decrease on the middle school students' self-regulation over years (Gungoren, 2009; Yavuz-Gocer, Sungur & Tekkaya, 2011; Guvercin, Tekkaya & Sungur, 2010), a movement towards sophisticated to naïve scientific epistemological beliefs in years (Boz, Aydemir & Aydemir, 2011), and low and moderate levels of mastery in integrated science process skills (Cansiz, 2014; Aydinli, 2007; Ozgelen, 2012). In this vein, the experimental design of the current study allows to compare the curriculum oriented science instruction and 7E learning cycle instruction, and the findings may have some implications concerning integration of 7E learning cycle method to the existing curriculum.

Actually, in science classes, students hold various ideas related the science topics which arouse based on their previous experiences and instructions. It was evidenced and accepted by educators and researchers that these ideas affect their further learning (Ausubel, 1968; Duschl & Gitomer, 1991). The science topic utilized in this study is human body systems unit which was taught in 6^{th} grade science curriculum. The unit covers three systems namely, skeletal, circulatory, and respiratory systems. In the literature, several studies reported that students hold naïve ideas and difficulties in understanding of skeletal system (Caravita & Falchetti, 2005), circulatory system (Arnaudin & Mintzes, 1985; Sungur, Tekkaya & Geban, 2001), and respiratory system (Alparslan, Tekkaya, & Geban, 2003). Moreover, a considerable amount of research points out that the students have difficulties to relate the organs in a system and to connect the body systems with each other (Arnaudin & Mintzes, 1985; Reiss & Tunnicliffe, 2001; Cuthbert, 2000; Ozsevgenc, 2007). For example, López-Manjón and Postigo (2005) reported students fail to scientifically explain the relationship between the heart and the lungs. In fact, the human body system concepts are a part of students' life since they experience this topic every single day in their own body. However, the abstract and micro-structured nature of content may result in development of unscientific ideas towards the subject matter (Haugwitz & Sandmann, 2010). Additionally, science curriculum of Turkish elementary education has a spiral nature, which results in the high influence of acquired conceptions in previous grades on student understanding. The findings of this study may shed the light on the effectiveness of instruction based on 7E learning cycle model on providing a better understanding of these concepts. The studies in the literature evidenced higher acquisition of the related science topics when the students construct their own knowledge through hands-on activities, exploration the organs through dissection, and development of models reflecting organs and systems (Hymelo et al., 2000; Lee, 2001; Lee, 2004). 7E learning cycle model enables to combine such activities in the instruction. Moreover, the model provides the link between the substantial knowledge and new experiences to build the knowledge. In this instruction, teacher considers the existing knowledge of students and struggle with them if they are unscientific. Actually, development of a better understanding of skeletal, circulatory, and respiratory systems is important in middle school students since it is necessary to know about own body to maintain a healthy life (Steve & Kim, 1998). Furthermore, as recommended by Arnaudin and Mintzes (1985), using instructional interventions in early grades is necessary to prevent the remaining of difficulties as the students continue to their educational process. Therefore, this study is significant since the instruction based on 7E learning cycle model may contribute a better understanding of human body system concepts in middle school students.

Various empirical studies supported the effectiveness of learning cycle approach to promote meaningful learning and scientific conception related with several science concepts in a constructivist environment (Wang & Andre, 1991; Chambers & Andre, 1997; Mikkila, 2001; Balci, Cakiroglu & Tekkaya, 2005). Distinctively from them, the current study investigates the influence of 7E learning cycle instruction over student understanding of three sequential science topic as well as the retention of the acquired concepts. The unique design of the study allowed the researcher to examine the continuous effect of instructions on each human body systems topic separately besides it gives an idea about the student understanding in relation of distinct systems with each other. Furthermore, in the current study, the enactment of 7E learning cycle instructions in human body systems topic investigated in terms of not only comprehension of concepts but also retention of acquired knowledge, developing self-regulation strategies, adopting sophisticated epistemological beliefs towards science, and the acquisition of certain skills utilized in science processes, which were evidenced to be highly interrelated with each other in the literature. Actually, investigation on how to foster these aspects of student outcomes through instructional methods was suggested by many researchers (Meyer & Turner, 2002; Pintrich, 2005; Tolhurst, 2007; Ceylan, 2008). The current study will provide an opportunity to find out if 7E learning cycle instruction is effective on development of these collective variables.

Another significance of the study is the conceptual inventories developed by the researcher. Students hold various conceptions that differ from the corresponding scientific explanations. Considering their interference in the comprehension of further scientific knowledge the need to assess students' naïve ideas occurs in the classroom. As claimed by Morrison & Lederman (2000), whilst the teachers are aware of the necessity to determine students' unscientific ideas, they are unable to achieve this because of the absence of applicable assessment tools. Conceptual inventories are appropriate tools to use in classrooms to assess student conceptual understanding. In the current study, three conceptual inventories were developed which the item context are skeletal system, circulatory system, and respiratory system. Each item of the inventories was developed by an extensive research and carried over from a validation process. The study provides reliable and valid tools to assess students' conceptual understanding towards skeletal, circulatory, and respiratory systems that can be used by science teacher, researchers, and educators.

Finally, the activities designed in the 7E learning cycle lesson plans may diversify the materials available for in-service science teachers regarding the human body systems concepts. In addition, these activities and lesson plans provide comprehensive examples and informative sources that the teachers may use while constructing their own activities and lesson plans.

CHAPTER II

LITERATURE REVIEW

In this chapter, a detailed review of the literature related with the study is provided. In the first section, the constructivist theory of learning described. In the second section, learning cycle model defined together with the review of empirical studies about the effectiveness of the model with respect to academic performance and other various outcomes. In the third section, the studies about understanding of human body systems concepts were reviewed and the studies about effective learning environments to develop better understanding are summarized. In the fourth section, general overview of self-regulation theory was presented including the review of research on self-regulatory components and how to promote self-regulation in students. In the fifth section, the review about the scientific epistemological beliefs was reported. Finally, the literature related with science process skills was reviewed.

2.1 Constructivism

Among the theories of learning, constructivism has become the most investigated over the recent research in science education. The curriculum and teaching in science education were impressed by the perspectives of constructivism in last decades (Matthews, 2002; Pelech & Pieper, 2010). In this theory, understanding of knowledge is an active construction process in the mind of the learner instead of being the acquisition from outsiders in an already organized form (Rowlands & Carson, 2001; Eggen & Kauchak, 1994). The importance of students' prior experiences in constructing knowledge is also emphasized in the theory (Ausubel, 1968; Bischoff & Anderson, 2001).

The basic description of constructivist idea according to Driver, Asoko, Leach, Mortimer & Scott (1994, p.5) is "knowledge is not transmitted directly from one knower to another, but is actively built up by the learner.". However, various meanings may emerge based to definer's perspective and position (Jones & Brader-Araje, 2002). Beyond its psychological or epistemological perspectives and terms, there are three alternate forms of constructivism within educational context; personal constructivism, social constructivism and radical constructivism.

All types of constructivist ideas meet in a common ground, the learner builds up own learning through a process, not absorbs from the outside sources. Moreover, all conceives the role of experiences of individual that was already acquired. As Ausubel stressed the significance of prior knowledge, it is the most influential factor that affects the meaningful learning (Driscoll, 1994). Individuals' existing knowledge assists or interfere their further learning and this situation needs to be taken in to account to promote learning in the class. Constructivist ideas emphasize the influence of the knowledge already held to generate knowledge (Duit & Tregaust, 1998).

Distinctively, personal constructivism emerges from Piagetian ideas and defines the aim of learning as 'to meet own needs'. Piaget believed that knowledge is organized as schemata in individual's mind and the changes in this intellectual organization take place through a process. He described the intellectual development as functions of organization and adaptation. Human begins arrange, combine, recombine or rearrange the experiences in their mental structures to use them effectively. This natural process of organization derives the effective use of the information. Adaptation is adjusting oneself to the new conditions and provided through assimilation and accommodation processes. Assimilation occurs if the new experiences fit the existing cognitive structure and the existing concepts are recalled to perceive new objects or events. That is, the individual interprets information and add in existing mental structure. Accommodation occurs if students' existing structure is inadequate to explain new experience. At this moment, disequilibrium arises from the cognitive conflict between the new information and existing conception. In order to reach equilibrium, individual transforms or extends the current conceptions to balance with the newly comprehended one. This process of transformation from disequilibrium to equilibrium to reach the stability on mental structure is called as equilibration (Wadsworth, 1971). Briefly, according to Piaget, knowledge is constructed by learners in a continuous self-construction process including three basic concepts assimilation, accommodation and equilibration (Pulaski, 1980). These ideas of Piaget were accepted as the kernel of the constructivism theory. However, individual is not isolated from the environment and also interact with the others during the knowledge construction. In his theory, Piaget did not denied the cooperation of external relations. However, Vygotsky stressed the influence of social interactions during the development of mental constructs as well as learning process.

Social constructivism outlined by Vygotsky suggests the significance of social interaction between learners and cultural factors in cognitive and intellectual growth. It was defended that the learning is an active and social process which also derived based on the background of the students (Pritchard & Woollard, 2010). Thus, the incorporation of learner with the other individuals in the learning environment is essential in the development of mental processes. In this manner, constructivism emphasizes the knowledge gained through social negotiation in a collaborative learning environment that provides communication, discussion, and sharing the meanings and ideas. Meaning generation is not an internal process but a social process of communication which means learning is a product of collectivity (Gergen, 1994).

Radical constructivism, on the other hand, is more individualistic. It was advocated by Von Glasersfeld inspired from Darwinian evolutionary theory and Piagetian cognitive developmental theory (Raskin, 2002). In line with their ideas, within radical constructivism, an individual experiences the world and organize the perceptions with the aim of adaptation in the environment to survive. According to Glasersfeld (1995), these experiences are essentially subjective for each individual which means everybody has a unique perception from the same situation.

Within educational contexts, constructivist ideas especially social constructivism have appeared to influence instruction and curriculum design (Jones & Brader-Araje, 2002). The researchers report a number of points about teaching and learning based on constructivist approach (Driver & Bell, 1986; Savery & Duffy, 1995; Driver, Asoko, Leach, Mortimer & Scotti, 1994; Brooks & Brooks, 1999). First of all the researchers empirically shows that students comes class with their already constructed experiences and learning outcomes depend not only on the learning environment but also what the learner already knows (Driver & Bell,1986). Knowledge is not transferred from teacher to students rather constructed by the learner through experiences. Learners are responsible for their own learning and they must actively involve in the learning process to construct their own knowledge. Moreover, they must construct their meaningful learning in a social content in which they allowed to expert and share their ideas. Thus, the meaning construction occurs through observation and exploration of events and the interaction with materials, and others in the environment (Driver et al., 1994). A classroom environment based on constructivist approach is disparate from a regular classroom environment based on direct instruction and explicit explanations. Brooks and Brooks (1999, p.17) summarized the structures of a constructivist classroom environment compared to traditional classrooms as in Table 2.1.

Table 2.1 Comparison Between Traditional and Constructivist Classrooms

Traditional Classrooms	**Constructivist Classrooms**
Curriculum is presented part to whole, with emphasis on basic skills.	Curriculum is presented whole to part with emphasis on big concepts.
Strict adherence to fixed curriculum is highly valued.	Pursuit of student questions is highly valued.
Curricular activities rely heavily on textbooks and workbooks.	Curricular activities rely heavily on primary sources of data and manipulative materials.
Students are viewed as "blank slates" onto which information is etched by the teacher.	Students are viewed as thinkers with emerging theories about the world.
Teachers generally behave in a didactic manner, disseminating information to students.	Teachers generally behave in an interactive manner, mediating the environment for students.
Teachers seek the correct answer to validate student learning.	Teachers seek the students' points of view in order to understand students' present conceptions for use in subsequent lessons.
Assessment of student learning is viewed as separate from teaching and occurs almost entirely through testing.	Assessment of student learning is interwoven with teaching and occurs through teacher observations of students at work and through student exhibitions and portfolios.
Students primarily work alone.	Students primarily work in groups.

Source: Brooks and Brooks, 1999, p.17

As Brooks and Brooks (1999) verified, students are responsible for their construction of own learning in the constructivist learning environment. The teacher is responsible to mediate this process through creating a structure that permits students to associate the current knowledge with the new situation, to gain experiences by actively involving the process, to think autonomously in development of integrated understanding. Students are encouraged to generate questions and seek answers through self-initiated inquiry. The materials presented in the classroom are up to challenge student ideas promoting curiosity and a desire to learn. The relevance of the concept for the learner is conceived in the activities. Each student's diverse perspectives are encouraged to convey learning by social interaction in the class. The assessment of learning is embedded through the whole process which aims to investigate the learning and to monitor students for their own learning. A constructivist teacher mainly focuses on managing the class environment in which the students interacts with materials and the world around them (Pelech & Pieper, 2010). Fosnot (2005) suggest that, in a constructivist class the role of teacher becomes facilitator, provocateurs, and questioners who builds workshops and structures discussions around big ideas.

Moreover, Savery and Duffy (1995) explain principles of constructivist instruction as following. Firstly, the purpose of the learning activities should be clearly perceived and accepted by the learner. Since the goals of the learners determine what they learn, a task should be established in a way that learners may adopt it as their own. Secondly, similar to the first principle, students should be encouraged to take on the ownership of the process used for the task. Thirdly, authentic tasks and complex environments should be generated for students. These tasks and learning environments should be challenging for learners' thinking skills. Fourthly, teachers' roles in instruction should be to support effective functioning of learners in complex environments, to encourage their alternative views, their discussions in the collaborative learning groups, and to encourage testing their ideas and hypotheses. Lastly, the evaluation should be based on learning process as well as the knowledge learned.

Considerable research on constructivist instruction revealed the effectiveness of constructivist methods compared to the traditional teacher or textbook based methods in many areas; early childhood education (Schattgen, 1997), elementary and secondary education (Kim, 2005; Hubber, 2005; Pelech & Pieper, 2010; Karaduman & Gultekin; 2007), and college education (Becker & Maunsaiyat, 2004; Lord, 1997) with respect to literacy (Schattgen, 1997), mathematics (Pelech & Pieper, 2010), science (Becker & Maunsaiyat, 2004; Lord, 1997) and social science (Karaduman & Gultekin; 2007). Elementary education is the basic education step to enable students gain basic knowledge, skills and values (Karaduman & Gultekin, 2007). Configuration of cognitive competencies in early years of schools is fundamental for the kids, especially for their later life (Stern, 2005). The continuum of these educational perspectives needs to be supported also in later years of education in order to sustain and improve the gained skills and knowledge. For that reason, it is valuable to educate kids in an environment allowing active participation, development of own sense of information, combination or modification of existing knowledge in new knowledge construction, and interaction with the other actors in the learning environment to enrich learning. For that reason, many instructional strategies were developed based upon the assertions of constructivism.

Some learning approaches compatible with the constructivist epistemology towards science education are cooperative learning (Soyibo & Evans, 2002) situated cognition, anchored instruction (Bransford, Sherwood, Hasselbring, Kinzer & Williams, 1990), apprenticeship learning (Collins, Brown & Newman, 1989), inquiry-based learning, problem-based learning, and experiential learning (Kirschner, Sweller & Clark, 2006), exploratory learning (Rieman, 1996), and learning cycle (Abraham, 1989). Among these teaching strategies, learning cycle model is the concern of the present study. The model will be defined in the following part.

2.2 Learning Cycle Model

Learning cycle is a constructivist instructional model developed by Karplus and Their in 1970s as a curriculum project of Science Curriculum Improvement Study (SCIS). Thus, it is not only a simple teaching method but also a curriculum organization model (Abraham, 1989; Renner, Abraham & Birnie, 1988; Sunal & Hass, 1992). The origin of the model dates back to the research of Karplus and Atkin in the late 1950s and early 1960s to develop curricula that allow students connect their existing conceptions with the new information. Inspiring form the Piagetian ideas; they developed a teaching model covering two steps; invention and discovery. The former was aiming the introduction of the concept by teacher considering students' initial observations. The latter was providing verification of information through students' own discovery on new patterns of same concept (Lawson, Abraham & Renner, 1989). Over the conducted research with his colleague on the elementary students, Karplus realized that the students needed time to explore the intended subject at their own capacity before the scientific explanations were submitted to themselves (Hanley, 1997). Thereupon they developed a three phased approach named “Learning Cycle” including exploration, invention, and discovery. However, the titles of the consecutive phases were revised to exploration, concept introduction and concept application to increase the expressiveness (Hanley, 1997).

More specifically, the phases can be described as following. In the first phase of the learning cycle, *Exploration*, students use their prior knowledge, generate and test hypotheses Students develop their prediction skills and learn by their own actions under minimal guidance of the teacher. This phase provokes conflicts with the cognitive structure and establish questions that students unable to solve with their previously acquired knowledge (Lawson et al, 1989). In the second phase, *Concept Introduction*, the scientific conceptions are introduced to students by teacher. The exploratory activities that students engaged on the first phase are related in this phase in order to develop understanding based on the ideas students generated on the previous tasks (Sunal & Haas, 1992). The teacher facilitates a discussion between students to allow them to share their observations with other students. The last phase, *Concept Application*, increase the familiarity through activities that make students able to integrate and generalize recently learned concepts in different situations. This step helps students to understand concepts more meaningfully and apply them in real life experiences (Cavallo, McNelly & Marek, 2003).

As stated before, the model was developed based on the Piaget’s theory of cognitive development. Before describing the relation, it would be informative to explain the theory briefly. According to Piaget, knowledge acquisition occurs over three concepts; assimilation, accommodation and equilibration. His theory also suggests that students bring varying ideas about science and natural world (Duit & Treagust, 2003). Ausubel (1968) suggests that this existing knowledge structure influence the learners’ conceptual development. According to Piaget’s theory, if the new information is compatible with the existing knowledge, assimilation occurs.

However, if the new information is incompatible with the substantial cognitive structures, the individual needs to create new structures or revise the existing ones. This process called as accommodation. The balance in the mental structure referred as equilibrium, which learner seeks to achieve that state. In the course of accommodation, disequilibrium occurs due to the conflict in the mental structure. This situation encourages the learner to change or adapt or the existing mental structure to reach equilibrium. This motion from disequilibrium towards equilibrium is defined as equilibration.

Actually, correspondence between basic principles of Piaget's theory and the phases of the learning cycle can be explained as following (Abraham & Renner, 1986; Marek, Eubanks & Gallaher, 1990; Balci, Cakiroglu & Tekkaya, 2005). The essence of the concept can be assimilated in exploration phase. Additionally, students start to reevaluate their existing conceptions in this phase which results in disequilibration. To be able to reach equilibrium, they accommodate the concept in an environment that they are allowed to explain and discuss their ideas in the concept introduction phase based on the data obtained from the exploratory activities. This phase is the essential to allow students to accommodate through the discussion and interpretation of data. In the concept application phase, both assimilation and accommodation occur since the students organize or relate the newly developed concept to prior concepts or daily life applications. Moreover, occurrence of accommodation, modifying or reshaping the current mental structure, necessitates several important conditions. The conditions common to most cases of accommodation are defined by Posner and his colleagues (1982).

In line with the Piaget, Posner mainly focused on accommodation process in individuals and suggested four conditions that are obligatory to adoption of the current concept by students; dissatisfaction, intelligibility, plausibility and fruitfulness.

Dissatisfaction: Students must be dissatisfied with their existing conceptions. Realization of current concepts' inadequacy to explain new phenomena by individuals is needed to consent for radical changes in their concepts.

Intelligibility: The new conception must be intelligible. Individuals must understand the terms and symbols used in the concept and construct a coherent representation of information.

Plausibility: The new conception must be convincing and consistent with other knowledge. An idea become plausible when the individual believes that it is correct or when the idea is consistent with already accepted ideas.

Fruitfulness: The instructed information must be valuable, suggest new possibilities, directions or ideas and must have explanatory power. Individuals must believe that they can solve problems in different areas with this information.

Learning Cycle Model considers these conditions in sequential phases in order to promote learning. As the model started to be implemented, investigated and refined over years, the number of phases were expanded and the name of the phases were modified (Wilder & Shuttleworth, 2005). In the late of 1980s, Biological Science Curriculum Study (BSCS) extended three phased learning cycle of Science Curriculum Improvement Study (SCIS) and developed 'Five Es' model of learning cycle. The most common learning cycle approach in use for science teaching is this model (Allen & Tanner, 2005). According to Bybee, Taylor, Gardner, Scotter, Powell, Westbrook, and Landes (2006), there are many universities that uses 5E model in their general courses and in teacher education. Moreover, they revealed that by World Wide Web research there is a huge number of examples of curriculum incorporating 5E model, and lesson plans designed based on 5E model. The model has also been successfully implemented in science education for years (Cakiroglu, 2006). The model includes five phases started with same letter; Engagement, Exploration, Explanations, Elaboration and Evaluation. The first phase of Engagement covers short activities or probing questions that aim to address students' prior knowledge and to take interest of students towards the topic. In Exploration phase, students meet with the new concepts which the students investigate, explore and try to interpret by using their own conceptions. Explanation phase is the step they reflect their ideas towards the newly explored concept and learn the scientific terms related with the concept through explanations of teacher. Elaboration phase provides the application of new concepts in different situations to deepen the understanding. The last step of Evaluation is the phase that students and the teacher evaluate learning of concept and conduct modifications if needed.

Another model of learning cycle is 7E which is the expanded version of the 5E model. 7E model includes two phases in addition to other five. 7E separated the first phase of the 5E model, Engagement, in to two phases; Elicit and Engage. Additionally, the last two phases of 5E model, Elaboration and Evaluation, are allocated in to three phases; Elaborate, Evaluate and Extend. Accordingly, 7E model starts with the *Elicit* phase which emphasizes the importance of eliciting existing knowledge on which students build new knowledge. According to Eisenkraft (2003), the teachers may ignore students' prior conceptions related with the topic while getting their interest and preparing them to learn. 7Es model points to the importance of determining students' prior knowledge which provides a base for construction of new conceptions. Following the same five phases in 5E model, this model concludes with *Extend* phase that includes additional activities to allow students to practice transfer of knowledge and use the newly learned knowledge in new situations. Table 2.2 represents the comparisons of SCIS learning cycle, BSCS 5E learning cycle and 7E learning cycle. The table was adapted from the report presented by BSCS (2006) and the article of Eisenkraft (2003) to compare all models.

Table 2.2 Comparisons of the Phases of Learning Cycle Models

SCIS Learning Cycle Model	BSCS 5E Learning Cycle Model	7E Learning Cycle Model (Eisenkraft, 2003)
		Elicit (New)
	Engagement (New)	Engage
Exploration	Exploration	Explore
Invention (Concept Introduction)	Explanation	Explain
Discovery (Concept Application)	Elaboration	Elaborate
	Evaluation (New)	Evaluate
		Extend (New)

To be more comprehensible concerning the flow of the instruction, each phases of 7E learning cycle method will be described in detail in flowing paragraphs.

Elicit:

The learning cycle begins with the activation of prior knowledge in students about the subject matter. Raine and Collett (2003) claim that prior knowledge is the most important factor in students' learning. Similarly, Odom and Kelly (2001) suggest that the learner must possess concepts relevant to the new learning to be able to learn meaningfully. In this phase, the teacher has an opportunity to assess students existing concepts, while the students have the opportunity to recall their ideas. In general, the teacher directs students probing questions with respect to the subject to reveal students already acquired knowledge. Additionally, KWL chart (Ogle, 1986) is an organizer tool that reasonable to use in this phase to address students' prior knowledge. This tool encourages students to associate the existing ideas which they are going to engage towards the phases to facilitate the construction of meaning (Shelley et al., 1997).

Engage:

The learning cycle requires active engagement of students (Settlage, 2000). The motivated strategies that create interest in the topic, captivate students' attention and promote curiosity are implemented in this step. The role of this step is not only to make students focus on the lesson but also make them access and uncover their prior knowledge and struggle with their misconceptions. Students need to recognize their current conceptual structures to be able to build new knowledge over the existing ones. This step provides short activities seek to connect and organize to students' prior knowledge to prepare students for new learning (Allen & Tanner, 2005).

Cheesman (2005) lists the effective methods that may be used to engage the class: Jokes, cartoon, poems, songs, questioning, role-playing of the teacher, demonstrations, pictures, current events relevant to the topics being studied are mentioned methods in the researcher's study. It is also stated that none of the activities is better than other and the appropriateness of the activity for this phase depends on the instructor and the class. However, it is important to recognize the students' learning styles to select the appropriate activity.

Explore:

The general goal of this phase is to make student familiar with the concept and establish a desire to learn in the students. Students are challenged with additional tasks and situations that focus on the related concepts and skills with minimal guidance of the teacher (Allen & Tanner, 2005). They make observations, work collaboratively, raise questions, form relationships and generate hypotheses, test them and form new ones, and design and conduct experiments with the assist of prior knowledge. Students were aimed to acquire concrete experiences in the subject matter and realize the lack of their reasoning to explain the phenomena.

The teacher, on the other hand, guide students by asking probing questions and provides enough time to students for their exploration about the concept. These questions are generally the source of conflict between students' personal ideas. The teacher acts as facilitator or coach to encourage students to do inquiry, to connect the classroom instruction with their prior knowledge, and to direct their own learning. According to Wise (2006), the most powerful part of the learning cycle may be the emphasis on students' inquiry and facilitator role of the teachers. This phase confronts students with that their initial conceptions are insufficient to explain or get the idea.

Explain:

The explanation step is built on the first three phases and includes additional opportunities for students to demonstrate their understanding (Allen & Tanner, 2005). The involvement of students in this phase is necessary in order to avoid an expository format instruction (Hanley, 1997). Students explain and share their thoughts, their observations, experiences, discoveries, and claim evidence in their own words with other students. The teacher organizes a discussion period (Settlage, 2000) and connects students' explanations with scientific clarification by highlighting the important concepts. Students acquire new knowledge by connecting with prior experiences, and the new experiences in this phase causes the reevaluation of previous experiences (Balci et al., 2006). According to Hanuscin and Lee (2007) this phase is important to make sense about the concepts that students need to learn. Students get familiar with the language or the scientific vocabulary with respect to the related subject through the student-student and teacher-student verbal exchange (Hanley, 1997).

Elaborate

The goal in this step is to deepen and consolidate students' understanding by alternative activities that allow students to implement their understanding in a different situation (Allen & Tanner, 2005). The teacher offers activities that may include problem solving, inquiry, projects, lab experiments and discussions to students. These activities provide an opportunity to relate new information with previous ones and use their recently learned knowledge and skills to apply in additional but similar situations to reach reasonable conclusions. Students verbalize their understandings by using previously experienced knowledge during former phases. Additionally, the application of knowledge in similar situations aids student who could not adequately relate the teachers’ explanations to their experiences by encouraging their self-regulation (Karplus, 1977). This phase also assist the teacher through addressing students understanding. According to students’ performance, the teacher may decide to turn previous steps if it is necessary.

Evaluate:

This step aims to assess students to determine whether they gain the necessary knowledge and skills and also whether they change their thinking or behavior. Although the assessment of the learning occurs over all phases of learning cycle, achieving to educational objectives and obtaining scientifically correct understanding of the concept are evaluated at this phase (Hanuscin & Lee, 2007). The teacher superintends the learning over students’ reflected ideas, explanations, and responses through all phases. At the end of the instruction, the students reflect their understandings through different assessment techniques but the more important thing is that the students need to realize the change in their knowledge. Additionally, according to Cavallo et al. (2003), matching assessment techniques with the instruction is essential. The researchers advise to prefer open-ended questions rather than traditional assessments like multiple choice tests to be able to encourage and evaluate students’ science understanding rather than memorization of facts. Moreover, the teacher is supposed to give opportunity to self-evaluation and group-assessment to students. Another tool compatible with this aim is roundhouse diagram which allows the teacher to visualize students’ mental representation of knowledge that learned (Trowbridge & Wandersee, 1998).

Extend:

The activities in this phase aim to transfer of knowledge to encounter new phenomena and perform the learned knowledge in additional situations. This phase stress that the teachers need to be sure that students are able to apply their learning to new situations especially in daily life context (Eisenkraft, 2003). Teachers are expected to motivate students to use recently gained knowledge in new contexts so as to deepen the understanding and to build new experiences over them at this phase (Siribunnam & Tayraukham, 2009). This phase also used to connect the acquired information to the incoming subject.

In the literature, there are many studies that investigated the effectiveness of learning cycle compared to traditional methods. For example, Lawson (1995) conducted a review study examining early research on learning cycle based on the basic model developed by SCIS program. Lawson included the studies implemented from elementary to undergraduate years in his review. Six of the reviewed studies in different educational levels revealed that students who experienced learning cycle in science learning had grater gains in subject matter knowledge and retained more information in time. There were some studies reporting no difference in content achievement but in other outcomes such as usage of formal reasoning patterns and having more positive attitudes toward science. Considering scientific reasoning ability, the review demonstrates the superiority of learning cycle over the traditional approaches. Most of the studies noted gains in students' scientific inquiry abilities (e.g. identifying and controlling variables, describing object based on properties), development in science process skills (e.g. classifying, measuring, experimenting, and predicting). The review showed consistent findings that implementation of learning cycle results in more positive attitudes towards science in all grades. More specifically, reviewed studies indicated higher levels of self- concept, enhancement in motivation and enjoyment, positive attitude towards science, and lower likelihood of withdrawing from science courses after the implementation of learning cycle.

Contemporary research on SCIS's three phase learning cycle also documented the effectiveness of model over traditional approaches with respect to science learning outcomes. For example, Ates (2005) compared two approaches with respect to college students' mastery of resistive direct current circuits concepts. The groups were randomly assigned to instructional approaches and their prior knowledge was controlled in the analysis. The result revealed that, following exposure to learning cycle, the experimental group outperformed the comparison group with respect to understanding of related concepts. Barman, Barman and Miller (1996) also supported the effectiveness of learning cycle in science. They compared the model with textbook/demonstration method of instruction with respect to 34 5th grade students' understanding of sound concept. Students were randomly assigned to the groups which are instructed by same teacher. Students in textbook/demonstration group received a teacher-centered instruction in which the information explained from textbooks and discussions and demonstrations were conducted to verify these information. Students instructed through learning cycle, on the other hand, engaged in hands-on activities, encouraged to attend small group and whole group discussions, worked collaboratively, received the conceptual explanations considering their own observations and ideas, and had the opportunity to extended newly acquired ideas in new situations. Findings of the study suggested improvement in both group students' understanding of sound, however, students instructed with learning cycle approach showed significantly greater gain in understanding compared to the students who received textbook/demonstration instruction.

Moreover, there are some studies that aim to empower three phased learning cycle to promote learning and specific skills by combining the model with some approaches. For example, Lavoie (1999) preceded the learning cycle with a prediction/discussion step at the beginning and determine the effectiveness over traditional three phase learning cycle concerning concepts in genetics, homeostasis, ecosystems, and natural selection. The researcher proposed that stating predictions with explanatory hypotheses related with topic and following them by logical argumentations before the exploration of the concept may encourage students to construct their procedural and declarative knowledge as well as using thinking skills. The study was conducted with 250 10^{th} grade high school biology class students. Although both methods led to positive results concerning science process skills, logical thinking, conceptual achievement, and scientific attitudes, the enhanced learning cycle produced significantly higher gains scores for collective variables. This proposed model was replicated by Yilmaz, Tekkaya and Sungur (2011) but compared with two distinct instructional methods. The researchers compared the instructional methods of prediction/discussion-based learning cycle, conceptual change texts, and traditional instruction corresponding 8^{th} grade elementary students' conceptual understanding in genetics subject. Three classrooms instructed by same teacher were randomly assigned to receive each instructional method. The results revealed that, compared to traditional instruction, prediction/discussion-based learning cycle and conceptual change texts promoted higher conceptual understanding. The delayed measurements revealed higher retention of the acquired concepts in favor of prediction/discussion-based learning cycle and conceptual change texts classes. The result with respect to superiority of learning cycle over traditional instruction in genetics concept understanding of elementary students is compatible with the research of Atay and Tekkaya (2008). The researchers argued the effectiveness of learning cycle over the expository instruction may be the result of active participation of students especially in setting relations among the concepts through explorations and discussion instead of leaving this role to the teacher.

Similarly, a study conducted by Odom and Kelly (2001) compared the effectiveness of concept mapping, learning cycle, the combination of both methods and expository teaching in promoting understanding of diffusion and osmosis in 108 high school students. The researchers implemented learning cycle with three-phases as exploration, concept introduction and application. Students' logical reasoning was controlled in the analyses. During the implementation, in each phases of the learning cycle the teacher acted as a facilitator and student were actively engaged to learning process by manipulating materials, recording and analyzing data, discuss the findings with group members and other students in class. Students' understanding of concepts was assessed through Diffusion and Osmosis Diagnostic Test which implemented at the end of the instruction. The test was also administered after the 7-weeks period to appraise the retention of the concepts. The results of the study revealed that the combination of concept mapping and learning cycle was not significantly different from learning cycle approach, but more effective than expository teaching. The researcher claims that setting the connection between the concepts and engaging in the concrete experiences through the compared approaches might help students to improve comprehension.

Apart from the learning cycle developed by SCIS program, there is a considerable body of literature on 5E learning cycle model designed by BSCS and its versions. Distinctive from three phases of SCIS learning cycle which starts with exploration of concepts, 5E starts with warm up activities to activate prior knowledge and raise the interest which followed by exploratory activities. Additionally, the closing of the 5E instruction provides evaluation of the learned concepts compared to three phase model. Empirical studies demonstrated the superiority of model in terms of important learning outcomes (Treagust, 2007). The studies confirms that compared to traditional teacher-textbook based instructions, 5E learning cycle is more effective in helping students achieve in science subject matter (Akar, 2005; Cakiroglu, 2006; Balci et al., 2006), had positive impact on scientific reasoning (Boddy, Watson & Aubusson, 2003), on students' interest, motivation and attitudes toward science (Akar, 2005; Boddy et al., 2003; Tinnin, 2001; Ebrahim, 2004; Aydemir, 2012), developing sophisticated epistemological beliefs (Kaynar, Tekkaya & Cakiroglu, 2009), and improving higher order thinking skills (Boddy et al., 2003). In addition, according to an important body of empirical literature, 5E learning cycle instruction can promote students' understanding in science concepts (Chambell, 2000; Cakiroglu, 2006; Balci et al., 2006). Some of the studies conducted 5E learning cycle model in K-12 education and undergraduate education about in science learning will be summarized in the following paragraphs.

Campbell (2000) carried out a study to determine 5th grade students' understanding of force and motion concepts as they engaged in 5E learning cycle.

Students understanding of related concept was measured by a test developed specifically for the study. The sample of the study was 22 students in an elementary school. Various data sources such review of lab activity sheets, other classroom-based assessments, and filmed interviews were used to data triangulation to draw conclusion. The results demonstrated gain in the conceptual understanding. Additionally, students' preference on the best way to learning science was not towards the textbook-based instruction after receiving learning cycle instruction.

Boddy et al. (2003) implemented 5E learning cycle model in the unit of work from the curriculum including the activities such as marketing, food groups and human nutrition. They interviewed ten primary school students after experiencing 5E instruction, taped video footage of lessons, documented teacher field notes and conducted participant observation. Students' interviews indicated that the instruction was interesting, motivating and joyful for them. Some of them stated that they enjoyed since the activities improving their thinking skills and learning. The observational data also supported the amusement and the pleasure in the students. Besides the gain in learning, the study also pointed out 5E model promoted students' higher-order thinking skills (i.e. activity description, activity-concept relation, use of scientific terminology, and transfer of understanding to different concepts). Especially, students who had not previously demonstrated these skills had an improvement in their higher-order thinking.

Another study was conducted by Bilgin, Coskun and Aktas (2013). In this study, the authors used 5E learning cycle model to investigate its impact on elementary students' mental abilities. The data were collected from 160 4th grade students by World Association Test to reveal the connections of knowledge in students' minds and to test if the meaningful relations were structured between new knowledge and existing information. The intact classes were randomly assigned as experimental and comparison groups. Experimental group was taught by learning cycle approach and comparison group was taught by traditional approach based on teacher explanations, textbook and teacher directed questions in the unit of matter. The researchers compared the frequencies of relevant and irrelevant word use in groups and documented mind maps of students upon the responses to tests before and after the study. Although both teaching methods increased frequencies in adequate words and decreased frequencies in inadequate words, learning cycle approach was appeared to be more effective on these changes compared to traditional methods. Additionally, comprehension of concepts was grater in learning cycle group, which helped students to associate the concepts. The mind maps of the experimental group students reflected more links and branches between the concepts than the traditionally instructed students who did not constitute meaningful conception as a whole in their minds. The researchers concluded that the model is powerful to promote meaningful learning in more interrelated way, thus to establish the associations among the concepts.

Additionally, Cakiroglu (2006) investigated the effectiveness of 5E learning cycle on 8th grade students' understanding in photosynthesis and respiration. In the study, students' reasoning abilities were used as controlled variable and the results were explained based on within and between differences. The results showed that students instructed with learning cycle method demonstrated significantly better performance on the conceptual tests over the students who received traditional methods. Additionally, learning cycle promoted higher knowledge gain in the students about the related concept. The same subject matter was studied by Balci et al. (2006) to compare the effectiveness of three instructional methods; 5E learning cycle, conceptual texts and traditional instruction. 101 8th grade students in three intact classes instructed by the same teacher participated in the study. Students' prior knowledge and attitudes toward science were statistically controlled. The results showed that students in both learning cycle and conceptual chance texts groups understand the scientific conceptions related to photosynthesis and respiration in plant significantly better than students in traditional groups. However, no statistically significant mean difference was found between students in learning cycle and conceptual chance texts groups with respect to their understanding of photosynthesis and respiration in plant.

In addition, Sadi and Cakiroglu (2010) conducted a quasi-experimental study to compare the relative effectiveness of 5E learning cycle and traditional instructions on 11^{th} grade students' human circulatory system achievement. A total of 60 students from four classes participated in the study. The classes were instructed by two teacher and each teacher had one experimental and one comparison group. The authors developed a Human Circulatory System Achievement test to assess students' achievement in this topic. The test consists of 25 multiple-choice items related to blood, blood vessels, mechanism of heart beat, structure of the heart, the systemic circulation and the pulmonary circulation. Students in each group was administered the achievement test twice as pre-test and post-test. The results indicated significant differences between experimental group and comparison group in terms of students' achievement scores. The students instructed with learning cycle approach performed better on achievement test than the students who received traditional instruction. The authors concluded the learning cycle is an effective strategy to provide better understanding in human circulatory system concepts.

Moreover, Kaynar, Tekkaya and Cakiroglu (2009) compared effectiveness of 5E learning cycle against the lecture/discussion based instruction in the development of epistemological beliefs besides the conceptual understanding in the unit of cell. A sample of 153 students from 4 intact classes in grade six was selected for the study. The classes were instructed by the same teacher and randomly assigned as experimental and comparison groups as treated with 5E learning cycle instruction and traditional lecture/discussion based instruction, respectively. The implementation process lasted 3 weeks. Students in both groups were tested through cell concept test and Epistemological Beliefs Questionnaire (Conley et al., 2004) at the beginning and at the end of the treatments. The result of the study pointed out that experimental group substantially outperformed over comparison group in terms of cell concept achievement. Moreover, learning cycle instruction significantly improved epistemological beliefs of students in comparison with traditional instruction. The authors argued that providing an environment in which students learn science by practicing in authentic ways as scientists may promote development of more sophisticated epistemological beliefs.

In other study, Demircioglu, Ozmen and Demircioglu (2004) studied on solubility equilibrium subject with 46 10^{th} grade high school students. They reported striking differences between groups' concept test scores after receiving 5E learning cycle and traditional instruction in favor of learning cycle group. The interviews with five students also verified that the learning cycle promoted their learning in factors affecting solubility equilibrium in an effective and a permanent way while helping them to realize their wrong or deficient ideas to change. A similar study was conducted with same grade level by Ceylan and Geban (2009). In their study, the authors examined the impact of 5E learning cycle method and traditional instruction with respect to conceptual understanding in the state of matter and solubility concepts. 119 students conceptual understanding related to the subject was determined through multiple-choice and open-ended questions. The finding revealed students taught with learning cycle had better and significantly different conceptual understanding compared to other group. The study also indicated learning cycle instruction developed students' attitudes towards science, motivational constructs like intrinsic and extrinsic goal orientations, task value, and learning strategy use such as elaboration and organization. A compatible result was reported in the study of Aydemir (2012). She compared the 5E learning cycle instruction to traditional instruction with respect to knowledge acquisition in solubility equilibrium, perceived motivation, use of learning strategies and attitudes towards chemistry. 5E model appeared to cause a statistically significantly better acquisition and also retention of knowledge. Furthermore, learning cycle was found to help students develop positive attitudes towards chemistry, and to improve their intrinsic goal orientation, task value, and self-efficacy in chemistry. Additionally, the study revealed improvement in the students' use of strategies like rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment, and peer learning.

Overall, the effectiveness of 5E learning cycle on students learning is clear in the reviewed literature. On the other hand, 7E learning cycle model, the expended version of the 5E learning cycle, aimed to emphasis on eliciting prior knowledge at the beginning and to ensure the transfer of knowledge at the end of instruction. Eisenkraft (2003) argues the importance of setting a separated phases as a reminder of eliciting the prior knowledge and transferring and connecting the knowledge with other subjects. Accordingly, 7E learning cycle was also promising to provide interconnection between the topics as well as the concepts. In a comparative study, Mecit (2006) studied with 46 grade 5 students to investigate the effect of 7E Learning Cycle instruction on the improvement of critical thinking skills. The researcher formed two groups and randomly assigned learning cycle instruction and curriculum based instruction to the groups. Both of the groups were taught the same subject from the regular curriculum "water cycle". Students receiving curriculum based instruction followed the information in the textbook and conducted activities suggested to verify the exposed knowledge. The group receiving learning cycle instruction, on the other hand, acquired the subject matter through an inquiry-based learning design. Students' critical thinking skills were measured by The Cornell Conditional Reasoning Test before and after the instruction. The researcher found that, 7E learning cycle instruction significantly improved students' critical thinking skills.

In the light of the literature, it can be concluded that learning cycle has a long history in science education. Although, there are various version of the approach, all starts with an engagement phase to take students attention and connect their prior knowledge. Moreover, all models foster inquiry, facilitator role of the teacher and being to apply learned knowledge to new situations. There are studies that support the effectiveness of approach to acquire scientific concepts and skills. It is found that learning cycle caused a better acquisition of scientific conceptions than the traditional methods. Furthermore, the phases of the cycle provides opportunity to students to focus on and become interested in the subject, actively engage in the process, use their prior knowledge and construct new knowledge by the help of previous experiences, develop inquiry skills and self-evaluation. In a similar manner, the studies demonstrated that the learning cycle is an effective method to clarify students' thought process and to correct their misconceptions (Ceylan & Geban, 2009; Balci et al., 2006). According to Odom and Kelly (2001), the phases of learning cycle help students to explore their belief system and provides knowledge construction and self-regulation skill by developing inquiry skills such as argumentation, prediction and hypothesis testing. Similarly, Wise (2006) reports that the learning cycle fosters inquiry and provides students a situation that students are able to work collaboratively, explore, ask question and seek scientific explanations and answers. Moreover, the researcher adds that students gain invaluable skills that they also need in their future life in learning cycle. Implementing learning cycle to teach science in any grade level is recommended in the literature. It would be benefical to increase the number of learning cycle activities in different subjects to encourage the instructors to implement this effective method in science teaching. In fact, Bybee et al. (2006) points to need of more research about the effectiveness of learning cycle and about when and how to implement it. Moreover, none of the studies in the reviewed literature directly looked for the effect of 7E learning cycle approach on the improvement of elementary students' conceptual understanding of skeletal system, circulatory system and respiratory system concepts all together in a sequenced design. Moreover, studies investigating the relative effect of learning cycle in elementary level students' motivation, learning strategy use, scientific epistemological beliefs and science process skills are very limited. In following parts of this chapter, the studies about these collective variables will be reviewed.

2.3 Understanding of Human Body Systems Concepts

Many studies have attempted to gain a perspective on students' conceptual understanding of human body systems. The studies have shown that students do not fully understand the major concepts of human body systems and have knowledge deficiencies, difficulty to interpret the subject, and hold alternative views or misconceptions (Yip, 1998a; Bahar, Johnstone & Hansell, 1999; Tekkaya, Ozkan & Sungur, 2001). The reasons behind these problems are probable the abstract, complex and micro structured nature of concepts as well as the obstacles in students' priory constructed knowledge. Students actively construct the knowledge through their experiences not only in school but also in real life. Consequently, they bring many conceptions in class which they constructed by associating with their world before they were instructed with the subject matter. These existing knowledge structures influence their understanding of introduced concepts since learning consists of not only acquisition of new knowledge but also iterative interactions between new knowledge and students' existing conceptions. Thereby, these existing conceptions may facilitate or impede learning. In fact, this situation was argued by Ausubel (1968), and the influence of existing conceptual knowledge on the learners' conceptual development was empirically supported by the research in the literature (Duschl & Gitomer, 1991). Some of the prior experiences can support learning in school. On the other hand, some of them may be obstacles for further learning since they are in conflict with the currently accepted scientific knowledge. In the literature, these conceptions are labeled as 'misconceptions' or 'alternative conceptions' (Nakhleh, 1992; Hewson & Hewson, 1983; Abimbola, 1988). Scientifically acceptable or not, concepts and ideas already possessed by the learner are so powerful in that they influence students' further learning. Such conceptions in science have been searched and listed by many researchers in order to aware the teachers and other researchers in considering these conceptions while designing their lessons and effective teaching strategies. Concerning the human body systems, a body of research has explored and listed the students' misconceptions and difficulties in understanding (Mann & Treagust, 1998; Reiss & Tunnicliffe, 2001; Ozsevgec, 2007; Aydin & Balim, 2009), specifically in skeletal system (Caravita & Falchetti, 2005), circulatory system (Arnaudin & Mintzes, 1985; Sungur, Tekkaya & Geban, 2001), and respiratory system (Alparslan, Tekkaya & Geban, 2003). In these studies different techniques such as drawings, interviews, open-ended or multiple-choice questions, concept maps and conceptual inventories were utilized in order to get an idea about students' understanding on related subject.

For example, Reiss and Tunnicliffe (2001) explored what the students know about inside of their body through drawings. 158 students in various grades ranging from primary school to college were participated in the study. All students were given a blank page to draw their ideas about what they think exists inside their body. Among the organ systems, digestive system was the one which was the mostly drawn while the muscular system was the least one. The drawings revealed that students' knowledge about the organs and systems increases with the age but there was a general tendency in each grade to reflect independent organs that not connected in a whole system of the body. In other words, the drawings indicated that students perceive organ systems as functioning in an isolated manner and they had difficulties in drawing an organ system with its all parts. For instance while drawing circulatory system, some students drew heart but not blood vessels. Additionally, the same authors conducted an international study investigating the drawings of 586 pupils from 11 different countries (Reiss et al., 2002). The participants were in two groups of age; 7 years and 15 years old. As expected, the results revealed significantly higher conceptual understanding for 15 years olds' drawings. However, deficient representations of organ systems revealed that even older students have little understanding of interrelations among organ systems.

Similarly, Ozsevgec (2007) investigated sixth and eighth grade students understanding of their internal structure. The participants of study were 112 students attending two junior high schools. The students were requested to draw the organs existing in their body on a given body map. They were also asked to write the function of organs which they draw. The results of the study indicated students are aware of a wide variety of organs. However, they failed in locating the organs accurately, explaining the correct function of the organs, and relating the organs with a body system. Students tend to draw individual organs without connecting them with other related structures. The mostly drawn organs were the hearth and lungs. However, none of the students were able to draw a correct shape of heart. Moreover, they appeared to have confusions related to the function of heart. Most of the explanations directed by students were wrong such as ‘cleans blood’, ‘collects the clean blood’, and ‘separates the clean and dirty blood’. The rate of incorrect responses for the function of lungs was half of the explanations for example ‘lungs help the inhaling and exhaling’, ‘circulate the blood’, and ‘provide fresh air’. The drawing about skeletal system was muscles which have drawn only in the elbow. Students also reflected unscientific terminology like ‘clean or dirty blood’ to refer ‘oxygenated or deoxygenated blood’.

Arnaudin and Mintzes (1985) carried out a study to identify students’ alternative conceptions of the human circulatory system. The study was conducted at two phases. The participants of the first phase were 25 fourth grade children and 25 college students. The data were gathered about students’ conceptions by asking students to create a concept map with given eight concepts and explain the ideas through structured-interviews. Responses of the students to the interview questions comprised the basis for a conceptual inventory to be developed and used in the second part of the study. 495 students at grades ranging from 5th grade to college were administered the conceptual inventory. Both phases of the study revealed and validated that students hold alternative conceptions with respect to structure of blood, function of blood, structure of heart, function of hearth, circulatory pattern, and association between circulatory and respiratory systems. The grade level comparison showed the pertinacity of common alternative conceptions from elementary levels through college years.

Considering the skeletal system concept, the study conducted by Caravita & Falchetti (2005) implied the perception of students regarding the bones; if the bones of a living organism is also living or nonliving. The data were collected from 189 students ranged in age from 7 to 12 years who visited the Civic Zoological Museum. Each student was interviewed with the following questions: “Are bones alive when they are inside the living body?”, “What evidence do you have to this effect?”, “What are bones made of?”, “Can bones grow? How do they grow?”, and “Do children or newborn animals have the same bones as adults?”. The answers of students especially in secondary school level indicated a large frequency of the nonliving statement towards bones. Moreover, students who stated bones as alive mostly failed to express acceptable criteria to justify their answers. Rather, they argued the movement of bones or presence of bone components like marrow as criterion. These justification criteria were also observed student who state the bones as not alive, but in opposite way. They explained, for example, bones are not alive because they cannot move themselves. Despite this, most of the students agreed that the bones grow and denied that newborns and adults have the same bones. The authors discussed that students tried to justify their ideas through function rather than structure of the organs. In this manner, they suggested to focus on the interrelationships among the structure and function as a priority in task developments in science.

Besides documenting the understanding difficulties and misconceptions with respect to human body system concepts, there are studies empirically demonstrating the influence of instructional strategies employed in the classrooms on students' understanding of human body systems. In general, students' conceptual understanding of these concepts appeared to better when the classroom provides students with opportunities to actively engage in activities that help them recall prior knowledge and identify the associations between the concepts. In addition classroom environments the promote social interaction with teacher and peers, encourage students to generate questions and seeking solutions, and require teachers act as to encourage and challenge students to construct their own knowledge are likely to causes better acquisition of scientific concepts (Aydın & Balım, 2009; Alparslan et al., 2003; Sungur et al., 2001; Hmelo, Holdon & Kolonder, 2000; Alkhawaldeh, 2007). Moreover, as Jeong and Chi (2007) suggest, collaboration in small group works increases the common knowledge among the students. Additionally, Monzack and Petersen (2010) discuss that learning in an activity that students not only mentally but also physically active may effectively engage students and increase retention of information. On the other hand, compulsory education which directs the traditional methods in teaching is not promising to eliminate the existing misconceptions or to provide meaningful learning (Arnaudin & Mintzes, 1985, 1986; Sungur et al., 2001). Although various teaching methods were suggested to develop conceptual understanding, there are some studies revealed that the robustness of some initiative ideas and representation with respect to human body systems even after the instructions (Sungur et al., 2001; López-Manjón & Angón, 2009) Following paragraphs summarize the studies investigating the contribution of different instructions on understanding of human body system concepts.

In their quasi-experimental, Aydın and Balım (2009) compared the effectiveness of three instructional techniques namely, technologically-supported mind-mapping technique combined in 7E learning cycle, technologically-supported concept-mapping combined in 7E learning cycle, and curriculum driven instruction on students' understanding of body systems. The sample of the study consisted of 62 6^{th} grade students in three intact classes. Two of the classes were randomly assigned to experimental groups to be taught the concepts through 7E learning cycle instruction. Particularly, students in each experimental group prepared either mind-map or concept-map on subjects related with skeletal, circulatory and respiratory systems in computer environment. One of the classes assigned as comparison group in which the instruction was carried out based on the activities suggested by curriculum. Students understanding of human body systems concepts were identified using a conceptual comprehension test including 13 open-ended questions. The test was implemented only at the end of the instruction. The analysis of the students' responses revealed a meaningful difference in favor of the experimental group which prepared mind-maps. That is, the frequency of correct answers on almost all of the items was higher for students employing technologically-supported mind mapping technique than that of the students in other groups. The study also documented students' existing misconceptions regarding skeletal, circulatory and respiratory systems. The authors stated that activities that provide the linkage among the concepts enhance the meaningful learning and contribute to students' academic achievement.

In other study, Sungur et al. (2001) investigated the influence of conceptual change texts accompanied by concept mapping instruction and traditional instruction on 10th grade high school students understanding of human circulatory system concepts. Before the main study, the authors developed a Human Circulatory System Concept Test with an extensive research. The distracters of items in the tests were generated with the misconception of students derived from the literature and the interviews conducted with ten 11th grade students. The study documented a list of misconceptions appeared in the interviews and the literature with respect to blood structure and function, heart structure and function, circulation of blood, the relationship between homeostasis and the human circulatory system. The concept test was implemented before and after the treatment. Beside the concept test, students were administered Science Process Skills Test before the treatment. Conceptual change text instruction accompanied by concept mapping was applied to 26 students in experimental group while traditional instruction was applied to 23 students in the comparison group. The authors conducted Multiple Regression Correlation Analysis to investigate the relative contributions of treatment, prior knowledge, and science process skills on students' conceptual understanding of human circulatory system. The model of analysis significantly accounted for 78% of the variation in conceptual understanding in which each variable appeared to have significant contributions. In the second step of analysis the authors compared the influence of instructions on students' understandings by controlling the prior knowledge and science process skills. The results suggested that students engaged in conceptual text/concept mapping instruction performed better on the conceptual test then those learned with traditional instruction. The study carried out a detailed analysis on the basis of groups' responses to the items. This analysis revealed that some misconceptions still exists in both groups after the instruction, although the experimental group scored significantly better on the concept test. The study concluded that conceptual change instruction is an effective method to develop conceptual understanding and traditional instruction is relatively ineffective to eliminate the existing misconceptions.

In a similar study exploring the effectiveness of conceptual change texts on students' understanding of circulatory system concepts, Alkhawaldeh (2007) studied with 73 ninth grade female students from two classes. The classes were randomly assigned as experimental group and comparison group to receive conceptual change text instruction and instruction respectively. In order to determine students' conceptual understanding the researcher developed a concept test that covers 14 multiple-choice items. The distracters of each item of the test comprise students' general conceptual difficulties and misconceptions derived from the related literature and interviews conducted by the researcher. Students in both experimental and comparison group were administered the concept test at the beginning of the instruction, at the end of the instruction and after one month period to determine their understanding and retention of concepts. The researcher found significant mean differences between groups in terms of post-test and delayed-test scores. The results showed that the experimental group students outperformed comparison group in terms of conceptual understanding. The delayed implementation of concept test results also indicated higher retention of concepts in favor of experimental group. The researcher argued that instructing the concepts through methods explicitly dealing with the misconceptions of students is more effective for acquisition of scientific conceptions and elimination of misconceptions related with the concept.

Hymelo et al. (2000) carried out a study to investigate the contribution of design activities to 6th grade students' learning a complex system. The authors selected respiratory system concept to study since it is a complex system that covers causal interactions and functional relations between the parts and with other systems. The intervention was conducted with 42 students in two classes. Another class was attained as comparison group which learned the subject by reading textbook, participating lectures, and teacher directed discussions. The experimental group, on the other hand, learned through design activities. The students in experimental group classes were given a problem statement that directs students to design a practical artificial lung and to build a model of some piece of their design. Students worked in small groups. Firstly, they elaborated the important statements in the problem, plan their steps to follow during the project, and then generated an impressive list of learning issues. Then they tried to find the solutions to these issues. To facilitate students, teacher provided some printed and electronic sources related with the structure and function of respiratory system to promote self-directed learning. During students' research and design process, the teacher posed a variety of open-ended questions to follow their progress, to stimulate their thinking, and to help them on their investigations. During their investigation and model development the teacher also engaged students with hands-on activities such as measuring the lung capacity with the spirometers. At the end, the students presented their models and explained the function of respiratory system. The conceptual understanding of students in both groups was determined through 12-item true-false test, drawings, and interviews which were conducted before and after the instructions. The test results indicated a significant development in the conceptual understanding of students in the experimental group who designed a model while there was not a significant mean difference for comparison group students' scores. Students were asked to draw the inside of human body before and after the study. As reflected by their drawings, their mental models related with human body revealed that experimental group students had a better understanding of the relation between the organs of the system. Moreover, the conducted interviews with 18 students from experimental group revealed that the design activities promoted students' thinking about how the organs of respiratory system work. The authors concluded that students engaged design activities had a better understanding with respect to respiratory system organs compared to students learned by lecture.

To sum up students have difficulties in learning body systems and hold various misconceptions on related concepts. The studies on the skeletal, circulatory and respiratory systems revealed that although the students are aware of the organs of the systems separately, they fail to form mental models reflecting the interrelationships among body systems and the associated organs (Arnaudin & Mintzes, 1985; Cuthbert, 2000; Ozsevgenc, 2007). For example, according to some studies, students are unable to explain relationship between the heart and the lungs correctly (López-

Manjón & Postigo, 2005). As suggested by Arnaudin and Mintzes (1985) the function of heart can be scientifically acquired by rote memorization which, however, it fails to provide a whole understanding towards the body systems (López-Manjón & Postigo, Angon, 2009). Actually, many of the concepts in this subject are such as, blood, hearth, muscles, respiration, gas exchange, oxygenated-deoxygenated blood are abstract and theoretical entities (Alparslan et al., 2003). Understanding of these kinds of biological structures and functions is often difficult because of their complexity and micro-structure (Haugwitz & Sandmann, 2010) in addition to requisite of interdisciplinary expertise to understand (Sungur et al., 2001). In this manner, the traditional instruction techniques based on teacher explanations, textbook readings or teacher-directed discussions do not adequately support the understanding of human body systems. The studies investigated the superiority of other instructional techniques over traditional methods in terms of improvement in students' scientific conceptions, acquisition the idea of structure-function in the framework of human organ systems, and construction of cognitive connections concerning the entire human body. The general characteristics of these instructional methods involve students' active participation in the learning process, consideration of prior knowledge and misconceptions in concept acquisition, engaging in activities that provide concrete examples to understand the abstract nature of subject, and facilitator role of the teacher. That is, the better acquisition of scientific knowledge in human body systems appeared to occur in constructivist approaches. Accordingly, the LC model could be helpful in addressing students' preconceptions about the skeletal, circulatory and respiratory concepts of providing multiple learning experiences. Actually, the reviewed studies were indicated the superiority of conceptual change text instruction as a constructivist approach on students' conceptual understanding of human body systems. In the present study, on the other hand, 7E learning cycle instruction was implemented since it provides concept learning not only through raising cognitive conflicts in students but also enabling to combine several approaches that suggested in the mentioned literature such as hands-on activities, model development, and dissections of organs.

Learning cycle phases are favorable to help students recall and evaluate their prior ideas, explore the concept through hands-on minds-on activities, construct their own knowledge structure, and receive the scientific terms from the teacher while developing their own learning through activities providing concrete examples. More specifically, the first phases is ought to elicit prior conceptions and make to students, as well as teachers, aware of the conflict between the scientific knowledge and their own knowledge. Following phases provides concrete samples to acquire the knowledge with the guidance of teacher. Actually, to provide more concrete understanding in such complex systems subject hand-on activities, model development and dissection of organs are suggested (Hymelo et al., 2000; Lee, 2001; Lee, 2004). The studies empirically propose that students gain better understanding as well as higher interest towards the subject when they design and build models (Haugwitz & Sandmann, 2010; Hymelo et al., 2000). Moreover, as Jones et al. (2004) point out dissections of organs in the classroom may facilitate the understanding of structure and function. In this study, the exploration and explanation phases of learning cycle provide such activities to students. The ending phases indicate evaluation of knowledge and possible remained misconceptions. The human body systems concepts are important for middle school students to comprehend since it is necessary to know about own body to maintain a healthy life (Steve & Kim, 1998). As Arnaudin and Mintzes (1985) recommended, using instructional interventions in early grades is necessary to prevent the remaining of difficulties as the students continue to their educational process. Therefore, instruction based on the 7E learning cycle is taken into consideration of middle school students' conceptual understanding towards skeletal, circulatory, and respiratory systems in this study. Implementation of 7E learning cycle is expected to result in greater conceptual understanding in mentioned subjects and better retention of concepts compared to curriculum based instruction.

2.4 Self-Regulation

In this part of the literature review, self-regulation will be defined based on Social Cognitive Theory proposed by Bandura. Then, two models which are grounded within this theory to explain self-regulation will be summarized. Afterwards, the research about the strategies employed by the self-regulated learners will be reviewed. The relationship between cognitive, metacognitive, and motivational constructs of self-regulation and achievement will be documented. In addition, the literature in learning environment that supports and develops these constructs will be outlined to provide a rationale for learning cycle as an effective teaching strategy in this respect.

2.4.1 Self-Regulation Theory

The transition in the learning environments from teacher-centered towards student-centered in recent years calls a need for developing students who have the ability to learn by themselves and able to regulate their own learning. Development of self-regulated learners is considered as an important factor in education to raise independent learners not only in academic life but also their real life situations. Boekaerts (1999) points out that many educators agree on teaching self-regulatory skills as a major goal of formal educations, since these skills are also critical for up-dating knowledge after leaving the schools. Additionally, Zimmerman (2005) stresses the importance of self-regulated learning in the development of lifelong learning skills.

Pintrich (2005) defines self-regulated learning as “an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition motivation, and behavior, guided and constructed by their goals and the contextual features in the environment.” (p.453). Self-regulated learners are efficient at setting realistic goals for the task, selecting effective strategies to make an effort toward the attainment of goals, monitoring their learning process and strategies, planning for their strategies, managing their time and evaluating their own learning.

There are many self-regulated learning models developed to explain the self-regulated learning process (i.e. Pintrich, 2005, Winne, 2001, Boekaerts 1997, and Zimmerman, 2000). Each of the models has both special features and common characteristics. Wolters, Pintrich and Karabenick (2003) describe the characteristics shared in all models as four main assumptions. The first assumption is the active and constructive role of learners in the process. Learners are active participants in the process of constructing their own ideas, setting goals and selecting appropriate strategies to achieve these goals. The second is existence of potential in learners to control, monitor and regulate their own cognition, motivation and behavior. The prompt of this potential by a learner may be interfered by biological, developmental, contextual, and individual differences. The third assumption is learners' determination on some kind of standards, criterion or goals in order to decide the continuum of process or need for a change. The learner sets goals to strive and then regulate his/her own cognition, motivation and behavior to achieve the goals. The last assumption is that learners' personal characteristics and contextual characteristics influence their achievement and performance while the self-regulatory activities mediate this association.

Among the self-regulated learning models, two of them were grounded within Social Cognitive Theory and developed by Zimmerman (2000) and Pintrich (2000). Social Cognitive Theory defines human functioning through a three-point model namely "triadic reciprocal causation" (Bandura, 1986). The model explains the mutual dependence among the personal factors, contextual factors and the behavior (See Figure 2.1). That is, each elements of the model has a dynamic interplay with each other as affecting and being affected.

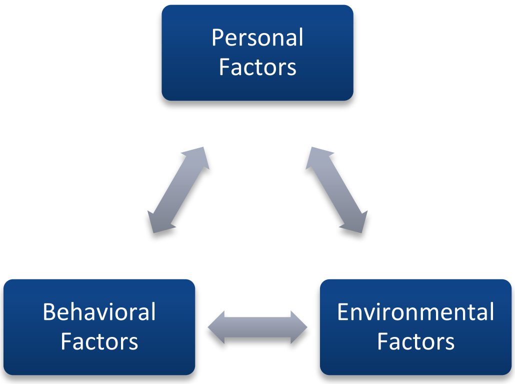

Figure 2.1 Triadic Reciprocal Causation Model

Source: Bandura, 1986, p.24

Bandura explains personal factors such as intentions, beliefs, expectations, goals and self-perceptions mediates the actions of humans and the consequences of these actions in turn, shape their own cognitive and affective reactions (Personal - Behavior). Personal aspects of human, additionally, developed and modified by social influences (Personal - Environmental). People also impress their environment based on their physical characteristics (eg. age, size, and race) and their role or the statues in the social environment. Environmental factors and behavioral factors influence each other whereby the human selection and formation of situations affects their environment while they are also behaving upon the influences of environment (Behavioral - Environmental). Overall, the way the person behaves alters the environmental and personal factors in which influence the future behaviors. However, according to theory, the intensity of alterations between these factors varies depending the involved situations, tasks and circumstances.

Among the personal factors in his theory, Bandura identifies three key processes; self-efficacy beliefs, outcome expectations and self-regulated learning. Self-efficacy briefly refers to individuals' own confidence to attain within a specific task. Outcome expectations mean the reactions that individuals anticipate as the result of their own performances. Finally, self-regulated learning indicates the process in which the individual actively takes control and responsibility of their learning.

Influencing from Bandura's Social Cognitive Theory, Zimmermann and Pintrich defined self-regulated learning and developed models related with the self-regulation process. Zimmermann (2000) developed a cyclical model to explain self-regulation process (See Figure 2.2). The model describes the self-regulation process through three phases; forethought, performance or volitional control, and self-reflection phases. Forethought phase covers thinking and planning processes and beliefs that precede the learning efforts. Sub-processes within this phase are task analysis (eg. goal setting and strategic planning) and self-motivation beliefs (eg. self-efficacy, outcome expectations, task value, and goal orientation) which are intended to enhance the efforts that learner employs to learn. Performance phase involves processes that occur during the learning intended to improve the action and self-monitoring. The phase constitutes two sub-processes; self-control and self-observation. Self-control encompasses self-instruction, imagery, attention focusing, and task strategies. Self-observation encompasses metacognitive monitoring and self-recording. The last phase of the model is self-reflection phase occurs following the performance efforts. The phase divided in to two sub-processes; self-judgment and self-reflections which are intended to evaluate the performance and make necessary adjustments. Self-judgment includes self-evaluation and causal attribution while self-reaction includes self-satisfaction and adaptive-defensive strategies.

According to this model, learners' thinking and planning processes sequentially affect their own effort and monitoring process which then affects learners' interpretations and need adjustments with respect to their performance.

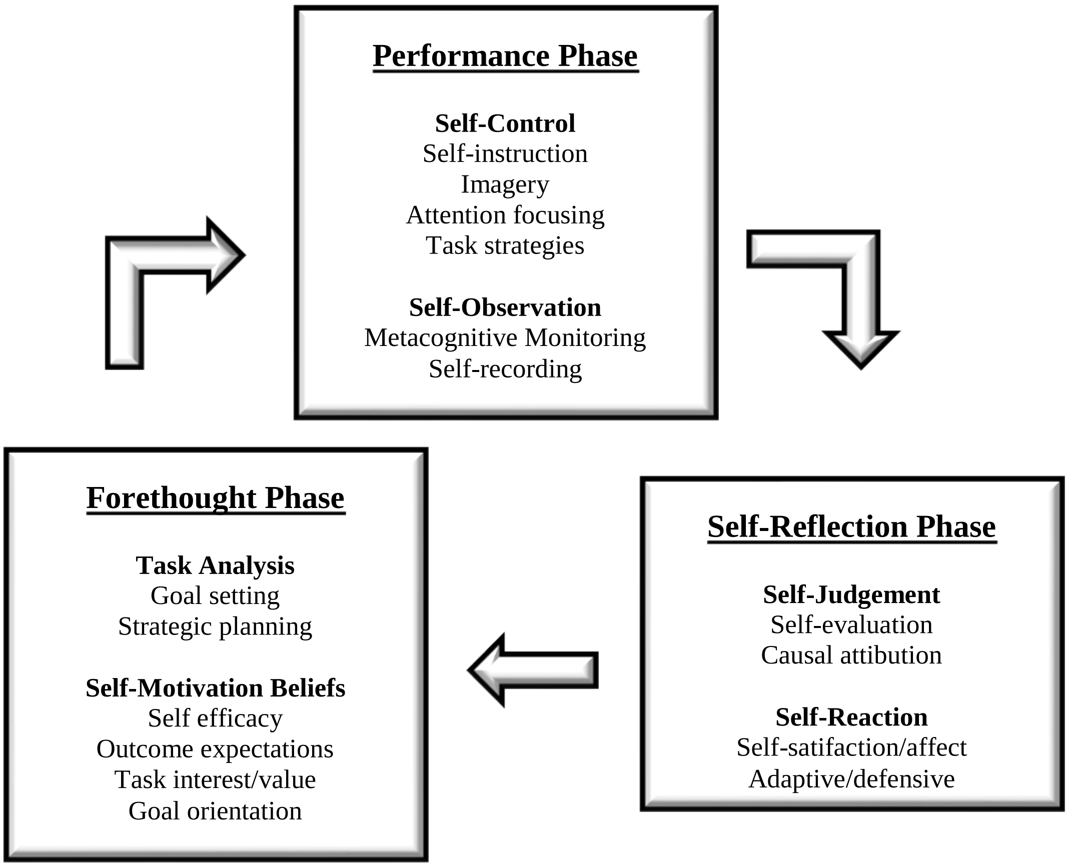

Figure 2.2 Phases and Sub-Processes of Self-Regulation
Source: Zimmerman &. Campillo, 2003, p.239

In line with the social cognitive ideas, Pintrich (2000) generated an eclectic model including a general framework for self-regulated learning by focusing on *phases* and *areas* of regulation. According to the model, there are four phases of self-regulation including forethought, monitoring, control and, reaction and reflection phases. Pintrich (2005) emphasized that phases of the model do not have to move in a linear way, although the model includes a hierarchical framework. In addition, the model suggests that there are four areas of regulation which involve regulation of cognition, motivation, behavior and context. Table 1.3 presents the descriptions for four phases and four areas of self-regulated learning.

As displayed in the table, in the forethought, planning and activation phase of the model, target goal setting, prior content knowledge activation and metacognitive knowledge activation takes place within the cognition area of regulation. The motivation/affect area for regulation involves goal orientation adoption, efficacy judgments, ease of learning judgments, perceptions of task difficulty, task value activation and interest activation. In behavior area, planning for time and effort and self-observations occur. The context area for regulation includes perceptions of task and contexts.

The second phase of model is monitoring. This phase covers metacognitive awareness and monitoring of cognition in the cognition area. In the motivation area, awareness and monitoring of motivation and affect takes place. Behavior area embraces awareness and monitoring of effort, time use, need for help, and self-observation of behavior. Context area, finally, consists of monitoring and changing task, and conditions of context.

In the control phase of the model, cognitional control refers to selection and adaptation of cognitive strategies for learning and thinking while the motivational control refers to selection and adaptation of strategies for managing, motivation, and affect. Behavioral control encompasses expending effort, persisting on the task and help seeking behavior. Contextual control is related with changing or renegotiating the task and the context. Generally, this phase is highly connected with the previous phase.

In the reaction and reflection phase, the judgments and attributions of individual are considered. Cognitive reactions indicate cognitive judgments and attributions while motivational reflections indicate affective reactions and attributions. Behavioral reflections comprise one's choice of behavior. Contextual reaction and reflection concerns evaluation of task (Pintrich, 2004; 2005).

Table 2.3 Phases and Areas for Self-Regulated Learning

	Areas for Regulation			
Phases	Cognition	Motivation/Affect	Behavior	Context
1. Forethought, planning, and activation	Target goal setting Prior content knowledge activation Metacognitive knowledge activation	Goal orientation adoption Efficacy judgments Ease of learning judgments; perceptions of task difficulty Task value activation Interest activation	(Time and effort planning) (Planning for self-observations of behavior)	(Perceptions of task) (Perceptions of context)
2. Monitoring	Metacognitive awareness and monitoring of cognition	Awareness and monitoring of motivation and affect	Awareness and monitoring of effort, time use, need for help Self-observation of behavior	Monitoring changing task and context conditions
3. Control	Selection and adaptation of cognitive strategies for learning, thinking	Selection and adaptation of strategies for managing, motivation, and affect	Increase/ decrease effort Persist, give up Help-seeking behavior	
4. Reaction and reflection	Cognitive judgments Attributions	Affective reactions Attributions	Choice behavior	Evaluation of task

Source: Pintrich, 2000, p.454

As reflected in the models, learners regulate their cognition, motivation, behavior and context during self-regulation process. In academic settings, self-regulated students employ various strategies to acquire the information. Zimmerman and Martinez-Pons (1988) identified self-regulated learning strategies used by high school students such as self-evaluation, organizing and transforming, goal-seeking and planning, seeking information, keeping records and monitoring, environmental structuring, self-consequences, rehearsing and memorizing, seeking social assistance and reviewing records. Among these strategies, most frequently referred strategies in the studies are organizing and transforming information, seeking assistance, goal setting and self-evaluation (Salisbury-Glennon, Gorell, Sanders, Boyd & Kamen, 1999; Sink, Barnett & Hixon, 1991).

Wolters et al. (2003) categorized the strategies used by the learners depending on the areas of regulation suggested by the Pintrich's model of self-regulation. Concerning regulation of cognition, Wolters et al. (2003) suggested that learners use different cognitive and metacognitive strategies to regulate their cognition. The main cognitive strategies used by the learners include rehearsal, elaboration, and organization strategies. Moreover, the authors added metacognitive self-regulation as fourth strategy to regulate cognition. The researchers described each strategy as follows: Rehearsal strategy refers to memorization of materials by repeating over and over. On the other hand, elaboration strategy aims to reach a deeper learning by summarizing the material with learners' own words. Organizational strategies reflect learning while organizing the material such as via note-taking or developing a concept map. Metacognitive self-regulation refers to awareness of existing strategies and planning, monitoring and regulating them during the learning process.

Regarding regulation of motivation, Wolters (2003) reported that strategies that students attempts to regulate their motivation include self-consequating, goal-oriented self-talk, interest enhancement, environmental structuring, self-handicapping, attribution control, efficacy management, and emotion regulation. More specifically, self-consequating refers to students' determination of an extrinsic outcome like a reward or a punishment to engage in the learning process. Goal-oriented self-talk is subvocal statements of learner to remind their goals which in turn to motivate themselves to persist on the task. These goals may become mastery oriented like satisfying the curiosity or increasing the learning, may become extrinsic oriented like doing task to be able to get higher grades or become a good student in the class, and may become performance oriented such as being better than others. Interest enactment occurs when students learn the material by connecting it with their own personal interest or their own life as well as when the students tries to increase the enjoyment of the task to motivate themselves. Environmental structuring involves students' regulation of their environment to conducive to their learning. Self-handicapping is to produce obstacles that makes the task more difficult, such as procrastination or avoidance of studying which may results in low achievement. Attribution control concerns purposeful selection of causal attributions to increase motivation towards the task. Efficacy management is defined as the ability to monitor, evaluate and control of expectations, perceptions and self-efficacy. To achieve this, students use proximal goal setting, defensive pessimism and efficacy self-talk strategies. Finally, emotion regulation is emotional control to ensure effort providence and task completions. To control their emotion students use strategies like using inner speech to calm dawn or controlling the breath. Test anxiety is such emotion that related with the achievement of students.

Concerning regulation of behavior and context, Wolters et al. (1993) classified related strategies utilized by the learners as effort regulation, time and study environment regulation, and help seeking. Students optimize their effort based on the task difficulty in order to reach their goals and plans. They also manage their time and context via planning for study period and modify their environment when it is necessary. Help seeking is an important self-regulated learning strategy. Being aware of need for help and others can assists, determining the contributor person, and prefer to ask help instead of to quit in a predicament on the task are adaptive help seeking characteristics of a self-regulated learner. While other strategies are carried out independently, students perform this strategy through social interaction with others (Newman, 2002). Wolters et al. (1993) details the help-seeking as students' intentions to seek or avoid seeking help, perceived cost or benefits of help-seeking, help-seeking goals as instrumental and expedient, sources for help-seeking as formal and informal sources, and perceived teacher support of questioning. Some of the students may prefer not to seek help even this may cause their failure on the task. This avoidance may arise from students' perceived costs of help-seeking. On the other hand, perceived benefits of help-seeking may result students' intention to seek help. Help-seeking goal orientation gives information about why the students seek help, to increase their autonomous or to finish the task as quick as possible. Students' determination of helper is another strategy. Wolters et al. (1993) explains this strategy in two demotions as formal sources like teachers, and informal sources like students and peers in the class. Students' perception of teacher support is another important factor for their help-seeking behavior.

Considering aforementioned literature, current study aims to examine student self-regulation based on Pintrich's model of self-regulation. Accordingly, current study focuses on the strategies used by the students for regulation of cognition, motivation, behavior, and context. More specifically, within the regulation of cognition area, students' use of rehearsal, elaboration, organization strategies as well as their critical thinking and metacognitive self-regulation will be explored. Concerning regulation of motivation, students' goal orientations, self-efficacy, and task value will be investigated. Regarding regulation of behavior and context, students' time and study environment management, effort regulation, peer learning and help-seeking strategies will be a focus of this research.

Among the regulation of cognition strategies, rehearsal strategies include repeating the information over and over to recall or reading aloud the name of important items in a text. Highlighting or underlining the sentences that appeared to be necessary to learn is another rehearsal strategy. These strategies provide the learning of simple tasks and working of item in short-term memories, but not effective to structure a deep level of processing and to acquire new information in long-term memory. Elaboration strategies involve restructuring the information to learn such as; paraphrasing, note-taking, creating analogies, and express the ideas in the materials in own words. These kinds of strategies are effective to promote internal connections between the items learned and to acquire the information in long-term memory. Organization is another type of deeper processing strategy that comprises clustering, outlining, selecting the main idea from text, and mapping the interactions between the ideas. These strategies provide discernment of appropriate information and interrelation among the information to be learned. Critical thinking strategy refers to learners' ability to apply acquired information in a new situation to solve a problem or to make a decision. The strategy also includes reflecting critical evaluations to ideas. Metacognitive self-regulation refers to regulation of cognition through controlling the process and ensuring the goals has been achieved. The strategies include planning or goal setting, monitoring and regulating (Pintrich, 1999; Pintrich et al., 1991; Pintrich et al., 1993; Pintrich & De Groot, 1990).

Regulation of behavior and context strategies concerns the regulation and control of environment. Time and study environment is related with adjusting study time by scheduling and planning as well as arranging the study environment well organized and free from distractors. Effort regulation is about the control of attempt and attention on the task in addition to persistence on a difficult or boring task. Peer learning strategy involves studying with others or a group of people to learn the materials. Finally, help-seeking strategy is seeking the assistance of others (eg. peers or teacher) to acquire the information.

In the present study, the abovementioned self-regulation strategies were determined through the administration of Motivated Strategies for Learning Questionnaire (MSLQ) which developed by Pintrich, Smith, Garcia & McKeachie (1993). The questionnaire covers the strategies under two essential sections; motivation section and learning strategies section. Motivation section covers the strategies related with the variables of regulation of motivation while learning strategy section includes the variables of regulation of cognition, behavior and context. More specifically, motivation section composed of six subscales which are Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy, and Test Anxiety. On the other hand, learning strategy section of MSLQ includes nine subscales namely; Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment Management, Effort Regulation, Peer Learning, and Help Seeking.

A self-regulated learner uses these strategies effectively in the learning process. However, students also need to be motivated to achieve learning to exert effort in a task while using these strategies (Paris & Paris, 2001; Sungur, 2007). Within the regulation of motivation area, the motivational constructs investigated in this study are divided into three self-regulatory components as; *expectancy component* (beliefs about own ability to perform a task), *value component* (goals and beliefs in the importance and utility of the task), and *affective component* (feelings and emotional reactions to the task) (Pintrich et al., 1990; Pintrich et al., 1993). Expectancy related constructs are *self-efficacy* and *control of learning belief*s. Self-efficacy refers to beliefs in terms of existing ability to accomplish a task. This component is highly related with others since stronger efficacy beliefs promote the effort and persistence towards the task (Pintrich & Shunk, 2002; Linnenbirnk & Pintrich, 2003). Control of learning beliefs is known as the beliefs related the consequences of efforts employed to learn. Thus, it involves the belief that one's own effort makes a difference in learning and outcomes depend on individual's own effort. Value component covers *intrinsic* and *extrinsic goal orientations* and *task value*. Goal orientation is perception of reason to engage in a task. Intrinsic goal orientation is pursued when the learner set the aim of task engagement to acquire the information, to understand the material, or to satisfy the need for curiosity. Extrinsic goal orientation, on the other hand, is attempted when the learner perceives the purpose in the tasks as receiving a good grade, reward, or compliment. Task value is known as the perception of task in terms of interest, importance, and utility. It has four components as intrinsic interest, utility, importance, and cost (Eccles & Wigfield, 1995). Finally, the affective component is *test anxiety*, which related to students' worry and concern to take an exam (Pintrich et al., 1990; Pintrich et al., 1993). Following part presents the review of empirical studies concerning the mentioned components.

2.4.2 Research on Self-Regulation

In the literature there are various studies that reveal the interrelation between the self-regulatory components mentioned in previous part in addition to their relative influence on academic performance. The studies show that all four areas of self-regulation (i.e. cognition, motivation, behavior, and context) are highly associated with achievement related outcomes. Relevant research also documented significant relationships among these four areas. For example, Pintrich (1999) reported that student motivation is significantly linked to the use of self-regulatory strategies involving regulation of cognition, behavior, and context. Similarly, in an extensive studies conducted by Pintrich and his colleagues (Pintrich, 1989; Pintrich & De Groot, 1990; Pintrich & Garcia, 1991), the results revealed that students' self-efficacy and task-value beliefs were strongly and positively related to cognitive aspect of self-regulation. More specifically, according to the results, students perceiving higher self-efficacy and interest towards task reported using all types of cognitive strategies (eg. rehearsal, elaboration, and organizational strategies) and metacognitive strategies (eg. planning, monitoring, and regulating) and indicated higher academic performance. Considering the goal orientation, the author reported positive relations between mastery goals and cognitive strategies as well as metacognitive strategies. On the other hand, a negative relation of extrinsic goals to metacognitive strategy use and performance was found.

More recently, Yumusak, Sungur and Cakiroglu (2007) studied the contribution of motivational beliefs, cognitive and metacognitive strategy use to high school students' achievement in biology. For this purpose, 519 tenth grade students were surveyed using the Motivated Strategies for Learning Questionnaire (Pintrich et al., 1991) and biology achievement test developed by the researchers. The results indicated that 10% of variance in the students' biology achievement was explained by motivational variables. Moreover, higher levels of intrinsic goal orientation, task value and self-efficacy beliefs were related with higher cognitive and metacognitive strategy use. In addition, a positive association was reported between achievement and organization strategy use as well as time and study environment management.

Classroom environment has a significant role in students' self-regulation (Pintrich, 2005; Meyer & Turner, 2002). Paris and Paris (2001) proposed that promoting self-regulation is possible in a classroom that allow students to be autonomous, to seek challenges, to reflect on their own progress, and to take responsibility and pride in their accomplishments. The authors also suggested the teachers should develop open-ended instructional activities and guide collaborative work instead of workbook exercises and routine tasks. The evaluation should involve performance-based assessments rather than objective tests in order to motivate students and improve their self-monitoring skills. Similarly, according to Corte, Verschaffel and Masui (2004), the necessary factors in a classroom to foster self-regulation include social interaction, active participation and construction of knowledge, and enabling the transfer of knowledge in authentic situations. Empirical studies also stressed the association between perceived learning environment and self-regulation

For example, the study conducted by Eshel and Kohavi (2003) aimed to determine the impact of classroom environment on 302 sixth grade students' use of self-regulated learning strategies. Student-Decision-Making Scale was conducted to determine shared authority in the class by students and teachers. Students' cognitive strategies, intrinsic value, self-efficacy, self-efficacy for self-regulated learning and self-efficacy for academic domains were measured by various scales. Additionally, students' mathematics achievement was determined by the Israeli Center for Educational Technology Test. The analysis provided that self-efficacy, self-efficacy for self-regulated learning and self-efficacy for academic domains, self-regulated learning strategies, intrinsic motivation, and cognitive strategies were positively related with students' mathematics achievement. Moreover, self-regulated learning strategies appeared to be associated with students' perception of classroom control, which in turn had a positive effect on students' mathematic achievement. It was found that students' self-regulatory strategies are lower when the perception of own control in the class is same with the control exerted by the teacher as well as when high control emphasized by teacher. These strategies were found to be higher when students' view of their control was also high in the learning environment.

Another study that focuses on the learning context and self-regulated learning was conducted by Grinsven and Tillema (2006). The researchers compared effectiveness of different instructional formats on vocational education in terms of students' motivation and self-regulated strategies. Instructional formats conducted in this study were traditional education, open learning center, which requires individual working, independent group work, problem-oriented learning and project-based learning. The findings revealed that students' perception of their learning environment affects self-regulation strategies. Among all instructional formats, problem-oriented learning was mostly powerful learning environments for self-regulation strategies since it enhance autonomy of students.

Similarly, in the comparative study of Stright and Supplee (2002), 3rd grade students' (mean age= 8.6 years) self-regulatory behaviors in different learning environments; teacher directed, seat-work and small group was examined. The results of the study showed a relationship between classroom context and self-regulatory behaviors. In small-group work and seat-work designed classes, students were more self-regulated learners since they were more likely to monitor their progress and ask for help.

These studies show how the learning environment influences students' motivational beliefs and learning strategy use as components of self-regulation. There is also extensive research in the area specifically points out the influence of perceived goal structures in learning environment on students' cognitive and motivational aspects of self-regulation such as metacognitive strategy use, self-efficacy, and especially their own goal orientations (Anderman & Young, 1994; Kaplan & Maehr, 1999; Anderman & Anderman; 1999). For example, Wolters (2004) examined the relation of junior high school students' own goal orientation and their perceived classroom goals. In the study, 525 students were administered by related items and subscales of questionnaires developed by Midgley et al. (1998) and Pintrich et al. (1993). The results showed students' perceptions of goals with respect to their classroom directly and indirectly affects their adapted goals, motivation, cognitive and metacognitive strategy use, and mathematic achievement. Students perceived mastery goals in mathematic classrooms appeared to have persistence on the task engagement, put forth effort to complete, motivation to take more classes in math, and more likely to adopt mastery goals for themselves. On the other hand, students perceived performance-approach structure in their classrooms reported low persistence on the task, delay on start to study on math, give up quickly when the task difficult, not voluntary taking math class in the future, and more likely to adopt performance-oriented goals for themselves. Moreover, both of the perceptions were positively related with cognitive and metacognitive strategy use. However, the findings indicated students emphasizing their classroom as mastery goal oriented and also adopting mastery goals for themselves were more tended to report the use of cognitive and metacognitive strategy use. Respecting academic performance in the class, mastery structure perception was a positive and strong predictor while performance-approach orientation and self-efficacy of students were accounted for a significant portion of variance in the achievement scores of students. Efforts of students in the class were explained by the interaction between mastery structure and mastery orientation and the interaction between performance-approach structure and mastery orientation. That is, students who perceived mastery structures in class and mostly adapted mastery goals were reported higher effort in the learning. On the other hand, students in a classroom emphasizing performance-approach goals and adapting mastery goals for themselves were more likely to report lower levels of effort. Another interactional relationship explained for metacognitive strategy use. Students who both viewed their classroom as mastery goal structured and adopted mastery goals were appeared to use higher levels of metacognitive strategies. However, students perceived their classroom as stressing performance-approach goals and tend to adopt performance-avoidance goals for themselves reported lower levels of metacognitive strategy use.

In line with the presented results, the study carried out by Tas (2008) demonstrated that 7^{th} grade students more tended to adapt mastery goals in a learning environment stressing understanding of science materials and self-improvement of students. On the other hand, they tended to adapt performance-approach goals in learning environments focusing on performance and relative ability of students.

Focusing the associations between the cognitional, motivational, behavioral and contextual strategies of self-regulation and their relative influence of academic performance in the classroom settings brings us the importance of usage and improvement of these strategies. The studies suggest the effective learning environments and approaches to foster students' self-regulation. In the frame of the featured learning environments, following part explains promoting self-regulation through the learning cycle instruction.

2.4.3 Promoting Self-Regulation by Learning Cycle

Epstein (as cited in Pintrich & Shunk, 2002, p.232) identified six dimensions of classroom to concern during the design of a climate in order to support and develop student motivation. These are listed as task, authority, recognition, grouping, evaluation, and time. Task dimension is related with the design of learning activities and assignments which are suggested to be interesting, meaningful, and supportive for personal relevance, avoiding social comparability, and offering an optimum level of challenge for students. Authority dimension concerns the degree of perceived leadership roles, the sense of independence and control in the classroom. Epstein proposes to give students opportunities that they can make choices in the class such as deciding the time period of an assignment or how a task will be accomplished. Recognition involves providing the informational feedbacks with respect to their progress or the competence including formal and informal rewards, incentives and praise. This provides recognition of students' effort, development and accomplishments by not only teacher but also students. Grouping relates to the working effectively with others and suggests small group works in class to develop students' responsibility, shared success, and self-efficacy. Evaluation dimension focuses on the methods that employed to monitor and assess student learning. Considering the assessment, it was advised to evaluate individual progress and mastery, to give students opportunities to improve their work, to apply various assessment methods, and to evaluate students privately instead of public announcements. Finally, time dimension concerns the design of task in terms of optimization of workload, the pace of instruction, and the time allotted for completing work.

Considering the defined characteristics of a learning environment to foster students' self-regulation in the previous chapter and the six dimensions generated by

Epstein, the learning cycle model seems sensible to offer as an effective learning climate in class. The preliminary phases of learning cycle intend to capture students' attention, to raise their curiosity and interest, and to engage them in real life situations. These kinds of tasks are suggested to develop mastery goals and task value in students (Pintrich & Shunk, 2002). In the study conducted by Boddy et al. (2003), students expressed learning through learning cycle as funny and interesting and they perceive themselves as motivated to learn.

The center phases of learning cycle provide active participation of students. Atay and Tekkaya (2008) express the learning cycle reflects scientific inquiry processes, facilitate students to become active participants as they construct own understanding of scientific concepts. The researchers added that in learning cycle, students are encouraged to realize the links among concepts explicitly and connect newly learned concepts with the previously acquired ones. These phases provide opportunity to implement and develop various self-regulatory strategies. Actually, Odom and Kelly (2001) point out that learning cycle promotes self-regulation and knowledge construction through providing opportunities that allow students to explore their belief systems and to conduct argumentation, prediction, and hypothesis testing. During their learning cycle process, students take the responsibility of their own learning, feel the autonomy, monitor and control over their progress, generate questions and hypotheses, express their ideas and acquire scientific vocabulary from the teacher. In such environment, students had opportunity to use elaboration and organizational strategies, to feel control of learning beliefs, to reflect critical thinking and to develop metacognitive self-regulatory strategies. That is, the middle phases promise improvement in many motivational contracts and learning strategies (Schunk, 1991). The hands-on activities presented in the exploration and explanation phases may lead to positive motivational outcomes such as task value and self-efficacy (Renner, Abraham & Birnie, 1985; Thompson & Soyibo, 2002). Moreover, exploration phase help the students to figure out the answers which in turn provides motivation for students to complete the activity well (Wilder & Shuttleworth, 2004). This phase may be effective to develop control of learning beliefs of students and increase the persistence on to task. Engagement of students in the activities collaboratively or individually and the facilitator/assistance role of teacher are also effective on students' strategy use, and motivation (Slavin, 1996). What is more, discussion among students, like performed at explanation phase, is an effective technique to motivate all students (Klosterman & Gorman, 1990). Elaboration phase helps motivate students to find correct answers rather than convenient answers (Wilder & Shuttleworth, 2004) which let them to develop adaptive help-seeking and peer learning skills. Although the self-efficacy may be repressed due to awareness of shortage in existing knowledge in exploration phase in addition to the conflicts emerge in the discussion during the exploration and explanation phases, the whole processes of learning cycle is promising to develop self-efficacy beliefs and effort regulation. Indeed, students' self-efficacy beliefs can be developed in a classroom in which they engage in challenging activities, and experience successful outcomes (Pintrich & Shunk, 2002; Pintrich & Linnenbrink, 2003). That is, higher experience of accomplishment brings high efficacious individuals (Ward & Lee, 2006). Additionally, small group work conducted during the learning cycle phases may enhance even the low achiever students' self-efficacy (Pintrich & Shunk, 2002).

Concluding phases of learning cycle provides transfer of knowledge in new situations and self-evaluation of the understanding. Application of knowledge in new situations let the students to monitor their understanding and manage the necessary changes in their ideas. Karplus (1977) states that these phases support self-regulation of students especially whose conceptual reorganization occurs more slowly or who failed to relate the teachers' explanations to their experiences. Moreover, in learning cycle, students are encouraged to question their own conceptions (Boddy et al., 2003) which provide self-evaluation of the process, knowledge and effort. Teacher is also responsible to observe the development of students among all phases and provide the necessary feedbacks. Meanwhile, there is some research showing the positive impact of learning cycle on students' motivational constructs and learning strategy use.

As an example, Ceylan (2008) investigated and compared the development of self-regulation of 10th grade students receiving 5E learning cycle instruction and traditionally designed teacher-textbook based instruction. The participants of the study were 119 students from two intact classes. The classes were assigned as experimental and comparison groups to receive the comparable teaching methods. Both groups were instructed same concept by the same chemistry teacher. All students were administered Motivational Strategies for Learning Questionnaire (MSLQ) twice; before and after the interventions. The findings of the study revealed a statistically significant mean difference between groups with respect to their intrinsic goal orientation, extrinsic goal orientation, and task value. Students receiving the learning cycle reported higher attempts to set intrinsic and extrinsic goals as well as higher perception of the course as interesting, important, and useful. On the other hand, no significant difference was found between groups with respect to other motivational components such as control of learning beliefs, self-efficacy, and test anxiety. Related with learning strategy use, the author reported significant mean difference between experimental and comparison groups with respect to elaboration and organizations strategy use. Students in the learning cycle class tend to use elaboration and organization learning strategies compared the other group students. Nevertheless, there was no significant difference between two groups with respect to their perceptions of using strategies such as rehearsal, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, peer learning, and help-seeking.

A similar study conducted by Saygin (2009) indicated that compared to traditional instruction, three-phased learning cycle instruction improved high school students' conceptual understanding in nucleic acids and proteins subject as well as their intrinsic goal orientation, control beliefs and learning, self-efficacy, metacognitive self-regulation and help seeking. Wilder and Shuttleworth (2004) also explained teaching cell subject through 5E learning cycle model increases student motivation. In a study carried out by Aydemir (2012) significant differences in motivation and learning strategy use was emerged between high school students who instructed chemistry concepts through two comparable instruction; learning cycle and traditional instruction. Students who acquired 5E learning cycle instruction appeared to report higher intrinsic goal orientation, task value, and self-efficacy in addition to lower extrinsic goal orientation compared to students taught by traditional instruction. Students in learning cycle classes perceived themselves using more strategies than comparison group such as rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment, and peer learning.

Overall, considering abovementioned studies, it can be concluded that the self-regulated learning is an important construct that influence students learning outcomes. In order to facilitate students' motivation and learning strategy use for practicing self-regulation, active participation and perceived anatomy of students are prerequisite in the learning environments. Previous research demonstrated the learning cycle is effective teaching method to promote in students motivational constructs and learning strategy use. Therefore, in this current study, 7E learning cycle model has been investigated as an instructional approach to foster students' self-regulation.

2.5 Scientific Epistemological Beliefs

In this part, firstly the scientific epistemological beliefs and pioneering studies were reviewed in terms of multidimensional model of personal epistemology. Afterwards, the research conducted to explain the students' ideas on knowledge and knowing and the nature of development and change in epistemological beliefs were summarized. In addition, the literature in learning environment that supports and develops sophisticated beliefs regarding science was outlined to propose learning cycle as an effective teaching strategy in this respect.

2.5.1 Epistemological Beliefs Within a Theoretical Perspective

Epistemological beliefs are the theories people hold about knowing and nature of knowledge (Hofer, 2000). Driven from the work of Perry (1968) on explanation of the students' views toward knowledge, the topic has been studied for a long time in classroom context. Perry investigated how college students interpreted pluralistic educational experience and showed that they hold various perspectives towards knowledge and learning. In this longitudinal study, the interviews with male college students revealed their perspective of knowledge change from dualistic thinker to realistic thinker across grade level (Hofer, 2000; Buehl & Alexander, 2001). In later years, various studies and models proposing epistemology as one dimensional construct were generated by the influence of this study (Hofer & Pintrich, 1997). For example, distinctive from the male sample of Perry, females' interpretation over their educational experiences was studied by Belenky, Clinchy, Goldberg, and Traule (as cited in Hofer & Pintrich, 1997). Their study indicated 'women's ways of knowing' in terms of truth, knowledge, and authority. Their model consist the five developmental path of women's' view ranging from silence (experience such as passive, voiceless, receiving from authority) to constructed knowledge (experience such as knower is an intimate part of knowing to construct knowledge). Considering both gender and setting a gender-related comparison in knowledge perspective, Baxter Magolda's study (as cited in Buehl, 2003) generated four ways of knowing (i.e. absolute, transitional, independent, contextual) varying from relying on authorities for certain knowledge to judging the knowledge on the basis of contextual evidence. In each ways of knowing, the individuals' reasoning corresponded to distinctive reasoning patterns influenced by their gender (e.g. in absolute knowing; receiving reasoning is mostly adopted by females while mastery reasoning was mostly adopted by males) (Hofer & Pintrich, 1997). In contradistinction to previous studies, Kitchener and King (1981), argued the influence of ways that the individual understand knowledge and knowing (under the name of epistemological conception) on individuals' reflective judgment towards knowledge. To develop this idea, a sample of over 1700 students were interviewed with respect to their conception of knowledge, knowing, as well as justification and reasoning of their ideas towards the information in the ill-structured problems that they may face with in daily life. On the basis of their longitudinal studies over fifteen years, they developed a reflective judgment model composed of seven stages. The stages were categorized in three levels as pre-reflective, quasi-reflective and reflective which refer to the continuum from concrete knowledge and no need for justification to the existence of multiple truths and need for judgment based on context (Hofer & Pintrich, 1997).

Contrary to the previously mentioned models focusing on unidimensional nature of epistemological beliefs and the argumentations of fixed developmental stages, Shommer (1990) proposed the multidimensional model of epistemological beliefs as a system including five independent dimensions for the epistemological beliefs; *structure* (knowledge is isolated or integrated), *certainty* (tentative or unchanging), *source of knowledge* (authority or own observation and reasoning), *control* (fixed or improvable) and *speed* (quick or gradual). She hypothesized that students' beliefs about knowledge and knowing may range from naïve to sophisticated epistemological beliefs and this range is less or more independent for each dimension. That is, students may hold naive beliefs about one dimension while holding sophisticated beliefs in another. However, she also mentioned the influence of the dimensions between each other. She developed a likert scale based on these dimensions and four factors (except for source) emerged on the exploratory factor analysis on data collected from college students. Her study showed that the dimensions of the epistemological beliefs are related with students' academic performances. For instance, students who hold naïve ideas about speed of learning appeared to have lower understanding on the texts. This factor structure has been replicated in other studies (Dunkle, Schraw, & Bendixen; Jehng, Johnson & Anderson, as cited in Schommer-Aikins 2002). Schomer (1993) has also replicated her study with 1000 high school students and reported that the more students believe in the structure of knowledge is certain and has an isolated structure, the more poorly they report in academic performance and GPA. Finally, in her later study, Shommer-Aikins, (2002) reported her 30-items Epistemological Belief Scale and defined four factor structures as Ability to Learn, Speed of Learning, Stability of Knowledge, and Structure of Knowledge. Students may have an opinion about ability to learn as it is fixed at the birth or it can be changed and improved. They may think that knowledge acquisition is a simple and quick process or it takes time and effort since it is complex. They may believe knowledge is absolute and certain or knowledge is tentative. They hold ideas about knowledge as it is organized as isolated bits and pieces or it is organized as highly interwoven concepts.

However, in their review study, Hofer and Pintrich (1997) criticized that control and speed dimensions are not related with nature of knowledge but about learning. They argued that students' scientific epistemological beliefs can be dimensioned as students' views on the purpose of science, sources of scientific knowledge, role of evidence and experiments, changeability of knowledge in science, and coherence of scientific knowledge (Elder, 1999; Hofer & Pintrich, 1997; Hofer, 2000). These constructs were explained as follows: Students hold ideas about the *purpose of science* as to explain how things work or to discover and to invent things. Related with the *source of knowledge*, they may believe knowledge resides in either own thinking and reasoning or external authority. Students may realize the relationship between *theory and evidence* or they fail to comprehend that the evidence derived from *experiments* lead to create or verify the theories. Students either believe *tentative and changeable* nature of scientific knowledge or believe the knowledge is stable and certain. With respect to *coherence of scientific knowledge*, students regard science as a body of knowledge of interrelated concepts or a collection of separate pieces of knowledge. Based on these arguments they proposed four dimensions namely; certainty of knowledge (stability), simplicity of knowledge (structure), source of knowing (authority), and justification for knowing (evaluation of knowledge claims). Parallel with the ideas and dimensions of them, Conley, Pintrich, Vekiri, and Harrison (2004) developed a questionnaire to measure student epistemological beliefs. The measure includes 26 likert-type items based on four dimensions, namely Source, Certainty, Development and Justification. Source of knowledge is related with the origin of the knowledge. Students hold a belief about the knowledge derived from either authority or personal observation and reasoning. Certainty is about the belief on a right answer. They may believe there is an absolute truth and there is only one right answer in science or existence of multiple truth and complexity of knowledge. Development is in the changing nature of science. They may have beliefs about science as a concrete or evolving and changing subject.

Justification measures students' views on role of the experiments and how individuals evaluate knowledge claims. Distinctive from the other scales implemented in adults, this instrument was developed for younger students and suggested as a reliable and valid instrument by various studies (Conley et al., 2004; Kizilgunes, Tekkaya, Sungur, 2009). In the present study, students' epistemological beliefs were measured by the administration of Conley's Epistemological Beliefs Questionnaire in the reason of grade level and reliability appropriateness.

To sum up, epistemological beliefs are defined as the views towards nature of knowledge and knowing. Originating from the work of Perry, the epistemological beliefs were defined by psychologist through many theories and investigated by researchers. Especially recent studies consider the epistemological beliefs as a belief system includes more or less independent beliefs that not possess a coherent developmental structure. The conducted studies in line with this multidimensional beliefs theory will be reviewed under the following heading.

2.5.2 Research on Epistemological Beliefs

Empirical studies on epistemological beliefs in science have been conducted through both qualitative (Perry, 1970; Lee, 2010) and quantitative approaches (Shommer-Aikins, 2002; Conley et al., 2004; Hofer, 2000) in order to describe students' epistemological beliefs. The importance of rising sophisticated ideas over knowledge and knowing becomes clearer with the review of the studies reflecting the association of epistemological beliefs with other learning outcomes. Students' beliefs about knowledge are likely to influence their academic performance (Schommer & Walker, 1997; Cano, 2005; Hofer, 2000), how they approach to learning (Chan, 2003; Cano, 2005; Ozkal, 2007), what they expect from their learning in classroom (Kizilgunes et al., 2009; Phan, 2008), and the strategies that they use in the learning process (Dahl, Bals & Turi, 2005). The studies drawing the interrelation of these variables as well as the change in beliefs according to development, gender, socioeconomic status, and experienced instruction were reviewed in the following parts.

Considering the elementary students' epistemological beliefs, Elder (1999) investigated 5th grade students' beliefs about nature of scientific knowledge and their relation to science learning. Students participated in inquiry-based, hands-on science program which involved students to conduct experiments in group, construct their own knowledge and generate questions during the science instructions. A total of 211 students' ideas were taken through open-ended questions and a 25-item questionnaire with respect to purpose of science, sources of scientific knowledge for scientists and for themselves, roles of evidence and experiments, changing nature of knowledge in science, and coherence of a scientific knowledge base. Most of the students appeared to hold naïve beliefs about purpose of scientific works such as; developing medicines, conducting the experiments and activities rather than explaining the scientific phenomena or discover how things work. Moreover, they thought that scientific work and thinking conducted by themselves and real scientists were different: They tend to believe that their ideas are generated from passive sources (e.g. teachers, books) while the scientists' ideas are generated by active endeavors (from thinking and wondering) in addition to passive sources. Regarding the other dimensions, students tend to view scientific knowledge as a developing, changing construct that is generated by reasoning and testing. In the same study, Elder also investigated the links between epistemological beliefs and science learning of students in elementary grades. For this purpose, 194 5th grade students enrolled in 6 intact classes were surveyed with revised version of previously stated open-ended questions composed of four scales; Authority, Certainty, Developing, and Reasoning. Students' learning was measured with regular test that used by schools in same distinct and performance assessments towards two units. Students were instructed about Powders (chemical properties) unit for 9 weeks and Circuits (electricity) units for following 9 weeks based on inquiry model of learning in which they participated in a guided set of hands-on activities and experiments. In the course of the study, a repeated instrumentation process was conducted that students' epistemological beliefs measured in 3^{rd} week of each 9 weeks and immediately after the 9^{th} week. The results of the study revealed that students' epistemological beliefs are modestly related with their learning in circuit topic but not in powders topic. In addition to giving idea about task dependence for the relation, the study also revealed the effect of students' epistemological beliefs on learning indicating that holding more sophisticated beliefs results in better learning.

Other studies focusing on the relationship between epistemological beliefs and general or course specific academic achievement showed significant associations of some dimensions of epistemological beliefs with achievement. For example, Schommer and Walker (1997) found out that the students who hold naïve believes in Quick Learning obtained higher GPA in college which means students holding less beliefs like the knowledge can be learned quickly reported higher grades. They described similar results for middle school students indicating the less students believed in quick learning together with fixed ability, the better GPA they achieved (Schommer-Aikins, Mau, Brookhart & Hutter, 2000). In another study, Cano (2005) reported that the students who believed in quick learning and simple knowledge had poor academic performance in secondary grades. Similarly, Paulsen and Wells (1998) indicated that students with sophisticated beliefs in simple knowledge reported higher GPA compared to ones with naïve beliefs. A comparable result was reported by Hofer (2000) suggesting a negative link between students' GPA and beliefs in Simple and Certain knowledge reflecting the more students believe in the simple knowledge and existence of absolute truth, the lower they achieve in the academic performance. Similar with this, in another investigation Ozkan (2008) explained that the more sophisticated beliefs the students endorsed about the existence of more than one right answer that can be constructed by the individual, the better achievement they get in science classes. The study conducted by Conley et al. (2004) also revealed significant and positive relationships between achievement and epistemological belief dimensions of Source, Certainty, Justification, and Development indicating that the higher sophisticated beliefs in students were related with better achievement in science class.

However, as pointed out by Schraw (2001), the more sophisticated epistemological beliefs the students have, the more thinking and problem-solving skills they employ which may imply the improvement in achievement. For that reason, the influence of epistemological beliefs on academic performance was also investigated including its relative influence on other outcome variables such as, learning approach, motivation and learning strategies. In this manner, the study of Chan (2003) confirms that the college students adopt more surface learning approaches such as rote memorization when they believe the ability is fixed, the source of knowledge is authorities, and the knowledge is a certain subject. On the other hand, they tend to use deeper approaches when they believe the ability is not fixed in the birth but requires effort to learn and the knowledge is not always a subject to arise from the authorities. Similarly, Cano (2005) revealed that the more students believe the knowledge is quick and learning is independent from effort the more they adopt surface learning approaches which in turn negatively affect the academic achievement. Ozkal (2007), also reported same results but in different direction. She stated students with rote learning approach are more likely to endorse the fixed views of epistemological beliefs while the others with meaningful learning approach are more to have tentative views.

The interrelationships among various variables were investigated by Kizilgunes et al. (2009), in terms of elementary students' epistemological beliefs, self-efficacy, goal orientation, learning approach, and achievement. The employed path model indicated significant and positive associations between certainty, development and justification of knowledge, learning approaches, and science achievement. Students' epistemological beliefs were found to be linked to learning approach both directly and indirectly through their influence on achievement motivation. In general, results revealed that holding more tentative beliefs leads to meaningful learning approach. In terms of motivational variables, the study showed that students who hold beliefs as knowledge is an evolving subject but sourced from authority were tend to have higher self-efficacy and adopt higher levels of learning and performance goal orientations. Students' belief on the fixed ability was also associated with their motivation. In the study it appeared that students who hold belief on ability is not fixed but improvable had more adaptive motivational beliefs which in turn positively related with achievement.

In another investigation, Ozkan (2008) explained that the stronger beliefs in the existence of more than one right answer that can be constructed by the individual results in avoiding rote learning approaches. Moreover, students' beliefs in the necessity of experiments and evidences in knowledge construction were discovered to be associated positively with meaningful learning approach and negatively with rote learning approach. However, her study did not confirm the relationship between epistemological beliefs and self-regulation strategies which is similar with the results reported by Neber and Schommer-Aikins (2002). On the contrary, the study of Dahl, Bals and Turi (2005) showed significant associations between undergraduate students' epistemological beliefs and self-regulated learning strategies. Specifically, the students who hold naïve beliefs in simple knowledge were less likely to use rehearsal, organization and meta-cognitive self-regulation strategies while students who hold again naïve beliefs in fixed ability were less likely to use elaboration, critical thinking and, metacognitive self-regulation strategies. Paulsen and Feldman (2007) also found that students holding naïve beliefs in the ability is fixed at birth and cannot be improved have a negative influence on their engagement in cognitive strategies of rehearsal, organization, elaboration and metacognition. Considering the naïve beliefs in simple knowledge, Paulsen and Feldman found a positive link with elaboration strategy use as well as negative link with rehearsal strategy use. In addition, Braten and Stromso (2004), carried out a study to investigate the influence of epistemological beliefs on college students goal orientations. Their study emphasized that students are less likely to adopt mastery goal approach when they believe learning occurs quickly and knowledge is stable and relies on external sources.

In conclusion, the above mentioned studies evidence that sophisticated scientific epistemological beliefs are significantly related with achievement, and cognitive and metacognitive outcomes in the classrooms. Therefore, it leads a recommendation to the educational researchers and teachers that instructional strategies and classroom activities should be developed and incorporated into lessons in order to develop sophisticated beliefs toward scientific knowledge.

2.5.3 Promoting Epistemological Beliefs by Learning Cycle

Apart from the interrelation of epistemological beliefs with other learning outcomes the studies empirically substantiated that the epistemological beliefs changes over time (Conley et al., 2004; Schommer, 1993; Paulsen & Feldman, 2007). Most of the studies showed students' epistemological beliefs become more sophisticated in years (Schommer, Calvert, Gariglietti & Bajaj, 1997; Schommer, 1998; Cano, 2005). However, this change is not just developmental but also related with educational experiences in classroom settings (Schommer, 1998; Valanides & Angeli, 2005). The studies investigating the relative effect of different instructional methods on epistemological beliefs have found that the type of instruction that the students receive may impact their beliefs towards knowledge and knowing. For instance, Tsai (1999) reported a progress towards more sophisticated beliefs in high school students after receiving a Science-Technology-Society instruction providing them with inquiry, various sources to reach information, and student centered learning. Tsai also assigned a comparison group to instruct with traditional instruction that covers lecturing, practicing with examples, and textbook information. Results showed that students in the experimental groups had more sophisticated beliefs than the students in the comparison group. Similar results were reported by Brownlee, Purdie and Boulton-Lewis (2001): They designed a teaching program for pre-service teachers in order to foster the sophisticated beliefs which resulted in higher sophistication in Innate Ability and Omniscient Ability. Actually, Saunders et al, (1999) suggest that the teachers who not presents themselves as an authorities source of knowledge have the students to develop the idea that the source of scientific knowledge is students' themselves. What is more, it is possible to modify epistemological beliefs of students through collaborative work, and opportunities to reflect on their thinking and skills (Hofer, 2001; Southerland, Sinatra & Matthews, 2001). Following studies summarizes the studies empirically investigating the effect of instruction on epistemological belief development.

Saunders, Cavallo and Abraham (1999) investigated the relationships among college students' epistemological beliefs, gender, approaches to learning and type of instruction. The authors observed five teachers' chemistry laboratory instructions and categorized them in two patterns; less inquiry and more inquiry. In laboratories endorsing less inquiry, the teachers tended to give directions about how to design and perform the experiment, to give direct answers to questions of students, to tell the expected results of the experiment and how the interpretation of the result should be. On the contrary, in more inquiry laboratories, teachers' explanations were often concerning the use of equipment and safety and students' focus on the concept, the answers to students' questions were rather to encourage students to find answers on their own. Self-report data were collected from 232 students by several instruments. Students' learning approach was measured using a modified version of Learning Approach Questionnaire, consisting of rote and meaningful learning scales. Epistemological beliefs were determined by an adapted questionnaire based on the items of existing instruments measuring either the beliefs on epistemology of science is constructed and reasoned or it is received. Students experiences related with laboratory instructions were collected by three open-ended questions. The study investigated the relationships between the collective variables. Although the perception of students related with instruction indicated they mostly agree that they were generated scientific knowledge in laboratory, the quantitative results failed to reveal significant association between the type of instruction and epistemological beliefs. The authors stressed that it is difficult to influence students' beliefs with brief and recent experiences. Nevertheless, they discussed that teachers in less inquiry instructions may have oriented students to endorse the idea that knowledge transmitted to them rather than that gained through direct experiences. Moreover, the teachers' directions about the expected results and conclusions in favor of correct results may lead students to disbelieve their own experience. Considering the other associations, students' epistemological beliefs were significantly related with gender and students' rote learning but not with meaningful learning. Male students were tended to believe in the reasoned nature of knowledge while the females tended to believe in the received knowledge in science. Moreover, students believing the reasoned knowledge were more likely to use rote learning compared to students believing received knowledge.

In another study, Smith, Maclin, Houghton and Hennessey (2000) compared the epistemological beliefs of 6^{th} grade elementary students who were instructed science in constructivist classroom and traditional classroom. The participants of the study were 35 students from two demographically same classes. The study compared two classes from different schools and that instructed with different teachers. Students in the constructivist class were receiving science instructions from same teacher for 6 years based on active participation in learning, engagement in their own ideas, small-group work, whole-class discussions, and facilitator role of teacher. On the other hand, comparison group was instructed by same teacher for 5 years through lecture of teacher and reading assignments. Structured interviews were conducted with each individual student to investigate the impact of elementary science experiences on their epistemological beliefs. The study revealed the students in constructivist classroom developed more sophisticated epistemological beliefs compared to students in traditional classroom. They believed that science involved the development and transformation of ideas about how the world works in addition that the experiments are important both to clarify and test ideas. They also view collaboration is necessary in construct scientific knowledge. This study verified that students' may develop sophisticated beliefs towards scientific knowledge when they supported with the learning environment.

In a study carried out by Conley et al., (2004), the change in students' epistemological beliefs over time and the influence of gender, ethnicity, SES, achievement, and type of instruction was examined. The authors developed a questionnaire which was an adapted version of a scale that developed by Elder (2002). The measure includes 26 likert-type items and it is based on four dimensions, namely Source, Certainty, Development and Justification. The questionnaire was implemented to 187 5th grade students enrolled in five distinct schools. The sample included students from various ethnicity and SES. The questionnaire was implemented as pre-test and post-test; before and after the nine-week hands-on science instruction in chemical properties of substances topic. Students received an instruction emphasizing performing science investigation, data collection, making observations, interpreting the results, and drawing and justifying conclusions. The other variables were collected from the school records. The analysis of data revealed a significant relationship between students' achievement and epistemological beliefs indicating high achiever students were holding more sophisticated beliefs. Considering the change over time, t-test results indicated significant mean differences between students' beliefs regarding certainty, source, justification and development. The mean scores revealed the change toward more sophisticated beliefs. In the next analysis, the variables of achievement, gender, ethnicity and SES were attained as covariate in separated analyses. Accounting the covariates (especially the achievement and SES), the mean difference between pre-test and post-tests scores were no longer significant for development and justification dimensions but significant for source and certainty indicating more sophisticated beliefs. The study concluded the instruction that provide less reliance on authorities (eg. teacher, textbook) and emphasis doubts about the certainty of knowledge may develop more sophisticated beliefs in students. It was also argued that in order to develop sophisticated beliefs in justification and development dimensions, students need to allow argue about their ideas and reflect on their investigations. The study suggested more studies comparing the hands-on science classrooms with other traditional instructions as well as inquiry-based instructions to understand the effect of instruction on scientific epistemological beliefs.

Tolhurst (2007) examined the development of undergraduate students' epistemological beliefs in a course designed based on active learning through web-supported independent activities as well as small group workshops. The sample consisted of 418 freshmen students. Schommer's (1998) Epistemological Beliefs Questionnaire and Hofer's (2000) Discipline Focused Epistemological Beliefs

Questionnaire were administered before and after the course of instruction to determine students' epistemological beliefs. The intervention composed of two steps; one is the individual work conducted prior to attending the class, and the other is the group work takes place in the class. During the 14-week instruction, students received Information Systems course focusing on web-supported activities requiring the individual work of students on content-focused tasks and research information from various sources; which constitutes the first step. As the second step of the 14-week instruction, students attended to eight workshops in classes based on their independent activities. These workshops were conducted in class and encouraged small and whole group discussions, debates, student presentations and active learning. Students were expected to support their opinions and discussions from credible sources. Considering the dimensions of Schommers' questionnaire, the study found small but significant development of more sophisticated beliefs in simple knowledge and innate ability. After the instruction, students reported a trend to reduced beliefs on seeking only one right answer and increased beliefs on the possibility to learn how to learn. On the other hand, students belief about the learning occurs in the first instance, knowledge depends on authority, and not criticizing the authority were also increased which were not anticipated. The results related with the Hofer's scale were also consistent with the mentioned results. Students become more to believe in the authority as the source of knowledge, and less to believe that knowledge is simple and certain. The study also revealed the significant relationship between the epistemological beliefs and achievement. More specifically, students holding more complex epistemological beliefs were found to better achievement. The researcher concluded that influencing students' epistemological beliefs is possible, and specified the importance of exploring how to improve this potential through instruction.

A qualitative design was utilized in the study of Ogan-Bekiroglu and Sengul-Turgut (2012), investigating the effectiveness of constructivist learning physic instruction on students' epistemological belief development. Sample consisted of 15 male students enrolled in 9^{th} grade in an urban high school. The physics course designed based on constructivism were implemented to students through one semester. The data were collected by semi-structured interviews. Students were interviewed twice (i.e. before and after the instruction) in terms of their beliefs in simplicity of knowledge (knowledge is simple and composed of isolated bits / composed of highly interrelated concepts), certainty of knowledge (knowledge is certain and absolute / knowledge is uncertain and contextual), source of knowledge (authority / actively constructed) and justification of knowledge (knowledge needs no justification / judging evidence in context). Then the students were categorized as low, medium, high and very high for each dimension based on their responses. In first interviews, students reflected low and medium levels of epistemological beliefs in all dimensions which was expected by researcher since the students have been instructed science with traditional methods for years. After one semester period, levels of epistemological beliefs were appeared to be more sophisticated. None of the students reported low level in certainty beliefs while most of them reporting medium and high levels in all dimensions. The authors concluded that students' epistemological beliefs can change and be improved through constructivist learning experiences.

In a recently conducted study, Kaynar, Tekkaya and Cakiroglu (2009) compared the relative effect of 5E-learning cycle and traditional instruction on students' achievement and epistemological beliefs. Total of 153 middle school students in 6^{th} grade from four intact classes participated to the study. The study utilized quasi-experimental design. That is, already formed class were randomly assigned into two of experimental and comparison groups. During 3 weeks period of treatment, students in the experimental group were instructed cell concepts through 5E-learning cycle instruction while comparison group students were instructed the same subject via traditional instruction. Implementation of both instructions to all classes was done by the same teacher. In the course of study, students in experimental group received two separate 5E-learning cycle lessons in the content of cell and organelles together with transportation of materials. These lessons were specifically designed to attract and motivate the students about the engaged topic, to activate their prior knowledge and provide interrelation between the information, to observe, explore and gather the data in which they encouraged to give the meaning of observations on their own, to share their explanations in student-student and student-teacher discussions, and finally to interpret and evaluate their own learning in order to conduct necessary modifications. On the contrary, comparison group students was taught the same subject based on teacher-directed explanations, textbook readings, demonstrations and small discussions emerged from questions posed by the teacher. In order to measure students' achievement in related topic, the researchers developed The Cell Concept Test covering 15-multiple choice question. Additionally, Conley's (2004) 26-item Epistemological Beliefs Questionnaire was administered to students to determine their general scientific epistemological beliefs (instead of multidimensional beliefs). Students in both experimental and comparison groups were completed two instruments immediately before and after the instructions. MANCOVA and univariate ANOVA were performed to determine between and within groups differences statistically. Pretreatment measurement of achievement and scientific epistemological beliefs were used as covariates and a significant contribution of prior achievement was revealed. The results of the study implied a statistically significant mean difference between experimental and comparison group with respect to achievement and epistemological beliefs. More specifically, the students in the experimental group outperformed in their achievement scores and reported to hold more sophisticated beliefs than to the students in the comparison group. What is more, the results of the univariate ANOVA revealed a significant change in scientific epistemological beliefs towards the sophisticated ideas in only experimental group students. The study concluded students may reach a sound understanding of related concepts and come to have sophisticated epistemological beliefs when they are supported with appropriate science instructions.

In Turkey context, a research conducted by Boz, Aydemir and Aydemir (2011) provides valuable information to criticize the science instruction concerning its effect on the development of epistemological beliefs. The current curriculum of science education has a main aim of students to become scientifically literate regardless their individual differences (MoNE, 2006). In the definition of scientific literacy the curriculum mentions about the necessity of understanding towards nature of science and scientific knowledge as well as possession of essential science concepts and science process skills. Although the curriculum suggests developing students' epistemological beliefs, the study of Boz et al. (2011) revealed that students do not have a satisfactory understanding of science and knowledge. They studied with middle school students instructed through the current constructivist science curriculum to document the changes in their epistemological beliefs in terms of grade level and gender. For the specified purpose, the sample of 427 students from 4^{th}, 6^{th} and 8^{th} grades were administered Conley's Epistemological Beliefs Questionnaire. The dimensions of scale consisted of justification, development, and a combined dimension for source and certainty. The data were analyzed by conducting MANOVA and univariate ANOVA. The findings revealed statistically significant differences in students all epistemological beliefs dimensions with respect to grade level. Students' beliefs regarding source/certainty of knowledge appeared be naïve in all grades but significantly lower in 4^{th} grade. On the contrary to previous findings reporting the change from naïve toward sophisticated beliefs over years, the results of study presented a negative change on students' epistemological beliefs indicating a movement towards less sophisticated beliefs in development and justification of knowledge as the students continue through their elementary education program from 4^{th} grade to 8^{th} grade. Considering the gender difference, the significant mean differences were found concerning justification and source/certainty dimensions. Female students reported more sophisticated beliefs towards justification and less naïve beliefs towards source/certainty dimensions. Besides providing evidence to the independency of scientific epistemological beliefs, this study gives evidence to criticize the implementation of science curriculum in middle schools. Although the curriculum suggests constructivist instructions, the authors argued that teachers were probably not implementing the science lessons in a suggested way. As a possible reason of this, the lack of experience in teachers towards constructivist applications in classroom was suggested. Moreover, students' preparation for the national examination test that they take at the end of each grade was discussed as a possible cause to the decrease on epistemological beliefs scores. Since the test requires solving multiple-choice questions in a limited time it was discussed by authors as orienting students to memorize the information, the facts, and even the examples in the textbook and that given by teacher. In order to enhance sophisticated beliefs, inquiry-based or hands-on activities were suggested by the authors.

The study conducted by Boz et al. (2011) brings an idea to mind that the perception of students towards constructivist learning environment might be different from the one the teacher or the curriculum up to present. In this view, investigating the influence of students' perception towards constructivist learning environment on epistemological beliefs can be informative. In this matter, Ozkal et al. (2009) found out significant associations between students' constructivist learning environment perceptions (i.e. personal relevance, uncertainty, critical voice, shared control, and student negotiation) and epistemological beliefs (fixed and tentative). The data were collected from over 1000 8th grade elementary students via several self-report instruments. The results showed that students who perceive relevance of subjects in their class with the daily life tend to have both fixed and tentative beliefs. Moreover, the more students perceive the negotiation of information with peers, tolerance to state the concern of their learning, and uncertainty of science in their classroom environment the more that they endorsed tentative epistemological beliefs. However, a negative association was reported between perceived autonomy and control and tentative beliefs.

Overall, the studies with older and younger students generally revealed that the students' epistemological beliefs were highly effected by type of instruction they receive. Students may develop more sophisticated beliefs when they are supported with well-planned strategies based on their grade levels in classroom learning environment. In their review study, Qian and Alvermann (2000) summarized four approaches that promote mature (sophisticated) beliefs in line with conceptual change in students. First approach is *criss-crossing the landscape* referring to encourage students to examine the concept from various perspectives. It suggests teaching complex topics through different approaches and several sources such as multiple demonstrations and reading a refutation text and fostering students' ability to construct a complete picture related with the concept. Second approach is *engaging in reflective inquiry* which first attempts to have students to realize how they learn something and the source of their ideas and then attempts to active construction of deeper theoretical understanding in students' minds. Third approach is *using images of scientists' activities from history*, which involves use of the stories of well-known scientists in the past in order to promote the epistemological ideas in students. Last approach suggested by Qian and Alvermann *concerns teachers' epistemological objectives* which emphasizes independent thinking and challenging authoritative beliefs, promoting concepts and avoiding formulas, and promoting coherence over pieces. Application of these objectives in class as a part of lesson routine endorses students' epistemological beliefs.

Moreover, in their extensive summary of related literature review, King and Kitchener (2002) described the fundamentals of a learning environment to facilitate improvement in students' epistemological beliefs. Accordingly, it is suggested to design a learning environment that is respectful to students' assumptions and accommodates cognitive and emotional support to engage in challenging discussions, to deal with ill-structure problems, to analyze others' points of view and modify or defend own ideas in controversial, to gather data and evaluate the data sources, to make interpretive judgments, and to apply their reasoning skills in classroom and other settings. Similarly, Smith et al. (2000) suggested the instructional factors that appeared to support development of students' epistemological beliefs as authentic inquiry, generative problems, representing ideas in multiple ways, and collegial learning communities and metacognitive discourse. Considering all these features, constructivist learning strategies give opportunity to students to become active constructer of knowledge rather than being passive receiver while associating the knowledge with other information (Olgan-Bekiroglu & Sengul-Turgut, 2011). In such classes, students are encouraged to construct their own knowledge based on their own thinking, judgments and reasoning. When these suggested features of classroom environment to improve epistemological beliefs are considered, 7E learning cycle instruction appears to be a good candidate to be implemented in the classrooms. Indeed, in 7E learning cycle instruction, students are encouraged to pursue personal understanding through their own experiences while designing and conducting experiments, pursuing dialogue with peers, receiving and judging others ideas, hypothesis and conclusions, and justifying their own idea in probing discussions. The facilitator role of teacher in the class rather than posing the basis of authority and active participation of students in learning process might results in sophisticated constructions about the source of knowledge and less reliance on authorities. What is more, observing, exploring and experimenting the issues and realizing variety in conclusions or ideas between peers may lead students to realize that the knowledge is not certain but a subject to change. In learning cycle, students' prior knowledge is taken into consideration and activated in instruction. Emphasis is given on integration of knowledge in whole learning process. They are encouraged to gain knowledge driven from their own critical thinking.

Thus, 7E learning cycle instruction appears to be promising instructional method to develop more sophisticated epistemological beliefs. Learning Cycle enables to combine all above suggested approaches and strategies such as inquiry, hands-on activities, collaborative learning, constructing own knowledge from multiple sources, and sharing ideas in multiple ways as well as respecting and judging other ideas. Accordingly, 7E learning cycle instruction which participants of the current study experienced through human body systems concept is expected to improve students' epistemological beliefs and make their beliefs more sophisticated. In line with this expectation, the present study has focused on the examination of the effectiveness of 7E learning cycle instruction on students' epistemological beliefs in comparison to the curriculum driven instruction.

2.6 Science Process Skills

This part presents an explanation towards the science process skills, a review of the studies conducted about the development of science process skills, and the rationale for proposing learning cycle as an effective teaching strategy in this respect.

Ascribing the science learning as a process origins to the early 1960s (Gagne, 1963, 1965; Livermore, 1964). Labeling the "skills" to the science process, on the other hand, was articulated by a curriculum development project "Science-A Process Approach" (SAPA) in the US (AAAS, 1967). Science process skills are the steps that a scientist conducts during the experiments and problem solving. Adopting these skills to the instruction in class become necessary not only to enhance science learning but also to develop scientifically literate persons. Furthermore, there are a number of researchers that assume the science process skills as an inseparable part of the science education (Gerald Dillashaw & Okey, 1980; Roth & Roychoudhury, 1993; Harlen, 1999; Solano-Flores, 2000).

Science process skills are classified in two sub-categories, namely basic science process skills, and integrated science process skills (Shaw, 1983). The former includes "observing, measuring, inferring, predicting, classifying, and collecting and recording data" and the latter includes "interpreting data, controlling variables, defining operationally, formulating hypothesis, and experimenting" (Shaw, 1983, p.615). Additionally to the mentioned skills, Martin (1997) and Rezba, Sprague, McDonnough, and Matkins (2007) states communication as a basic science process skill and data collection, designing an experiment, processing data and formulating models are stated as integrated science process skills. Although, there are some changes between the classifications, the basic skills are always seen as the prerequisite to the integrated skills during the science learning process (Ewers, 2001). The integrated science process skills which are the interest of the study include identifying variables, identifying and stating hypothesis, operationally defining, designing investigations, and graphing and interpreting the data as defined by Okey et al. (1982). Identifying variables is related to ability of categorizing the variables of an experiment as manipulative, responding and controlled variable while identifying and stating hypothesis is up to stating the expected outcomes of the experiment. Additionnaly, operationally defining refers to explaining how to measure the variable of an experiment. Designing investigations involves desinging an experiment based on a given hypothesis which also requires identifying the variables as manipulative, responding and controlled. Finally, graphing and interpreting the data is about organizing data, identify the graph representing the related data and draw conclusions from graphs about the relationships between variable.

As mentioned before, there is an emphasis on the science process skills as an inseparable part of the science learning. Acquiring these skills not only provides to use those processes in science class but also retain them for future use (Padilla, 1990). Actually, the general aim of science educators and curriculum formatives is to develop conceptual understanding together with the necessary skills in students to become scientifically literate in their future life (AAAS, 1998; MoNE, 2006). Concerning the development of scientific literacy in students, a revision has undergone in the Turkish elementary science and technology curriculum in 2004. The new constructivist curriculums have been applied from the year of 2006 and adopted these skills in the science lessons. Accordingly, the main vision of the new curriculum is to educate each of students as a scientifically and technologically literate person irrespective of their individual differences (MoNE, 2006). In the curriculum, mastering the science process skills was described as a fundamental dimension of scientific literacy and described as thinking skills that scientists employ in the course of knowledge construction, inquiry on questions, and formulizing the solutions. The necessity of these skills was emphasized on raising students who have a vision of a scientist, utilize the scientific methods to solve the problems that encountered in their whole life, question, investigate, and make the connection between scientific knowledge with their daily life. The skills integrated in the curriculum are listed as seen at the Table 2.4.

Table 2.4 Science Process Skills of 6th, 7th and 8th Grade Level Presented in Turkish Science And Technology Curriculum

Planning and Starting	Observation Comparison-Classification Inference Prediction Estimation Determining the variables
Application	Formulating hypothesis Designing experiment Knowing and using experiment materials and equipment Setting up an experiment apparatus Describing relationship between variables Functional description Testing Information and data gathering Recording the data
Analysis and Result	Data processing and modeling Interpretation and result Presentation

Source: MoNE, as cited in Adal, 2011, p.127

During the pilot implementations of the current curriculum, Aydinli (2007) compared the previous science curriculum and the new piloted curriculum in terms of their relative influence on students' science process skills. The participants of the study were 670 students attending the pilot school and regular elementary schools from the grades of 6th towards 8th. Students' science process skills were measured by the administration of Test of Integrated Science Process Skills and the data analyzed with one-way ANOVA. A statistically significant mean difference was found between scores of students instructed with previous curriculum and the new curriculum in the favor of the new developed one. The author also reported the significant effect of various student characteristics on their performance of science process skill test such as grade, gender, socio economic status, and education level of parents. Similar results were reported in the study of Basdag (2006) which defended new curriculum was more successful than the previous one in terms of promoting students' attainment of science process skills. Another study comparing the effectiveness of two science curriculum employed in elementary schools was employed by Delen and Kesercioglu (2012). They designed their sample from 8th grade students in four classrooms who have still been instructed with the previous curriculum and 6th and 7th graders in eight classrooms who have been instructed with the new developed curriculum. The total of 290 students were administered a science process skills test including nine questions adapted from a previously developed test (Aydoğdu, 2006). The mean scores revealed the positive impact of new curriculum on students' proficiency in science process skills compared to the previous curriculum. Moreover the study did not revealed a significant effect of gender on students' science process skills. Similar results considering the better acquisition of science process skills in students following the new curriculum compared to the previous curriculum were aroused in also other studies (Senyuz & Kanli, 2006; Arslan, 2006, 2008). Upon the enrollment of new science curriculum in all schools, Cakiroglu and Aydin (2009) conducted a study to describe the emphasis of science process skills on the curriculum objectives stated from grade 4 towards 8. They reported a heterogeneous distribution in the inculcation of science process skills through the grades. For example, in early grades the emphasis was mostly on the basic skills while it changes towards integrated skills over the higher grades. The most emphasized skill in grade 4 and 5 was the "comparing-classifying" while it was "observing" in all grades from 6 to 8. "forecasting", on the other hand was the least mentioned skill in all grades. Although the above mentioned studies evidenced the new curriculum is more effective than the previous one, the mean scores reported in those and other similar studies were indicating moderate or low level of integrated science process skills even in students instructed with new curriculum (Cansiz, 2014; Aydinli, 2007; Can, 2008; Ozgelen, 2012). This situation leads to seek alternate strategies to develop higher science process skills in students.

The origin of international research in science process skills has a long history, while the national studies investigating science process skills of students started with the study of Geban in 1990 comparing the effectiveness of two instructional methods on high school chemistry students' science process skills in addition to their achievement and attitudes (Yildirim, 2012). The following part provides the review of the national as well as international studies concerning the development of science process skills of students.

2.6.1 Research on Science Process Skills

Teaching science process skills in a continual manner is crucial since it promotes students' science process skills and increases their prospects of success to use them in scientific inquiries (Wilke & Straits, 2005). The studies indicated science process skills can be taught to students with appropriate learning approaches (Griffiths & Thomson, 1993; Germann, Aram & Burke, 1996; Dogruöz, 1998; Özdemir, 2004; Anagun & Yasar, 2009). The mostly investigated methods were inquiry, hands-on activities, laboratory investments, and learning cycle. For example, investigating the development of students science process skills, Simsek and Kabapinar (2010) reported that inquiry-based learning environment in the concept of matter had a positive impact on 5th grade students' science process skills. Moreover, the study conducted by Basdas (2007) showed that hands-on activities designed with simple materials resulted in higher proficiency of science process skills compared to the curriculum based instructions. The author suggested integrating hands-on activities to science learning in order to improve various learning outcomes such as achievement, motivation, attitude as well as science process skills which may also influence their future choices towards university departments or career options. Following paragraphs provides brief summaries regarding the research conducted in the effect of various instructions employed in science learning on science process skills.

Tatar (2006) carried out a quasi-experimental study with 104 Grade 7 students to investigate the influence of inquiry on students' science process skills, attitude and achievement. The sample selected from four classes in two schools which were assigned to experimental and comparison groups to receive different instructions towards the contents in the unit of Our Planet. In the inquiry class students designed problems and experiments, conducted the scientific research, used various sources to reach the information, and participated in the field trips. On the other hand, comparison group students were instructed with the lecturing, demonstration and questioning approaches. The results of the study revealed that the students of inquiry classrooms performed better in the science process skills test and achievement test, and showed more favorable attitudes towards science.

Similarly, Yager and Akcay (2010) compared the development of students' science process skills, creativity skills, conceptual understanding and attitude towards science in two instructional designs; inquiry instruction and traditional-textbook instruction. For the specified purpose, they trained 12 volunteer teachers regarding the implementation of the inquiry instruction in their classes. The student data collected from 24 classes enrolled in inquiry instruction group (n=365) and traditional-textbook instruction group (n=356). The collective variables were measured through a previously developed program; Iowa Assessment Package for the Chautauqua Program (Enger & Yager, 2001) implemented before and after the instructions as pre-test and post-test. The results of the study indicated that the both group students significantly increased their science process skill use. However, the increase in the scores of students instructed with inquiry was higher than the students instructed with traditional instruction. Same findings were reported also in terms of concept mastery and positive attitudes. The study pointed out the importance of inquiry in science learning and the training of in-service teachers to implement more inquiry activities.

On the other hand, Kula (2009) examined the effect of inquiry instruction and curriculum oriented instruction on 6^{th} grade students' science process skills in addition to achievement, attitude and conceptual change. A quasi-experimental design was utilized in the study. Experimental group students learned the skeletal, circulatory and respiratory system through inquiry-based instruction while the comparison group learned the same subject based on the current science curriculum which based on constructivist philosophy. The implementation of treatment took 5 weeks. The data gathered from 60 students were revealed no statistically significant mean difference between groups in terms of their science process skills but superiority of inquiry instruction in other collective outcomes. Moreover, it was appeared that both group students improved their science process skills after the instructions.

In their study implemented in a long term period, Turpin (2000) examined the effect of an integrated, activity based science curriculum and traditional science curriculum on achievement, science process skills, and attitudes toward science. A total of 983 Grade 7 students were pre-tested and post-tested at the beginning and the end of their school year. After controlling for their prior achievement test scores, students' science process skills appeared to differ based on received curriculum practices in the course of the study. Students exposed to integrated, activity based science curriculum evidenced higher scores in total mean of test as well as some subscales of test; which are identifying experimental questions, identifying variables, designing investigations, and interpreting data. However, no statistically significant mean difference was found between groups in terms of formulating hypotheses and graphing data scores.

In a study focusing on laboratory approaches, Yildirim (2012) investigated the relative effect of two laboratory experiment designs; based on guided inquiry approach and based on traditional approach on the acquisition of science process skills and content knowledge achievement in 8^{th} grade elementary students. Three intact classes of an elementary school were assigned to the experimental (2 classes) and comparison group (1 class) including a total of 55 students. Experimental group students learned the topic of floating, sinking, buoyancy and pressure subjects while conducting the experiments based the directions given in guided inquiry laboratory manuals with the limited guidance of teacher. Comparison group students, on the other hand, conducted the experiments based on the directions given the traditional manuals, which provides experimental procedures, to verify previously received information with the lecture of the teacher in the class. The data collected by implementing Unit achievement test and science process skills test (Burns et al., 1985) before and after the instructions. The results of the study indicated there were no statistically significant mean difference between groups in terms of science process skills scores and their achievement. Contrary to this finding, in their study Koksal and Berberoglu (2014) found the better contribution of guided inquiry approach on science process skills over the curriculum based instruction. Six science and technology teachers implemented the instructions in the concepts of reproduction and development in living things to 304 students at grade 6. The authors developed an achievement test and a science process skills test including 16 items to determine students' achievement and performance in science process skills. Experimental group students engaged in experiments through the supplied materials such as microscope and specimens while the comparison group received the teacher explanations to learn the content. The results indicated higher gains in the attainment of science process skills.

Overall, the findings of the studies revealed that students' science process skills are possible to be improved through student-centered methods that enable them to practice the science process skills through designing and conducting scientific experiments. Students need to become an active learner of science in class who inquire about the scientific phenomena, seek answers through the experiments, and reach conclusions with this process. A general conclusion aroused from the findings of studies conducted in Turkey context might be that the new science and technology curriculum is effective to develop science process skills since most of the comparison studies concluded similar improvements in groups exposed to new curriculum and other teaching approaches. However, reviewed studies in the following part concerning the effectiveness of learning cycle, although there are insufficient number of studies, proposes the positive influence of this approach on students' science process skills. In the frame of the featured learning environments, 7E learning cycle will be explained with respect to promote science process skills.

2.6.2 Promoting Science Process Skills With Learning Cycle

Focusing the previously reviewed studies about the improvement of science process skills through the instructions, 7E learning cycle instruction appeared to be promising to promote science process skills. Indeed, learning cycle approach provides an inquiry environment in which students construct their own learning, pose questions, seek information to find appropriate solutions to the emerged questions, and propose explanations. All phases of learning cycle are suitable to embed the prompting activities but the strongest ones are exploration and explanation (Settlage & Southerland, 2007). The exploration phase of the approach is suitable to comprise activities that encourage using science process skills while explanation and elaboration phases are appropriate to provide additional practices for these skills. Students might be given a research question in explore phase that they employ integrated science process skills to formulate a solution, such as identify hypotheses, design experiments, define the dependent, independent, and controlled variables in the experimental set, conduct the experiments, and gather, analyze and interpret the data. Explanation phase is also effective to emphasis the basic science process skill of communication since students share their observations and explorations with the peers and whole class and propose explanations for what they observed and defense their ideas relative to other ideas (Settlage & Southerland, 2007). Actually, the basic science process skills, which are the prerequisite of integrated skills, are fundamental for learning cycle since the knowledge construction occurs based on observations and self-discoveries, as well as the interpretations and inferences driven from the experienced information. Moreover, the phases of learning cycle enable to combine the previously suggested teaching approaches that improve science process skills such as hands-on activities and inquiry in a collaborative learning environment. As cited in the review of Bybee et al. (2006) there were quite a few earlier studies investigating the influence of learning cycle approach compared to the more traditional approaches on science process skills. They mostly reported better acquisition in science process skills such as identifying and controlling variables, describing objects by their properties, together with the higher gains in classifying, measuring, experimenting, and predicting after experiencing learning cycle. Following paragraphs covers the brief reviews of recently conducted studies in terms of the effectiveness of learning cycle instruction on students' science process skills.

The relative influence of 5E learning cycle instruction on development of students' science process skills were examined in the study carried out by Anagun and Yasar (2009). For the specified purpose, a class of 27 grade 5 students was instructed the science and technology course based on 5E learning cycle instruction through 50 hours. The authors focused on nine students in 5th grade to investigate the development of science process skills. The data were collected via various techniques like video records, semi-structured interviews, researcher and student journals, and Science Process Skills Test, developed by the researchers considering the skills emphasized in 5th grade science curriculum (i.e. observation, comparison and classification, prediction, forecasting, determining variables, collecting knowledge and data, data processing, forming a model, inference, designing an experiment, recognizing and using experiment materials, and measurement). The findings of the study implied an improvement in the science process skills after the completion of 5E learning cycle instruction. However, it was appeared that the development in the each sub-skills of focal students varied. From the quantitative data, striking differences were emerged for the skills in observation, comparison and classification, prediction, forecasting, determining variables, collecting knowledge and data, data processing, and forming a model. However there were no improvement in terms of inference and designing experiment. Qualitative data revealed all skills were improved in students except for determining variables skill.

Additionally, Kanli and Yagbasan (2008) conducted an experimental study to compare the relative effectiveness of 7E learning cycle model based on laboratory approach and deductive laboratory approach on development of science process skills. The sample was composed of 81 freshman university students attending a physic laboratory course. Students were administered the Science Process Skills Test (Burns, Okey & Wise, 1985) at the beginning of the course. They were re-administered the same test after the completion of the course. During the treatment, students in experimental group allowed to design experiments, identify dependent and independent variables, formulate analysis, explain the collected data, construct data tables, and draw conclusions, without a previously presented theoretical instruction. On the other hand, comparison group students were followed the steps which provide an identified problem, experimental designs, method to analyze data, and other necessary explanations. The findings of the study revealed a significant difference between students' post-measurements scores in the favor of experimental group. The authors discussed that the deductive laboratory approach leads students to focus on finding the correct results instead of the scientific process.

Another comparison study employing the learning cycle approach was conducted in Pakistan by Sornsakda, Suksringarm, and Singseewo (2009) investigating its relative effect on 11^{th} grade students' science process skills. Cluster random sampling was used to select 45 students in experimental group and 48 students in comparison group from a population of 500 students. The participanst were coming from various socioeconomic statuses. 7E learning cycle instruction with three metacognitive techniques (i.e. intelligibility, plausibility, and wide-applicability) was designed in 5 plans to implement in the experimental group. The activities presented in each phase were developed to lead students to practice scientific process skills repetitively. On the contrary, teacher's handbook approaches was implemented in the comparison group. Both groups received the same content in their instructions, Ecology System, through 5 week period. Students' achievement, integrated science process skills and critical thinking skills were measured by self-reported instruments. The results of the study revealed a gain in all collective scores of both group students. However, experimental group students evidenced higher integrated science process skills in general as well as each five sub-skills. The authors attributed this result the clear specification of each skill in all phases of learning cycle. The students were enabled to practice every aspect of science process skills regularly and continuously in every phase.

In line with the reviewed studies, 7E learning cycle instruction which participants of the current study experienced through human body systems concept is expected to promote students' science process skills since it may provide the practices of these skills through the activities in the phases. Consequently, the present study investigates the contribution of 7E learning cycle instruction on students' science process skills in comparison to the curriculum oriented instruction.

In general, 7E learning cycle instruction is promising to develop students' conceptual understanding, self-regulation, scientific epistemological beliefs and science process skills. In the literature review, it was appeared that there is a need to investigate the contribution of 7E learning cycle instruction on these collective variables.

CHAPTER III

METHODOLOGY

This chapter provides information about the procedures that are employed in the current study to gather and analyze data. In detail, the chapter covers the specifications regarding the design of the study, participants of the study, independent and dependent variables, instruments used to collect data, treatment, treatment fidelity and verification, analysis of the data, and the validity of the study.

3.1 Design of the Study

In this study, the quasi-experimental design was implemented (Fraenkel & Wallen, 2006) since it was not possible to assign the students randomly into the groups. Already formed six intact classes were randomly assigned to experimental group (EG) and comparison group (CG). Since the selected classes were instructed by two different teachers, at least one comparison and one experimental group class was assigned to each teacher. For the purpose of the study, the effect of two independent variables (i.e. two types of instruction and time) on the multiple dependent variables (i.e. conceptual understanding, motivation towards science, learning strategy use, scientific epistemological beliefs, and science process skills) was investigated. The design and implementation of the study were summarized at Table 3.1.

Table 3.1 Research Design of the Study

Groups	Pre-tests	Treatment	Post-tests	Follow-up
EG	SSCI CSCI RSCI MSLQ EBQ SPST	7E-LCI	SSCI CSCI RSCI MSLQ EBQ SPST	SSCI CSCI RSCI
CG	SSCI CSCI RSCI MSLQ EBQ SPST	COSI	SSCI CSCI RSCI MSLQ EBQ SPST	SSCI CSCI RSCI

In this table, EG refers to experimental group instructed the science concepts by 7E Learning Cycle method while CG refers to comparison group instructed by curriculum oriented science instruction. SSCI, CSCI and RSCI represent conceptual inventories related with Skeletal System, Circulatory System and Respiratory System, respectively. MSLQ represents the Motivated Strategies for Learning Questionnaire, EBQ is the Epistemological Beliefs Questionnaire, and SPST is the Science Process Skills Test. 7E-LCI refers to 7E Learning Cycle Instruction while COSI refers to Curriculum Oriented Science Instruction. The sequential implementation of treatment and instruments are specified at Table 3.2.

Table 3.2 The Sequential Implementation Design of the Study

Groups	Pre tests	Treatment	Post tests	Pre tests	Treatment	Post tests	Pre tests	Treatment	Post tests	Follow up*
EG	SSCI MSLQ EBQ SPST	Skeletal System 7E-LCI	SSCI	CSCI	Circulatory System 7E-LCI	CSCI	RSCI	Respiratory System 7E-LCI	RSCI MSLQ EBQ SPST	SSCI CSCI RSCI
CG	SSCI MSLQ EBQ SPST	Skeletal System COSI	SSCI	CSCI	Circulatory System COSI	CSCI	RSCI	Respiratory System COSI	RSCI MSLQ EBQ SPST	SSCI CSCI RSCI

* Follow-up tests were implemented 1-month later of each related post test.

As seen at the Table 3.2, at the beginning of the study, all participating students were pre-tested through SSCI, MSLQ, EBQ, and SPST to determine whether the groups differ with respect to their understanding of skeletal system concepts, motivation and learning strategy use, scientific epistemological beliefs, and science process skills. Besides, the experimental group received the instruction based on 7E learning cycle instruction and comparison group followed the curriculum oriented instruction. The treatment covers three subjects of human body concepts; Skeletal System, Circulatory System, and Respiratory System. This all subjects thought by 7E-LCI to the students in the experimental group sequentially. The same sequence was applied in the instruction of the comparison group based on COSI. Students in both groups were pre-tested by SSCI before the Skeletal System subject in order to determine their prior understanding of Skeletal System concepts. The same test was administered right after the instruction of Skeletal System concepts to examine the extent of learning. The test also implemented to groups one month later the completion of treatment in order to investigate the extent to which the acquired knowledge was maintained over time.

As mentioned before, after the topic of skeletal system was covered, the topic of circulatory system was started to be taught. The same pattern for pre-test, post-test and follow-up test administrations was applied for CSCI to investigate the conceptual understanding regarding circulatory system. At the beginning of the instruction concerning circulatory system concepts, both groups were pre-tested through CSCI to determine prior conceptual understanding with respect to circulatory system. When the circulatory system implementations were completed, CSCI was implemented as post-test in both groups to evaluate immediate effects of instructions on the related concept understanding. Afterwards, one month later the post-test, the same test was implemented again to assess the effects of treatment over time.

Respiratory System concepts were instructed after the circulatory system concepts. Therefore, just after the post-test administration of CSCI, both groups were administered to RSCI in order to determine prior conceptual understanding with respect to Respiratory System. At the end of the instruction, RSCI was administered to the two groups in order to evaluate the effects on the students' knowledge. Similar with the previous conceptual inventories, one month after the end of the Respiratory

System instructions, RSCI was conducted with both of the groups again in order to evaluate the continuous effects of treatment.

At the time that respiratory system concepts instruction was completed, all the students participating to the study were administered to MSLQ, EBQ, and SPST in order to compare the effectiveness of two instructions related with human body system concepts on the collective variables.

To be more clear and consistent throughout the study, Time1, Time2 and Time3 terms were used to refer pre-test, post-test and follow-up tests implementations of all conceptual inventories, respectively. On the other hand the pre-test and post-test terms were used for the administration of MSLQ, EBQ and SPST.

Following figure (Figure 3.1) represents the time line of the study. In the figure, each partition of the lines represents a science lesson. It summarizes the implementation process for each treatment type and instruments utilized for both experimental and comparison groups.

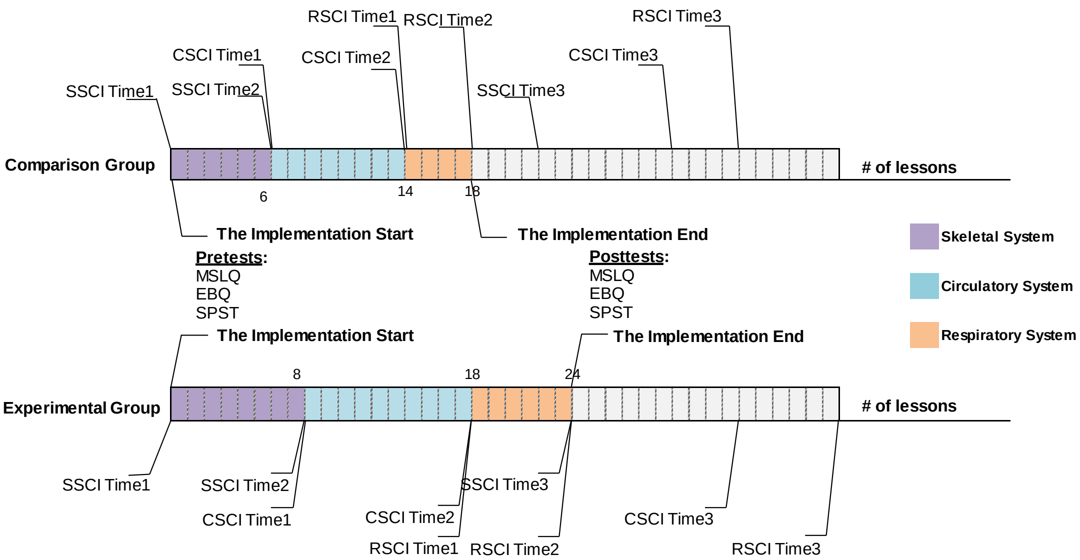

Figure 3.1 Design of the Study and Timeline of Implementation

The data collected in terms of each variable were statistically examined to identify possible differences between groups as well as the differences with-in groups over time. The variables were measured by calculating total scores for SSCI, CSCI, and RSCI and calculating means for MSLQ, EBQ, and SPST.

3.2 Sample of the Study

All 6th grade students attending public schools in Ankara were identified as the target population of the study while all 6th grade students in the public schools of Keçiören district of the city were chosen as accessible population. Accordingly, sample of the study consisted of 185 sixth-grade students (91 boys and 94 girls) attending a public middle school in Ankara. Most of the students were from middle-class families. The mean age of students was 12.18 years (SD= .51, range 11 to 15).

The study was implemented during 2010-2011 spring semester. The sample was selected by convenient sampling method and by considering the willingness of teacher and students who were supposed to implement and receive the treatment as well as instruments. The intact classes were randomly assigned to one of two modes of instruction namely, 7E Learning Cycle instruction (7E-LCI) and curriculum oriented instruction (COSI). Although took different amount of time, students in both types of classes received identical syllabus-prescribed learning content.

As mentioned above, students were from six intact classes thought by two female teachers. Each teacher had both 7E-LCI classes (n= 95) and COSI classes (n= 90). Both teachers had been instructed their classes since the beginning of 2010-2011 fall semester. In term of school context, participants was equipped with a science laboratory, one computer laboratory with internet connection, one multi-media room and a library covering several references, encyclopedia, textbooks and novels on different disciplines, including science. These resources were open to access of all students.

There were four inclusive students with mental disabilities attending the experimental and comparison group classes. These students participated to instructions and instrumentation processes but not included in the sample of study. The data collected from these students were also not included in the study since they had difficulty on focusing while answering the questions.

3.3 Variables

The present study has six main variables. They are explained by categorizing as Independent Variables and Dependent Variables to make clear statements.

3.3.1 Independent Variables

Independent variables of the study were the treatment and time (See Figure 3.2). The treatment was the mode of instruction namely, 7E-LCI and COSI. The instructions covered three topics included Human Body Systems as Skeletal System, Circulatory System, and Respiratory System.

Time variable, on the other hand, consists of three levels in the analysis of conceptual inventories as Time1, Time2 and Time3. At Time1, which corresponds to the beginning of the instruction for each topic, related conceptual inventories were implemented as the pre-tests of SSCI, CSCI, and RSCI. At Time2, which corresponds to the end of the instruction for each topic, related conceptual inventories were administered again as post-tests of SSCI, CSCI, and RSCI. At Time3, which corresponds to the one month later the instruction for each topic, follow-up tests of SSCI, CSCI, and RSCI were administered. The application time of each conceptual inventory varied based on the related concept instructions which are sequential, Skeletal System, Circulatory System, and Respiratory System.

In the analyses of MSLQ, EBS and SPST, time variable consists of two levels as pre-test and post-test. At pre-test implementation, students were at the onset of the treatment and MSLQ, EBQ and SPST were administered to be able to compare the experimental and comparison groups' prior scores in terms of collective variables and examine the change in their scores during the study. At post-test, treatment was completed and all students were instructed human body systems concepts. MSLQ, EBQ and SPST were administered as post-test to investigate the effect of treatment on related variables.

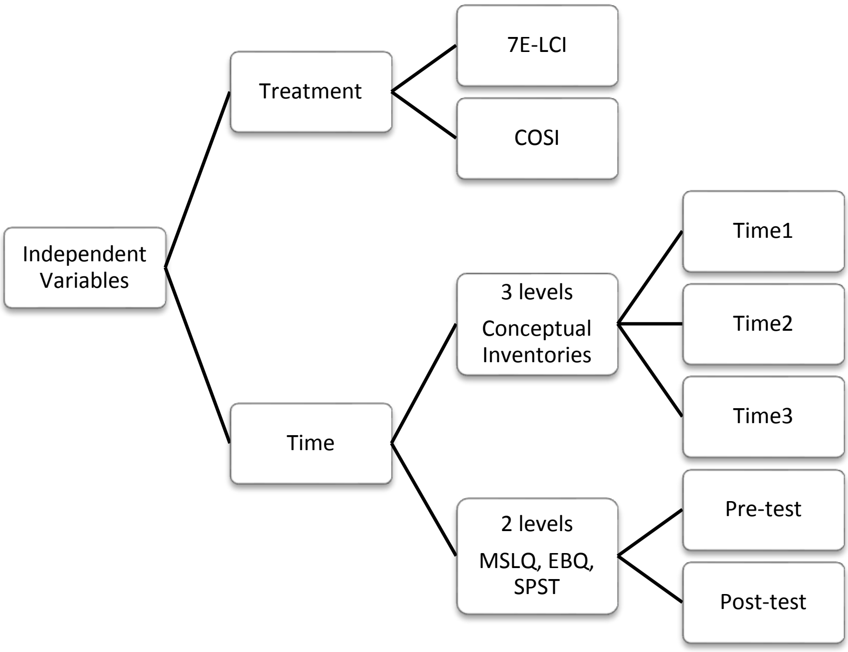

Figure 3.2 Independent Variables of the Study

3.3.2 Dependent Variables

There were five dependent variables in the study. These variable are the students' conceptual understanding on the unit of Human Body Systems (i.e., skeletal system, circulatory system, and respiratory system), motivation (i.e., intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy, and test anxiety), use of learning strategies (i.e., rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, peer learning, and help seeking), scientific epistemological beliefs (i.e., source, certainty, development, justification), and science process skills.

Students' conceptual understanding in the unit of Human Body Systems was measured by SSCI, CSCI, and RSC. Similarly, each of these conceptual inventories was administered at Time1, Time2, and Time3. Students' motivation and their use of learning strategies together with their scientific epistemological beliefs and science process skills were measured as pre-test and post-test.

3.4 Instruments

In the present study, six instruments were administered. Three conceptual inventories were used three times as pre-test, post-test and follow-up test while other instruments were used two times as pre-test and post-test. The instruments are Skeletal System Conceptual Inventory (SSCI), Circulatory System Conceptual Inventory (CSCI), Respiratory System Conceptual Inventory (RSCI), Motivated Strategies for (MSLQ), Epistemological Beliefs Questionnaire (EBQ), and Science Process Skills Test (SPST). In the following sections, detailed information about development of conceptual inventories was given firstly, and then the other instruments were documented.

3.4.1 Conceptual Inventories for Skeletal, Circulatory and Respiratory Systems

Three conceptual inventories were developed by the researcher by taking the basic concepts involved in Skeletal, Circulatory and Respiratory Systems into consideration (See Appendix A, B and C). They are 10-item multiple-choice tests specifically designed for assessing middle school students' conceptual understanding of human body systems concept in science courses. Conceptual inventory development relies on an extensive research since they assess students if they can select the correct concept among the common misconceptions as well as if they understand the concept correctly. Although there are various conceptual inventories on biological concepts and some were related with circulatory system topic, they are substantially more relevant for older students. For that reason, the researcher developed conceptual inventories for each of three human body system concepts specifically for middle school level science courses. In the following, development process of the conceptual inventories, including validation and reliability issues together with the results of pilot studies will be explained.

The development process was summarized in Figure 3.3. As seen in the figure, development procedures started with the examining the extensive research of human body systems. Firstly, the core concepts and the objectives of Skeletal, Circulatory and Respiratory Systems were identified to guide the developing items congruent with the purpose of the study. In this step, 6^{th} grade science and technology curriculum, and student and teacher textbooks were taken as the reference. The list of concepts planned to be covered in the inventories is listed in Appendix G. After taking the expert opinions from two experienced science teachers and two science education professors about the construct, the literature was searched to find out the common misconceptions of students with respect to human body systems concept. An initial pool of students' misconceptions was identified based on the review of the literature about human body systems (Aydin & Balim, 2009; Tekkaya, 2002), Skeletal System (Caravita & Falchetti, 2005), Circulatory System (Alkhawaldeh, 2007; Arnaudin & Mintzes, 1985; Chi, 1991; Sungur, Tekkaya & Geban, 2001) and Respiratory System (Hymelo, Holton & Kolodner, 2000; Gültepe Yıldırım & Sinan, 2008; Mann, 1995).

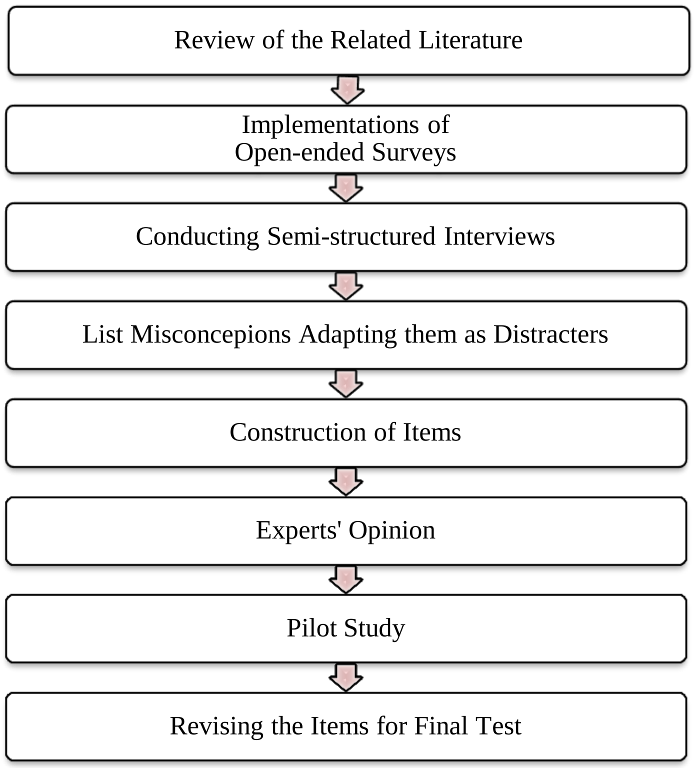

Figure 3.3 Development Process of Conceptual Inventories

With the guidance of abovementioned preliminary research, three open-ended questions were prepared in attempt to elicit students' ideas about Skeletal, Circulatory and Respiratory Systems. Students were expected not only to explain the structure of systems or organs but also to draw their ideas related with the systems Specifically, each of three open-ended surveys consisted of essay questions that ask explanations of students and drawing questions that asks students' ideas about their interior body. All questions were aimed to reveal students' misconceptions concerning structure and function of the systems as well as inter-relationship between systems that take place in order for the body to function properly. Resulting open-ended questions were administered to 203 students from six intact classes at 6th and 7th grade in a public school in the fall semester of 2010-2011. Participants from 6th grade were selected to investigate the students' ideas prior the concept acquisition. In previous grades they received a simple instruction about the human body systems but the detailed information is given in 6th grade. Students from 7thgrade, on the other hand, were selected to determine their constructed knowledge structures and ideas following to instruction of the related subject. This group was ensured that the participants have detailed knowledge about the human body systems which they were instructed in previous semester. Students' responses to each open-ended questions were presented in Appendix H. The answers of students were investigated by researcher and a science education professor in terms of students' knowledge deficiencies and misconceptions in order to construct the main inventories. Students' responses revealed that they have several misconceptions and most of them failed to reflect a scientific explanation. They confused the organs of the systems as well as the functions and structures of organs. The drawing of students also revealed the confusions in the organs of systems and the place of them in the body. In order to deepen the students' responses and get a clear picture of their understanding, semi-structured interviews were conducted with six students who already responded to open-ended surveys (See Appendix I for interview questions). To interview, students who possible to hold misconceptions on relevant concepts were identified from their responses. Two students were selected based on their response to Skeletal System open-ended questions and they interviewed about Skeletal System. Other two students were selected to interview about Circulatory System since they possessed some possible misconceptions on their drawings and explanations to open-ended questions. Finally, two students were selected based on their answers to identify if they have more misconceptions than they reflected on their essays about Respiratory System. All students were also asked about the relation between the systems.

Before the interviews, the participants were informed that they were selected based on their explanations on open-ended questions and the researcher will direct questions to receive deeper explanations. Firstly, they were provided with their answers on the open-ended surveys and requested to explain their answer again. During their explanations the researcher asked to further define a term, describe a process or clarify the function of the system or organs. During the interview process, the students were not given any indication about whether their answers were correct or incorrect. The interviews were transcribed and the transcripts of each interview were inductively analyzed to identify deficient explanations and misconceptions. Some of the misconceptions were compatible with the literature while some of them were novel.

The student explanations obtained from open-ended questions and interviews were listed and categorized under certain topics (e.g. function of heart, structure of heart, the type of bones). Compiled misconceptions based on responses from open-ended surveys, interviews and literature review were listed in Appendix J. During the development of items for conceptual inventories, the students' own words were adapted as alternatives for each multiple-choice question. More specifically, each of the items has a scientifically accepted correct alternative and three common misconceptions worded in the language that the students use to express the concepts. However, for some of the items it was not possible to arrange three misconceptions to generate alternatives. Hence, a few of items were directed to select the wrong alternative which covers a misconception between the correct ones. During the development of stems and alternatives for items, the researcher considered the plausibility, language, consistency and also avoided to provide a clue that may cause students to guess. Additionally, each item has a fifth choice as 'I have no idea about this question.' to distinguish the students without any prior knowledge on the related concept and to avoid guessing. After each item, the inventory asks students their confidentiality for their answers with a yes/no question to be able to distinguish students with deep misconceptions or students who select the right item by guess. Each item counts as correct if the students are able to pick up the correct answer and choose yes for their confidentiality. Related with this manner, Hasan, Bagayoko and Kelley (1999) suggested that high certainty on an incorrect answer is an indicator of a deep misconception on students. On the other hand, low certainty indicates lack of knowledge and correct answer with low confidence may display responding by guessing. That is, it is reasonable to ask students' their confidentiality to achieve more accurate idea in their learning. Based on these criteria, three conceptual inventories covering 10 items were developed related with Skeletal, Circulatory, and Respiratory System subjects.

After the development of items, expert opinions from 5 experts were solicited for a total of 30 items. The experts were two elementary science professors, two elementary science teachers, and a medical doctor. Professors and teachers were asked to verify if the items are plausible, accurate and clear, likewise if they are compatible with the grade level and addressing the target concept. The doctor was requested to review the accuracy of the correct answer and inaccuracy of distracters of each item with respect to his medical expertise. Some of the items were modified based on the opinions of experts and final forms of tests were composed.

The final versions of the tests were piloted tested with the 7^{th} grade students of the school where the main study was planned to be conducted. Pilot study was conducted in the fall semester of 2010-2011. 7^{th} grade students were considered as having background information about the subject since they have learned the related subjects in their previous semester. Each of three tests was administered to students from six classes, assigning two classes for each test. Specifically, SSCI, CSCI and RSCI were administered to 66 students, 63 students, and 60 students respectively. Participators' questions and comments about the items not only during but also after the administration of inventories were noted for revision. The collected data was investigated with respect to difficulty and discrimination indexes of items as well as the reliability coefficient of the tests.

Item difficulty is an index that expresses how difficult the item is based on the students' performance. The scores ranges from 0.0 to 1.0 which the higher scores refer easy items while lower scores indicate difficult items. Item discrimination is an index related with how well the item discriminates between low achiever and high achiever students. The scores can range between from -1 to +1. The closer score is to +1, the better the discrimination. The closer score is to 0, the lower the discrimination. Difficulty and discrimination indexes of each item of SSCI, CSCI and RSCI were reported in Table 3.3.

Table 3.3 Item Difficulty and Item Discrimination Indexes of SSCI, CSCI and RSCI

	SSCI		CSCI		RSCI	
	Difficulty Level	Item Disc.	Difficulty Level	Item Disc.	Difficulty Level	Item Disc.
Item 1	0.27	0.18	0.16	0.33	0.17	0.55
Item 2	0.41	0.18	0.35	0.43	0.20	0.55
Item 3	0.41	0.20	0.19	0.38	0.17	0.35
Item 4	0.36	0.26	0.36	0.67	0.07	0.10
Item 5	0.09	0.08	0.32	0.43	0.68	0.60
Item 6	0.59	0.33	0.28	0.10	0.32	0.65
Item 7	0.54	0.42	0.27	0.48	0.15	0.20
Item 8	0.36	0.65	0.27	0.24	0.38	0.55
Item 9	0.77	0.53	0.19	0.43	0.07	0.05
Item 10	0.45	0.39	0.24	0.33	0.10	0.15

SSCI has an average difficulty index of 0.42 with items ranging in difficulty from 0.09 to 0.77 (See Table 3.3). Considering the discrimination indexes, the scores range from 0.08 to 0.65. All of the items except the Item 5 were in an acceptable difficulty, and discriminate fairly well between high and low scored students. Item 5 was appeared to be a difficult item to students and did not successfully discriminate the students (lower number indicates low discrimination). The stem and the alternatives were modified to make the item clearer for students.

The average difficulty level of CSCI was 0.26, with the scores ranging from 0.16 to 0.36, indicating a relatively difficult test for students (See Table 3.3). Item discrimination indexes were acceptable, except for Item 6 which has a low discrimination value of 0.10. This was a negatively worded item and the stem was highlighted to increase the awareness.

RSCI was perceived as a difficult test by students with an average difficulty level of 0.23. The scores were ranging from 0.07 to 0.68 (See Table 3.3). With respect to item discrimination indexes, the scores were between 0.05 and 0.65 indicating that some items were not sufficient to discriminate between high and low performing students. Especially Item 4 and Item 9 were required the revision based on their scores. Item 4 was revised to make the question more understandable. However, Item 9 was not changed. The possible reason of low discrimination index of Item 9 is the long stem covering a case and long sentences in alternatives. The question was important for the study and was not eliminated from the test.

Reliability of the test was investigated by calculating an internal consistency measure of Kuder-Richardson 20 for all three inventories. The reliability coefficient of SSCI, CSCI and RSCI was found to be 0.57, 0.54 and 0.56, respectively. The values are lower than the desired reliability coefficient of 0.60 for a good classroom test (Gronlund, 1993). One of the possible reasons of low reliability values is not deriving the items in a unified body of content: although the subject of the items was under the same title of human body system, each question was covering a unique content about that system. This situation is typical of other concept inventories with a similar purpose such as the Genetics Concept Assessment (Smith et al., 2008), EvoDevoCI (Perez et al., 2013), and Conceptual Inventory of Natural Selection (Anderson et al, 2002). Another reason is that SSCI, CSCI and RSCI were short test, covering only 10 items. However, it was not only unreasonable to increase item number considering the intended age but also impossible since the items developed based on the preliminary work in a limited content area. Actually, Kehoe (1995) suggest that a minimum KR-20 value of 0.50 is satisfactory for short tests such as covering 10 - 15 items. In this manner, the inventories were considered as reliable and valid instrument to conduct in the current study.

After making the necessary revisions, the final forms of the inventories was administered to participants of the study to determine their conceptual understanding with respect to human body systems concepts. In this study, SSCI, RSCI and CSCI were implemented repeatedly three times to identify student's knowledge about related concepts at the beginning of the instruction (Time1), at the end of the instruction (Time2), and one-month later of the end instruction (Time3). During the instruction process, the three concepts of Skeletal System, Circulatory System and Respiratory System were instructed sequentially. Each conceptual inventory were implemented before the respective concept instruction, after and then one-month later. In the present study, the reliability coefficients of each implementation were presented in Table 3.4.

Table 3.4 KR-20 Values of Conceptual Inventories

	SSCI	CSCI	RSCI
Pilot test	0.57	0.54	0.56
Time1	0.42	0.49	0.50
Time2	0.62	0.57	0.67
Time3	0.59	0.51	0.64

3.4.2 Motivated Strategies for Learning Questionnaire (MSLQ)

MSLQ (Pintrich, Smith, Garcia & McKeachie, 1993) was used to measure the students' motivational beliefs and learning strategy use (See Appendix D). It is a self-report questionnaire that consists of 81 items scored in a 7-point Likert scale, from 1 (not at all true of me) to 7 (very true of me). The questionnaire has two essential sections as motivation section and learning strategies section. Motivation section is composed of 31 items from six subscales which are Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy, and Test Anxiety. Learning strategy section of MSLQ includes 50 items from nine subscales namely Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environment Management, Effort Regulation, Peer Learning, and Help Seeking. In order to calculate students' scores in each scale, total score after changing the reverse items was calculated for each scale and divided to item numbers.

During the development process, MSLQ was implemented to college students to investigate the reliability and validity of the scales (Pintrich, Smith, Garcia & McKeachie,1993). The reliability coefficients were ranged from 0.52 to 0.93. Moreover, confirmatory factor analysis indicated that the fit indices were reasonable for both sections (See Table 3.5). Translation and adaption into Turkish language was conducted by Sungur (2004). The questionnaire was examined with high school students and the reliability coefficients were found be ranging from .54 to .89. Additionally, the factor analysis showed a reasonable model fit according to original model (See Table 3.5). Many scales of the translated version were implemented to elementary and middle school students in other studies (Araz & Sungur, 2007; Kıran

& Sungur, 2012). In this study, the questionnaire was implemented to experimental and comparison groups before and after the treatment to investigate the effect of the treatment on motivation and learning strategy use. The internal consistencies of the scales were between .63 and .94 in the present study. Moreover, the confirmatory factor analysis results were compatible with the previously reported results (See Table 3.5).

Table 3.5 CFA Indices Related With MSLQ

		$\chi 2/df$	GFI	RMR	RMSEA	CFI	SRMR
MSLQ Motivation Scales	Original Version (Pintrich, et al., 1991)	3.49	0.77	0.07	-	-	-
	Translated Version (Sungur, 2004)	5.30	0.77	0.11	-	-	-
	In this study Pre-test	1.62	0.81	0.19	0.056	0.94	0.072
	In this study Post-test	1.77	0.79	0.07	0.065	0.94	0.072
MSLQ Learning Strategy Scales	Original Version (Pintrich, et al., 1991)	2.26	0.78	0.08	-	-	-
	Translated Version (Sungur, 2004)	4.50	0.71	0.08	0.08	-	-
	In this study Pre-test	1.93	0.65	0.36	0.08	0.93	0.092
	In this study Post-test	1.86	0.66	0.08	0.08	0.92	0.083

3.4.3 Epistemological Beliefs Questionnaire (EBQ)

Epistemological Beliefs Questionnaire (EBQ) was used to assess students' scientific epistemological beliefs (See Appendix E). The EBQ was developed by Conley et al. (2004) and translated and adapted to Turkish by Ozkan (2008). The questionnaire measure students' beliefs about the nature of knowledge and nature of knowing along four dimensions: Source, Certainty, Development and Justification. It consists of 26-items rated on a 5-point Likert scale (1= Strongly disagree, 5= Strongly agree). The Source dimension covers five items related with the beliefs about knowledge residing external authorities (e.g., "Whatever the teacher says in science class is true"). The Certainty dimension consists of six items concerning about the belief in a right answer (e.g., "All questions in science have one right answer”). The Development dimension directs six items to measure the belief about science as an evolving and changing subject (e.g., “Some ideas in science today are different than what scientists used to think”). The Justification dimension has nine items referring the role of experiments and how individuals justify the knowledge (e.g., “Good answers are based on evidence from many different experiments”). In order to calculate students’ scores in each dimension, total score of their answers for each dimension was divided to item numbers. While higher scores on the Development and Justification dimensions refer sophisticated beliefs, lower scores on Source and Certainty dimensions indicated sophisticated beliefs.

During the development of the questionnaire, Conley et al. (2004) tested the EBQ with a sample of 187 elementary school students. Internal consistency reliabilities of this sample were reported as .81 for Source dimension, .78 for Certainty dimension, .57 for Development dimension, and .65 for Justification dimension. For the present study, before the treatment, the Cronbach’s alpha coefficient of these scales was found to be .76, .61, .58, .83, respectively. The questionnaire was also administered to all students in experimental and comparison groups before and after the treatment. The confirmatory factor analysis for pre-test and post-test items indicated acceptable model fit for four factors (See Table 3.6). The Turkish version of this scale was also used in other studies (Kizilgunes, Tekkaya, Sungur, 2009; Boz, Aydemir & Aydemir, 2011).

Table 3.6 CFA Indices Related With EBQ

	Original EBQ (Conley et al., 2004)	EBQ pre-test	EBQ post-test
$\chi 2/df$	1.35	1.73	1.72
CFI	0.90	0.92	0.93
S-RMR	-	0.099	0.096
RMSEA	0.038	0.062	0.063

3.4.4 Science Process Skill Test (SPST)

The Science Process Skills Test was originally developed by Okey et al. (1982) and translated and adapted into Turkish by Ozkan, Askar, and Geban, (1989). The original version of the test covers 36 multiple choice questions that measure students' skills related to identify variables, identifying and stating hypothesis, operationally defining, designing investigations, and graphing and interpreting the data. Each question of the test presents four alternatives with only one true answer. KR-20 values were calculated as a reliability coefficient and it was reported as, .86 for original version and .81 for Turkish version. Although the developers of the original version administered the test to middle and high school students, 36 items were considered excessive for middle school students to complete the test within a class period. For that reason, a shorter version of the test which adapted by Can (2008) was used in the present study (See Appendix F). Can developed the short version by eliminating ten items having lower discrimination indices than .20, which is calculated based on the data collected from 227 7^{th} grade students from four elementary schools. KR-20 value was found to be .80 for the new 26-item test. However, KR-20 values in the current study were found as .44 for pre-test and .51 for post-test which were lower than the one reported by Can.

In the present study the science process skills were intended to be examined in terms of five sub-dimensions of the test separately to investigate the relative effect of 7E-LCI and COSI instructions on each skill. Unfortunately, the reliability values were too low and not sufficient to conduct related analyses, especially for the sub-dimensions including only three items (eg. operationally defining, designing investigations, and graphing and interpreting the data). For this reason, conducting analysis with total score of science process skills test was more reasonable. However, low KR-20 values even for the total test scores may hinder to reach a safe conclusion about the result of science process skills test. Thus, the low reliability scores for the SPST are a limitation for this study.

3.5 Treatment (7E-LCI vs COSI)

This study aimed to investigate the influence of 7E Learning Cycle Instruction compared with the Curriculum Oriented Science Instruction on 6^{th} grade students' conceptual understanding of Skeletal, Circulatory and Respiratory Systems, motivational beliefs, learning strategy use, scientific epistemological beliefs, and science process skills. In line with the specified purpose, the study was conducted over a six week period during the 2010-2011 spring semester. Skeletal, Circulatory and Respiratory Systems concepts were covered as part of the regular curriculum in the sixth grade science courses. 185 students from six intact classes of two science teachers were involved in the study. The science lessons in the school were four times per week and each lesson was 40 minutes.

The classes received 7E-LCI was referred as experimental group while the other classes named as comparison group. Students in the experimental group were instructed with hands-on and minds-on activities to recall prior knowledge, increase curiosity, engage students to learn, provide them an environment to explore the concepts and explain their understanding, apply their knowledge in new situations, evaluate and connect the content with the following concepts. The comparison group was taught based on teacher explanations, questioning, discussion, and knowledge and activities suggested in the textbook. The curriculum implemented from 2006-2007 academic year had a perspective of constructivist philosophy to help student gain "learn how to learn" skills. For that purpose, the instructions and activities suggested in the textbooks are student-centered instead of teacher-centered and aim to stimulate students' interest and curiosity. The curriculum presents daily life examples in each subject and questions to reinforce ideas previous the instruction. Thus, the offered instruction and science activities in the comparison group also force students to explore the concept by themselves.

Both groups were instructed with their regular science teachers and the researcher observed each lesson. The researcher got involved the instruction some times in experimental group especially when the teacher needed more direction about the activities. On the other hand, the researcher did not interfere the teaching in the comparison groups.

At the beginning of the semester, the researcher gave a brief information about the aim of the study, how to implement 7E-LCI, the planned activities, and the time schedule. During the implementation, the teachers and the researcher conducted a meeting at the beginning of each week to discuss how to implement the activities of 7E-LCI in the experimental group classes. These meetings also aimed to ensure the correspondence between two teachers during the treatment and to eliminate the differences that might arise from their practices.

Before the treatment, the students of experimental and comparison groups were administered the Motivated Strategies for (MSLQ), Epistemological Beliefs Questionnaire (EBQ), and Science Process Skills Test (SPST) to determine their prior motivation and learning strategy use, prior scientific epistemological beliefs, and prior science process skills, respectively. Students were also administered Skeletal System Conceptual Inventory (SSCI) to identify their prior conceptual understanding with respect to Skeletal System concepts. The teachers implemented the instruments to students in each class and the students were informed about the purpose of the instruments as well as the procedure to complete them.

In order to prevent the implementation treat, especially unconsciously using the directions of 7E-LCI plans in the comparison group, the implementation of topic in comparison group was always ahead of the topic in experimental group in all implementation process of the study. At the beginning of the study, the teaching of subjects in the experimental group started two lesson hours later than that the comparison group started. Throughout these two hours, the teachers practiced with the students how to fill a round house diagram in cell concept to prepare students to the evaluation phases of 7E-LCI.

The instructions in experimental and comparison groups followed the concepts in the same sequence as Skeletal System, Circulatory System, and Respiratory System concepts. In the following sections, implementations related with each concept were detailed for both groups. An important reminder here is that there were three classes for each of experimental and comparison groups. During the implementations the researcher observed all lessons. The teachers and the researcher put an effort to follow the same sequence on their lessons in 7E-LCI. Of course, the students' answers and the teachers' approaches may vary between classes but the processes in the classes were similar. Thereby, experimental group instruction will be explained in general frame. However, there were some teaching differences between two teachers' instructions based on curriculum in comparison groups. The observed differences will be detailed. Primarily, 7E-LCI and COSI implementations with respect to Skeletal System concept were described in the following section.

3.5.1 Instructions Related to Skeletal System

The Skeletal System instruction in the comparison group was curriculum oriented and conducted over one and a half weeks; 6 lessons. The teacher started the lesson by explaining the topic that is going to instructed; Skeletal System. Then she requested a volunteer to read aloud the information presented in textbooks. The passage was covering some questions about the terms of bones, cartilage, muscles, and joints to engage students and reminding their prior knowledge related with long, short and flat bones. When the volunteer student finished the reading, other students tried to answer the questions. They stated movement and posture of the body is impossible without the bones or muscles. One student shared his arm bone was broken last year and waited in plaster cast to recover.

An activity was suggested in the book to investigate a bone and to explore the effect of calcium deficiency in the bones. The teacher again asked a volunteer to conduct this experiment at home and share the results. She chose a volunteer student and let another one to continue on reading the text about the structure of the bone addressing specifically the function of calcium and phosphorous minerals in the bones, presence of veins, nerves and bone cells in the bones, and the types of the bones. Afterwards the teacher explained the parts of the bones on a figure drawn by her on the board. She asked a few teacher-directed questions to students about the structure and the types of the bones such as “which bone is a flat bone in our body?”. The rest of the class time devoted to reading the text concerning cartilage and the difference between skeleton of an embryo and an adult.

In the following lesson, the volunteer student who assigned to conduct the experiment related to the effect of absence of calcium in the bones explained her design of the experiment and what she found. She showed how the bone became soft and pliable after waiting in the vinegar and concluded that the calcium gives the strength to the bone. The teacher repeated the importance of calcium and other minerals over her presentation. At this point, it needs to be clarified that the activity served as verification of previously introduced idea, not to explore it. The teacher skipped the activity about the joints in the book but suggested students to try it at their home. She explained the types of the joints through the direct teaching. Students studied the figure on the book to understand the examples of joints. Afterwards, she let one student to read the information about the muscles and assigned another student to construct a model of muscle following the instructions written in the textbook and bring next lesson. The model constructed by student was observed by his classmates in the next lesson. The student and the teacher explained how the model represents the work of muscles. Then the teacher gave the explanation of muscle types and the unit of skeletal system was completed by reading from the textbook.

Distinctive from the explained part so far, one of the teachers showed a video related the human skeletal system in her comparison group class. On the video, there were animations explaining the function of bones and joints, and the cooperative work of muscles, joints and the bones during the body moves. After watching the video she lectured the content similarly with the other teacher. At the end of the subject, there was a concept map aiming to self-assessment of students. Some of the concepts in the given map were missing and the students were asked to fill the concepts. The teacher assigned to complete concept map after the class as homework.

The 7E learning cycle instruction in the experimental group was implemented over a period of two weeks. Two separate 7E-LC lesson plans were developed with respect to bones concept, and muscles and joints concept. The students received the instruction about the bones firstly in following seven phases of learning cycle: elicit, engagement, exploration, explanation, elaboration, evaluation, and extend. A summary of the activities conducted in each phases, their purpose, and the addressed student outcome were given in Table 3.7and Table 3.8 and described following each table. Additionally, the handouts used during the activities can be seen at Appendix K and Appendix L.

Table 3.7 Sequence, Purpose and Addressed Variable of Activities in 7E Learning Cycle Instruction Regarding Skeletal System – Bones

7E-LCI Phase	Activities	Purpose	Addressed Variable
Elicit	KWL chart	• To recall students prior knowledge	• Conceptual Understanding • Critical thinking
		• To activate student interest and curiosity through collecting what they want to know	• Task Value / Intrinsic Goal Orientation
	Questioning	• To increase curiosity	• Task Value / Intrinsic Goal Orientation
		• To stimulate students' thinking	• Critical Thinking
		• To take students attention	• Task Value
		• To connect the subject with real life situations	• Task Value
Engage	X-rays	• To develop the idea that x-ray is an imaging test used to observe the bones	• Conceptual Understanding
		• To activate students' curiosity	• Task Value / Intrinsic Goal Orientation
		• To observe x-rays of human bones	• Conceptual Understanding
	Historical Story 'Wilhelm Conrad Röntgen'	• To show how scientific knowledge can change and develop over time	• Scientific Epistemological Beliefs
		• To highlight the necessity of experiments on justifying the scientific knowledge	• Scientific Epistemological Beliefs
		• To illustrate different scientists can hold different ideas and conclusions on same subject.	• Scientific Epistemological Beliefs
	X-rays of Broken Bones /X-rays of Hand Bones at Different Ages	• To develop the idea that the bones are alive	• Conceptual Understanding
		• To think critically to realize the bones are alive	• Critical Thinking
		• To show that the bones grow as people age	• Conceptual Understanding
		• To show bone injuries recover	• Conceptual Understanding

Table 3.7 (Continued)

7E-LCI Phase	Activities	Purpose	Addressed Variable
	Bone cells	• To observe bone cell through a microscope • To develop the idea that the bones are alive	• Conceptual Understanding • Conceptual Understanding

Explore	Chicken Bones Exploration
	Bag # 1
		• To show that bones grow as organism age
		• To distinguish young and old chicken bones
		• To work collaboratively
		• To develop science process skills
		  ○ Observing
		  ○ Inferring
		  ○ Communicating
		  ○ Manipulating materials
			• Conceptual Understanding
			• Conceptual Understanding
			• Peer Learning
			• Science Process Skills

	Bag # 2	• To classify bones
		
		• To demonstrate the type of bones
		• To understand the subjective nature of scientific knowledge
		
		• To work collaboratively
		• To develop science process skills
		  ○ Observing
		  ○ Inferring
		  ○ Communicating
		  ○ Manipulating materials
			• Conceptual Understanding
			• Science Process Skills
			• Conceptual Understanding
			• Scientific Epistemological Beliefs
			• Peer Learning
			• Science Process Skills

	Structuring the Skeleton /Coloring the Skeleton /Exploring the Skeleton Model	• To get familiar with the human bones • To identify type of bones • To locate and name some human bones	• Conceptual Understanding • Conceptual Understanding • Conceptual Understanding

Table 3.7 (Continued)

7E-LCI Phase	Activities	Purpose	Addressed Variable
	Bag #3	• To observe the structure of bones	• Conceptual Understanding • Science Process Skills
		• To infer the functions of the parts of bones	• Conceptual Understanding • Science Process Skills
		• To work collaboratively	• Peer Learning
		• To develop science process skills ○ Observing ○ Inferring ○ Communicating ○ Manipulating materials	• Science Process Skills
Explanations	Questioning - Discussion	• To receive the explanations of students based on the concepts	• Critical Thinking
		• To facilitate the construction of meaning	• Conceptual Understanding
	Why the Bones are Hard and Strong?	• To show that bones consist of calcium	• Conceptual Understanding
		• To develop science process skills ○ Observing ○ Inferring based on observations ○ Hypothesizing ○ Identifying variables ○ Designing Investigations ○ Communicating	• Science Process Skills
Elaboration	Poster Preparation	• To deepen students' understanding	• Conceptual Understanding
		• To apply the learned information	• Conceptual Understanding • Control of Learning Beliefs • Self-Efficacy
		• To elaborate, organize and reconstruct the information	• Elaboration Strategy / Organization Strategy

Table 3.7 (Continued)

7E-LCI Phase	Activities	Purpose	Addressed Variable
		• To work collaboratively	• Peer Learning
		• To seek help from the teacher and others	• Help Seeking
		• To arrange time schedule and study environment	• Time and Study Environment
	KWL chart	• To determine what the students have learned	• Conceptual Understanding
		• To provide students with self-monitoring for their learning	• Metacognitive Self-Regulation
Evaluation	Round-house diagram	• To provide a summary of what is learned	• Conceptual Understanding • Elaboration Strategy • Self-Efficacy • Control of Learning Beliefs
		• To uncover remained misconceptions	• Conceptual Understanding • Metacognitive Self-Regulation
		• To extract the main ideas of subject and sequence the important information	• Organization Strategy
		• To interconnect the concepts of subject matter	• Elaboration Strategy
		• To reflect the concepts in their own words and drawings	• Elaboration Strategy
		• To help students reflecting and monitoring their own learning	• Metacognitive Self-Regulation • Self-Efficacy • Control of Learning Beliefs
Extend	Questioning	• To reveal how do bones move	• Conceptual Understanding
		• To connect the concept of muscles and joints	• Conceptual Understanding • Task Value

7E-LCI related with Bones:

Elicit:

The instruction began with a picture of a building that is under construction and held up by columns. The teacher asked how the building is similar with our body and how this building as well as our body stands. After relation of skeletal system and discussing similarities and differences, the teacher divided the table in two parts to address students' prior knowledge through a KWL chart. KWL chart, developed by Ogle (1986) to evoke what students know at K step, to identify what the students want to learn at W step; and finally to assess what students learned at L step. It was used in the first phase since it encourages students to use critical thinking strategies in order to associate prior knowledge with the recent information, to facilitate the construction of meaning, and to develop intrinsic goals and task value (Shelley et al., 1997). The teacher divided the table and requested students to state what they know about and what they would like to know about the skeletal system. The teacher listed answers of the students on the related part of the table. In this way, the teacher and the researcher had the opportunity to notice students' prior knowledge. Students were mentioned about the basic terminologies like bones, types of bones, the parts of bones, marrow, joints, cartilage, and muscles. Moreover, they stated they are curious about the structure and function of bones, marrow, muscles and joints, as well as how the bones are developed, and how the bones in their body are classified. After stating that they will all be taught about these concepts, the teacher directed several questions to stimulate their critical thinking such as: "How do we stand?, How do we move?", "What do protect our vital organs like hearth and brain?", "Do you know a name of bone in your body" and "Are bones alive or death?". These questions also aimed to connect the topic with students' daily life. The teacher did not present the correct answers of these questions but she asked more questions to deepen their ideas.

Engage:

The teacher asked students how we can see bones in our body. Once they have answered x-rays, the teacher gave the real human x-rays to students in order to investigate the bones and predict the state of the bone that they see in the x-rays on their body. In this way, the teacher let the students to wonder more about the bones and to emphasis the association of topic with real life. Students were asked to discuss about how they would be able to investigate the bones before the invention of x-rays. Then, a historical short story was distributed to students as a handout (See Appendix K). In this handout, the life of Wilhelm Conrad Röntgen, who produced and detected x-rays, was introduced to students (Adapted from http://en.wikipedia.org/wiki/Wilhelm_R%C3%B6ntgen). The aim of this story was to highlight that the science is an evolving subject, the experiments are necessary on the justification of scientific knowledge, and the scientists may derive different conclusions while working on the same content. In this purpose, the teacher directed probing questions when the students were finished reading. Students expressed their ideas about the story and the teacher tried to direct students' explanations in the mentioned aim. After listening the students' answers, the teacher explained that x-rays are helpful in diagnosing injuries on the bones and distributed students the real x-rays of broken human bones. When they were observing the broken bones, the teacher requested students to discuss how these bones will repair. After taking their ideas, she presented a picture showing x-rays of a person from ages of 8 months to 18 years (Derived from http://goo.gl/3PGsTv) (See Appendix K). Teacher encouraged a whole-class discussion about the differences between the pictures to make students realize that new bones start to form, some bones become compacted in the wrist, and some bones coalesce during aging. She also highlights the difference between the bones at baby ages and at grown ages. When the students realize the differences the teacher oriented them to think about how these processes occurred. During the discussion, the teacher challenged students' critical thinking by directing a question about if the bones are dead or alive. At this point, students were expected to realize the bones are alive and justify their idea by explaining that the bones are formed by cells. Once they gave the expected answer, the teacher let the students to observe bone cells through the microscope. The teacher justified students' ideas with stating that their body keeps bone-building throughout life, and their bones consist of cells that responsible to make new bones and to help repair the fractures.

Explore:

In the exploration part, the students formed groups including five people to explore the chicken bones. Each student was given a worksheet that explains their steps to follow during the activity and probing questions to think and discuss with the group members (See Appendix K). This activity consisted of three different bags of chicken bones. Bag #1 contained two leg bones removed from a young chicken and an old chicken to distinguish and intended to show that bones grow as organism ages. Bag #2 included all the bones removed from a chicken to demonstrate the different type of bones and allow the students to make their own classification. Bag #3 contained broken bones that students can investigate the structure inside of the bones. During this activity, students were expected to focus in science process skills such as, observing, inferring, communicating and manipulating materials. The worksheets were developed in the frame of this aim and firstly requested to fill out their observations and then draw inference about their observation while answering the driving questions in the group. Moreover, classification comparisons between groups conducted during the investigation of Bag #2 was intended to stress the subjective nature of scientific knowledge. The collaborative working in groups is intended to develop students' mutual knowledge development and peer learning skills. Moreover, students strive to interpret the explored phenomena by connecting their existing knowledge which in turn may develop their critical thinking and effort regulation. Investigation of each three bags can be clarified as following.

The researcher supplied the class with magnifies and three bags for each kind of Bag #1 and Bag #2. The groups in the class used the bags rotatory. That is, some groups were investigating Bag #1 while the others were working on Bag #2. When the groups completed answering the questions related their bags they switched them with the other groups. All of the bags were transparent and durable to let the students investigate the bones clearly and safely without removing from it. Moreover, Bag #1 and Bag #2 contained boiled bones to provide bones removed from all meat and other tissues. Bag #3, however, contained raw bones to let students observe the structure of a bone. During their explorations, the teacher assisted students to connect their own knowledge and experiences with the classroom instructions by asking inquiry questions. Sometimes students had difficulty to respond the question at the worksheet and requested the help of teacher. In that kind of situations she encouraged students to find out the answer by providing clues rather than answering the question.

When the students done the activities for Bag #1 and Bag #2, the teacher distributed 17-piece hard-paper human skeleton puzzle to connect the knowledge about chicken bones with the human bones and skeleton (See Appendix K for the puzzle pieces). Students were engaged to make the puzzle in order to shape the human skeleton while also discussing about the names of some bones on the pieces. During their group works, the teacher oriented them to use the names of some specific bones such as skull, femur, vertebra, ribs and phalanges. Once they finished the puzzle the teacher let them to explore a realistically detailed tabletop skeleton model and confirm their final shape of puzzle. Then she distributed crayons and a coloring page to highlight the type of bones in human body (See Appendix K). Students were expected to color the bones on the picture individually based on their classification as long bones, short bones, and flat bones. The teacher warned students about not to paint the bone if they are not sure about its type and she checked all papers and gave feedbacks during the activity. Students also labeled the name of bones that they know on the paper and shared with their peers. Afterwards, students reformed their groups with 5-people and the teacher handed out Bag #3 of chicken bones with the respective worksheet. This bag was including broken bones aimed to observe the structure and to infer the functions of the parts of the bones.

Once the groups concluded investigating the bags, answering the questions by in-group discussions, and also picturing their observations on the worksheets, the teacher passed the next page to engage them in a whole-class discussion to reflect their ideas related with their explorations.

Explain:

In this phase the students shared their experiences at the previous phase and introduce their explanations. All questions on the worksheets were referred in whole class discussions and the teacher asked more questions like “Why do you think like that?”, “Based on your which observation did you make this inference?” in order to get deeper and detailed explanations as well as to demand critical thinking. In general, students were agreed on distinguishing older and younger bones, type of bones, the importance of bones for chicken as well as human body, and the structure of the bones. While students were reflecting their observations and ideas, the teacher wrote the key terms on the board such as ‘bones are hard and strong’, the older chicken bone is longer than the younger chicken bone, ‘bones grow as you grow older’, and type of bones are long bones, short bones, and flat bones. Students’ own classification of bones were varied and some of them confused with the joints since they used terms like movable or mobile, immovable, and semi-mobile bones. At this point these students were asked how they decided if the bone is able to move or not, and encouraged to think about the joints. The teacher introduced that the bones classified as short bones if their vertical and horizontal dimensions approximately equal and they generally have a roughly cube shape. When she requested examples for this type of bones from the human body, some students had mistaken phalanges as short bone. She warned them to think about again if it fits the explanation for the shape of short bones. Then, she explained if the bones are longer than their width they are called as long bones. The students agreed about the type of phalanges and gave other examples for short and long bones. Explanation of flat bones was presented as thin and flattened bones and students gave the example of skull altogether.

Students were asked about their observations related with the structure of the bones. The teacher drawn a bone and extracted its parts on the board based on the students explanations. An argumentation occurred about the question of “What role does the hollow inside the bone, and spongy bone part?”. Some students argued that the only reason is having vessels and marrow inside. They also explained marrow might be very important and need to be protected by the bones. Following the students’ explanations the teacher added the information related to the bones are strong and hard, yet lightweight. Bones need to be light since it would be far difficult to make activities and its complex internal structure provides to maintain strength without being heavy. Moreover, it has some flexibility provided by spongy bone to tolerate the pressure on the bones during the activities. She gave a whole explanation about the structure of the bones, the role of the marrow on storing fat and developing blood cells and asked what makes the bones so strong. Most of the students answered terms like proteins, minerals and calcium. Some student asserted if they drink milk, the bones get stronger. Thereupon, the teacher asked which material in the milk may strengthen the bones and most of them predicted Calcium as the answer. Then students were challenged to design an experiment to test if the calcium is responsible with the hardness of the bones. A foreknowledge was given to students about that acid damages calcium mineral. The teacher handed sheets that developed to design an experiment considering science process skills like stating hypothesis, identifying variables, operationally defining and designing investigations (See Appendix K). Students were expected to shape the idea in the class and conduct the experiment at their home. Thereupon, they answered all parts except the observations and results on the sheet. Most of the groups decided to put the bone in vinegar and wait. Some groups determine to put a lid on the jar to be able to control their set up. One group decided to constitute a comparison group with a bone submerged in water. The researcher asked them the reason after the course and they stated they were curious about if it will be soft because of staying in a liquid. Next lesson, all groups were excited to show their bended bones to each other and to the teacher. She investigated all of the results and summarized students' design on the board. She highlighted the hypotheses, independent, dependent variables, controlled variables, and the procedure based on their answers. She asked their conclusions with respect to reason of strength in bones and all agreed on the effect of calcium mineral. Finally, the teacher added phosphor also helps to bones to be strong and discussed the importance of nutrition and exercise to have healthy bones.

Elaborate:

In this phase, the students had the opportunity to apply their knowledge in a new situation; a poster preparation about the skeletal systems and bones. For that purpose, the teacher divided the students to form 6 groups and explained her expectations for the poster; they were free to use any kind of material, it needs to be creative and present the accurate information for human bones, and also hand-writing is requisite but they can use pictures from other sources. Deadline for the poster was 1-week later and students' productions were displayed on the walls of the class. Examples of students' posters can be seen at Appendix P. During the poster preparation students were expected to use elaboration and organization strategies to decide the main ideas to cover in the poster. They arranged their own time schedule and study places with peers which may develop their time and study environment strategy use and peer learning. They asked for help from their parents, teachers and other groups about the design, materials, or information on the poster. Presenting the products of their efforts and realizing the change on their learning may develop students' self-efficacy, control of learning beliefs, and metacognitive skills.

Moreover, in this phase the teacher completed L part of KWL chart to provide a summary of what was learned. This part is also effective to make students aware of their progress which results in metacognitive self-regulation strategies. She wrote down all responses from the students to the question of what they learned about the bones. They generally stated the terminologies like type of bones, joints and muscles besides the important ideas of the subject such as; “the bones are alive and consists of cells”, “red marrow is responsible to produce blood cells while yellow marrow to store the fat and to help red marrow”, “Calcium makes the bones stronger”.

Evaluate:

The conceptual understanding of students was planned to asses through the related items of Skeletal System Conceptual Inventory which implemented at the end of the instruction about Skeletal System concepts. Moreover, students were requested to fill a roundhouse diagram which is a visual strategy to enhance learning, reflect the knowledge of students, and apply the acquired information (Ward & Lee, 2006). Students use various learning strategies in order to develop a roundhouse diagram. They extract the main ideas of the topic, develop a sequence between the detected information, form the relationship between the concepts and write and draw these concepts in their own style. These behaviors are related with elaboration and organization strategy use. Roundhouse is also efficient to make students realize their remained misconceptions which activate metacognitive skills such as reflecting and monitoring own learning. Their awareness on own progress may facilitate self-efficacy and control of learning beliefs. The diagrams investigated by teacher (see Appendix O) to determine if there was any deficiency on their comprehension and provided feedbacks.

Extend:

At this last phase, the purpose was to transfer students' learning to next concept, joints and muscles. In order to achieve this aim, the teacher directed following questions to connect their existing knowledge about the bones with the joints and muscles.

- How do we move our bones? What do allow our bodies to move in different ways?

- How the bones in our body connected to each other?

The students' initially responses were like 'through our brain, it gives the order to move' or 'it moves because we want to move'. The teacher oriented them to focus on the structures on her arm while she was moving it and asked them what they see as the responsible ones again. Then the students realized that she was talking about the joints. At this point the teacher asked what the structure that moves the bones and joints is. When the students figured out the muscles the teacher passed to the next subject.

Table 3.8 Sequence, Purpose and Addressed Variable of Activities in 7E Learning Cycle Instruction Regarding Skeletal System – Joints and Muscles

7E-LCI Phase	Activities	Purpose	Addressed Variable
Elicit	KWL chart	• To recall students prior knowledge • To activate student interest and curiosity through collecting what they want to know	• Conceptual Understanding • Task Value / Intrinsic Goal Orientation
	Questioning	• To increase curiosity • To take students attention • To connect the subject with real life situations • To recall students prior knowledge	• Task Value / Intrinsic Goal Orientation • Task Value • Task Value • Conceptual Understanding • Critical Thinking
Engage (I)	Attaching sticks to the fingers and arms	• To demonstrate the importance of joint use	• Conceptual Understanding
	Questioning	• To discuss the importance of joints • To discuss the reason of moving fingers more than necks • To realize the types of joints	• Conceptual Understanding • Critical Thinking • Conceptual Understanding
Explore (I)	Chicken Wings/Legs Exploration	• To investigate the structure of joints • To make observation and draw inference • To work collaboratively	• Conceptual Understanding • Science Process Skills • Peer Learning

Table 3.8 (Continued)

7E-LCI Phase	Activities	Purpose	Addressed Variable
	How to Reduce Friction?	• To demonstrate the cartilage and synovial fluid reduces the friction between bones	• Critical Thinking
Explain (I)	Questioning - Discussion	• To receive the explanations of students based on the concepts • To facilitate the construction of meaning	• Conceptual Understanding • Conceptual Understanding
Engage (II)	Questioning	• To discuss the importance of muscles • To discuss the reason of voluntarily moving arms but not internal organs • To realize the different types of muscles	• Conceptual Understanding • Critical Thinking • Conceptual Understanding
Explore (II)	Muscle Types Exploration	• To distinguish the structure of skeletal and cardiac muscles • To develop science process skills ○ Observing ○ Inferring ○ Communicating ○ Manipulating materials • To work collaboratively	• Conceptual Understanding • Science Process Skills • Peer Learning
	Muscle Cells	• To observe different types of muscle cells through a microscope • To distinguish the cells structures of skeletal, smooth and cardiac muscles • To make observation and draw inference	• Conceptual Understanding • Conceptual Understanding • Science Process Skills
Explain (II)	Questioning - Discussion	• To receive the explanations of students based on the concepts • To facilitate the construction of meaning	• Conceptual Understanding • Conceptual Understanding

Table 3.8 (Continued)

7E-LCI Phase	Activities	Purpose	Addressed Variable
Elaborate	Muscles and Joints Stations	• To discover the muscles and joints in their own body • To realize the systems of body are working cooperatively.	• Conceptual Understanding • Task Value • Critical Thinking
	Muscle-Joint Model	• To apply the learned information on a model • To elaborate, organize and reconstruct the information • To work collaboratively • To seek help from the teacher and others • To arrange time schedule and study environment	• Conceptual Understanding • Elaboration Strategy • Organization Strategy • Peer Learning • Help Seeking • Time and Study Environment
	KWL chart	• To determine what the students have learned	• Conceptual Understanding • Metacognitive Self-Regulation
Evaluate	Round-house diagram	• To provide a summary of what is learned • To uncover remained misconceptions • To extract the main ideas of subject and sequence the important information • To interconnect the concepts of subject matter • To reflect the concepts in their own words and drawings • To help students reflecting and monitoring their own learning	• Conceptual Understanding • Elaboration Strategy • Self-Efficacy • Control of Learning Beliefs • Conceptual Understanding • Metacognitive Self-Regulation • Organization Strategy • Elaboration Strategy • Elaboration Strategy • Metacognitive Self-Regulation • Self-Efficacy • Control of Learning Beliefs

Table 3.8 (Continued)

7E-LCI Phase	Activities	Purpose	Addressed Variable
Extend	Questioning	• To make a connection with the circulatory system	• Conceptual Understanding

7E-LCI related with Joints and Muscles:

Elicit:

To identify students' prior knowledge and to develop intrinsic goals in students, the teacher fill a KWL chart on the board based on the students' statements. They mostly specified the places of the joints, cartilage in joints structure, and their role in the movement of body. They demanded to know more about the structure and function of joints and muscles, how they work, and what their varieties are. Then the teacher asked some probing questions like 'What would happen if we do not have any joints?', 'Why cannot I move my neck as much as my arms?', "Why do we feel a pain on our legs when we run and exhaust?" and "Why do you think I can control the movement of my arm and but not my heart?". She did not expect the correct answer from the students but just activated their critical thinking and increased curiosity to facilitate task value.

Engage (I):

The teacher supplied little sticks to students and requested them to tide the sticks on their five fingers. Then she discussed the importance of the joints when the students exploring the impossibility of handling something with that sticks. Students' critical thinking was challenged by the teacher through a question. She asked if the sticks would prevent the movement less or more than fingers when they tided on their necks and let them discuss about the difference between fingers and necks with respect to joints.

Explore (I):

In this phase, the students explored the structure of joints derived from chicken wings and chicken legs. They took notes about their observations (color, shape, and strength) on the worksheets and replied the questions (See Appendix L). At the beginning, they formed groups and worked collaboratively with their peers during the investigation. Another goal of this activity was to draw inference based on the observations and the questions on the worksheet were developed in line with this goal. When students completed their worksheets the teacher gave them materials to explore the function of the parts of joints that they observed on the chicken legs. Actually, the last two questions of the sheet gave a clue about the function of these parts and this activity was designed to demonstrate the idea that cartilage and synovial fluid reduces the friction between the bones through an analogy. Students were asked to rub two wooden blocks to each other. Then they covered the blocs with the transparent plastic bags and rub them. Finally they put some liquid detergent between the blocs and tried again. In their handouts (See Appendix L), they were expected to order their experiences in each trial with respect to feeling of lubricity. Additionally, they were asked to match the materials with the parts of real joints. Students' explanations were taken about their all explorations in the next phase.

Explain (I):

At the end of the activity the questions were discussed with whole class and the teacher directed a question about if we have a joint similar to observed one in our body. With this question students stated the places of moveable joints like knee, shoulder, elbow and fingers. Some students referred the other types as stating joints in skull that connects the bones but stills stationary. After receiving these ideas the teacher let them to investigate how the bones on the body connect with each other on a mini skeleton model. This model was provided by the researcher to offer a hands-on learning experience. The teacher stated the joints are classified based on the degree of movement they allow and took students' ideas about the variety that they observed on the model. They stated the joints on the skull, vertebra and knees or arms as different from each other. The teacher provided a whole explanation about the types of joints and referred their confusions with the types of bones in the previous activates. Then she asked whether it would be possible to use joints without the muscles to move the next subject.

Engage (II):

The aim of this phase was to orient the students to think about the importance of muscles and to realize the types of muscles. For that aim, the teacher challenged the critical thinking of students with a discussion about the reason of voluntarily moving arms but not the internal organs. Students commented on this discussion and mostly stated the deficient answers such as; “Because the internal organs are vital.”, “Because we do not have any bones or joints in them (internal organs)”, “Because it is the function of brain to move them.”, and “Since we have muscles in our arms but not in our organs.”. Toward the end of this discussion the teacher established a desire to learn by stimulating their curiosity. Then she passed to the activity by stating “Let’s see if we find out the answer by observing the muscles”.

Explore (II):

The exploration activity was specifically designed to distinguish the structure of skeletal and cardiac muscles. Similar with the previous ones, students investigated the muscles and noted their observations on the related sheets (see Appendix L). Students formed groups of five people and conducted their investigations with their peers. Each student handled a worksheet to fill the observations and answer the questions. To investigate, a piece of boiled skeletal muscle (lamb meat) and a piece of boiled cardiac muscle (lamb heart) were supplied to students in a dissection pan. The meats were boiled in order to increase the dissection of fibers and prevent the possible infections of raw meat. During the activity students were recognized the structural difference between two muscles taken from different places of body while using science process skills like observing, inferring, communicating and manipulating the materials. The last question in the sheet directed students to make inference about the human muscles from their observations. After the students’ curiosity about the difference between the muscles in human body was emerged, the teacher obtained slides of three types of muscles: skeletal, cardiac and smooth to observe through a microscope. Students investigated each muscle type and took notes about the characteristics of them.

Explain (II):

The teacher oriented the students to explain their observations and driven inferences to their classmates. All groups, based on their experience, were agreed the idea that the functions of the muscles are different in the difference of structures. The teacher gave whole information about the types of muscles and their functions on the board. She directed the previous question related with not controlling the internal organs movements and but managing to move the arms or legs. This time students' responses were based on the types of muscles.

Elaborate:

In this phase, students are focused to use some specific muscles and joints in their body. At the break time, the researcher created four stations around the class each presents a mini poster about the related issue (See Appendix L). The posters were presenting pictures and information in terms of face muscles, cardiac muscles, chest muscles and diaphragm, and movement of joints. Students enjoyed guessing which muscle of their face is in use when they w ere performing different mimics in a station. In other station, they noticed the working of their cardiac muscles by feeling their heart. Another one presented information to feel the chest muscles as well as diaphragm muscle and to figure out how they move during inhalation and exhalation. Last station covered pictures of some basic movements on the body and have students to perform the figures on the poster while inquiring the joint moving in that moment and its classification. These stations were effective to connect the topic with students existing structures and to let students to internalize the subject matter. A general purpose of this activity was to have students understand human body systems work cooperatively. Skeletal System was emphasized as having important roles in working of Circulatory and Respiratory Systems. Students are expected to intercorrelate the systems by thinking critically about the body as a whole.

Afterwards, to apply their learning to a new situation, students were expected to build a model of arm that shows how the muscles work to move bones and joints. Students worked as groups of 5 people and a picture of example about the model was shown to students (See Appendix L for the example). Students firstly investigate the topic and decide the design of their model. They activated their creativity and critical thinking to design a model while applying peer learning, help seeking, and time and study environment strategies. During the construction, the teacher and the researcher helped them in accessing the materials. They brought their final models next week to the class and presented how they work. It needs to be mentioned that there were groups who did not prepare a model but they examined the others' products. Some models reflected the correct idea that the bones and joints are moving as a result of the muscle contraction. However, some others showed that the muscle was contracting because the bones were moving. The similarities and differences between the models were discussed in the class and the teacher helped the students to understand the mentioned correct idea behind the models.

Finally, the teacher completed L part of the KWL chart on the board with whole class to document what the students acquired. They briefly mentioned the types of muscles and joints, stated their functions, fiber structure of skeletal muscles, how they work together to move bones and how the muscles help to inhale or exhale. This part is effective to help students to realize their own effort and progress which facilitates metacognitive skills and self-regulation.

Evaluate:

Students' understanding of muscles and joints were assessed through the related items of SSCI. Moreover, they filled roundhouse diagrams to show their comprehension of concepts and summarize the topic (See Appendix O). They encouraged using elaboration and organization strategies while distinguishing the important ideas, ordering and summarizing the information, and correlating the concepts to fill the diagram. The teacher and researcher evaluated their diagrams and gave feedback to students. What is more, this diagram helps students to realize the knowledge deficiencies and to reconstruct knowledge if needed which activate metacognitive skills such as reflecting and monitoring own learning. In addition, the awareness of their own progress may facilitate self-efficacy and control of learning beliefs.

Extend:

In order to make a connection with the next subject, the Circulatory System, the teacher directed some questions to students. Firstly she asked "How do we produce the required energy for muscle contraction?" and students said "from foods that we eat.". Thereupon she added "How do we transport the foods that we eat to the muscles?". The students responded as the blood is responsible to carry them. The teacher directed them to say circulatory system instead of blood and asked "What is the importance of our skeletal system for our circulatory system?". They answered this question based on their experience gained during the activities. Then the teacher got through the next unit.

After the topic of Skeletal System was covered, SSCI was administered in both groups as post-test to measure students understanding in the concept. Additionally, CSCI was implemented to both groups as pre-test before at the outset of Circulatory System instructions. Moreover, one-month later the administration of SSCI, students were implemented again with the same test to investigate the follow-up results.

3.5.2 Instructions Related to Circulatory System

The curriculum based instructions in comparison group took about 2 weeks, including 8 lessons. Similar with the previous one, the teachers directly explained the concepts, asked questions to connect the subject with the daily life and have students read the related parts from the textbook. The subject in the textbook started with a passage from newspaper about the blood transfusion and directed questions to let the students discuss about hearth, blood types, and structure of blood. The teacher introduced the basic components of the Circulatory System as hearth, blood and blood vessels. She showed the place of heart over a human torso model and let the student examine it. She stated the function of the hearth as the body's circulatory pump and explained about the four-chambered structure of it. At this point, the textbook suggests activities with respect to dissection of a hearth and investigating blood cells through the microscope. However, the teachers preferred to use visual materials; one used animations to explain how the hearth works, the structure of hearth, and the constituents of blood and the other presented pictures of a dissected hearth and images of blood cells under a microscope. Then the teacher let a student to read aloud the descriptions on the textbook related with pulmonary and systemic circulation, vessels and function of blood cells. At some points, she stopped the reading and introduced extra information about the subject. Thereafter, the teacher asked if the students learned their own blood type as assigned in previous class. She listed each type came from the response on the board and made a joke over the students with 0 type by stressing the low frequency to exist. Then the parts about the blood donation and lymphatic systems were read from the textbook. Considering the immune system the teacher took students experiences over the illnesses and lectured how the body is protected against diseases. She explained the difference between bacteria and viruses and the role of medication based on the readings in textbook. At the end of the subjects, there was a flowchart to let student evaluate their learning individually. It was giving statements about the subject and a path that the students decide to fallow if the statement is true or false. The teacher assigned to complete the flowchart after the class as homework.

Students in the experimental group received Circulatory System instruction based on 7E learning cycle method over two and a half week period. Two separate 7E-LCI lesson plans were designed; first one covers the subjects of structure and function of the heart with pulmonary and systemic circulation while the other involves structure and function of blood, and blood types. A summary of the activities conducted in each phases and their purpose were given in Table 3.9 and Table 3.10. A detailed description for each activity was provided following the tables and handouts were presented in Appendix M.

Table 3.9 Sequence, Purpose and Addressed Variable of Activities in 7E Learning Cycle Instruction Regarding Circulatory System – Hearth and Circulation

7E-LCI Phase	Activities	Purpose	Addressed Variable
Elicit	KWL chart	• To recall students prior knowledge	• Conceptual Understanding • Critical thinking
		• To activate student interest and curiosity through collecting what they want to know	• Task Value / Intrinsic Goal Orientation
	Questioning	• To increase curiosity	• Task Value / Intrinsic Goal Orientation
		• To take students attention	• Task Value
		• To connect the subject with real life situations	• Task Value
Engage	Historical Story in Circulatory System	• To show how scientific knowledge can change and develop over time	• Scientific Epistemological Beliefs
		• To highlight the necessity of experiments on justifying the scientific knowledge	• Scientific Epistemological Beliefs
		• To illustrate different scientists can hold different ideas and conclusions on same subject.	• Scientific Epistemological Beliefs
		• To elaborate the main ideas in the text	• Elaboration Strategy
	Finding the Heath Beat with Stethoscope	• To find out the places to feel heartbeat on the body	• Conceptual Understanding
		• To activate students' curiosity	• Task Value
Explore	Changing My Heartbeat	• To investigate the effect of exercise on heartbeat	• Conceptual Understanding • Critical Thinking
		• To work collaboratively	• Peer learning / Help Seeking

Table 3.9 (Continued)

7E-LCI Phase	Activities	Purpose	Addressed Variable
		• To develop science process skills ○ Observing ○ Inferring based on observations ○ Hypothesizing ○ Identifying variables ○ Designing Investigations ○ Graphing the Data ○ Communicating	• Science Process Skills
	Dissection of a Lamb Heart	• To investigate the structure of the heart	• Conceptual Understanding
		• To infer the function of the heart based on the observations	• Scientific Epistemological Beliefs
		• To work collaboratively	• Peer Learning
Explain	Questioning - Discussion	• To receive the explanations of students based on the concepts	• Critical Thinking
		• To facilitate the construction of meaning about the heart	• Conceptual Understanding
		•	•
	Floor Map - Circulation of Blood	• To demonstrate the circulation of blood through the body	• Conceptual Understanding
		• To distinguish the pulmonary and systemic circulations in a visualized path	• Conceptual Understanding • Critical Thinking
		• To show the diversity of pulmonary artery and pulmonary vein from the other arteries and veins in the body	• Conceptual Understanding • Critical Thinking
Elaborate	Painting the Circulation	• To apply the path of oxygenated and deoxygenated blood	• Conceptual Understanding
		• To recognize the roles of blue and red colors on the circulatory system figures	• Conceptual Understanding • Critical Thinking

Table 3.9 (Continued)

7E-LCI Phase	Activities	Purpose	Addressed Variable
	KWL chart	• To determine what the students have learned	• Conceptual Understanding
		• To provide students with self-monitoring for their learning	• Metacognitive Self-Regulation
	Poster Preparation	• To deepen students' understanding	• Conceptual Understanding
		• To apply the learned information	• Conceptual Understanding • Control of Learning Beliefs • Self-Efficacy
		• To elaborate, organize and reconstruct the information	• Elaboration Strategy /Organization Strategy
		• To work collaboratively	• Peer Learning
		• To seek help from the teacher and others	• Help Seeking
		• To arrange time schedule and study environment	• Time and Study Environment
Evaluate	Round-house diagram	• To provide a summary of what is learned	• Conceptual Understanding • Elaboration Strategy • Self-Efficacy • Control of Learning Beliefs
		• To uncover remained misconceptions	• Conceptual Understanding • Metacognitive Self-Regulation
		• To extract the main ideas of subject and sequence the important information	• Organization Strategy
		• To interconnect the concepts of subject matter	• Elaboration Strategy
		• To reflect the concepts in their own words and drawings	• Elaboration Strategy

Table 3.9 (Continued)

7E-LCI Phase	Activities	Purpose	Addressed Variable
		• To help students reflecting and monitoring their own learning	• Metacognitive Self-Regulation • Self-Efficacy • Control of Learning Beliefs
Extend	Questioning	• To reveal the curiosity about the structure of blood	• Critical Thinking • Task Value
	Homework for Next Concept: Blood Test Result	• To realize the blood has a complex structure	• Conceptual Understanding • Task Value

7E-LCI related with Hearth and Circulation:

Elicit:

The teacher started the lesson by filling the KWL chart on the board with all students to evoke their prior knowledge and prompt their natural curiosity. In terms of prior knowledge, they had already known about the blood circulates through the vessels and the components of system are heart, vessels and blood. They were familiar with the four-chambered structure of the hearth but confused in the function of heart. Some of students were thinking heart is responsible to develop blood cells while some others adding it store the blood. They also mentioned that there are veins, arteries and capillary with respect to type of vessels but some were also mistaken abdominal aorta as a type of vessel. Moreover, they stated clean and dirty blood (temiz ve kirli kan) to refer oxygenated and deoxygenated blood while explaining type of bloods. Students wanted to learn more about how the blood circulates in the body, the structure and function of blood and blood cells, and Rh factor. Extracting what they want to learn leads students to develop intrinsic goals which refer to learning in order to satisfy the curiosity and to master the topic.

When the first two parts of KWL chart completed the teacher asked probing questions like “Does the blood circulates all over the body?”, “Why this is important for us?”, “How does it circulates in the body?”. Students were aware that blood circulation is vital for living things and blood is responsible to carry food and other important things through the body. However, they realized the deficiency in their knowledge and demonstrated a desire to learn.

Engage:

In engage phase, a short story about the history of discovery in Circulatory System was distributed to students as a handout (See Appendix M). In this handout, students were informed about the scientific views, investigations and explorations toward the Circulatory System from the times Before the Common Era to nowadays.

The story was derived from the scientific article (Aird, 2011) and Vikipedi (http://goo.gl/kZVp5o) to show students the thinking and knowledge of scientists on the circulatory system are not certain but evolving through the history. It was also emphasized in the story; the scientists make inferences based on their observations and the experiments which are necessary to construct and justify the scientific knowledge. The students were first asked to read the story individually then a volunteer student read it aloud. After they finished the reading, the teacher conducted a whole class discussion to stress the specified purposes. The teacher engaged student to argue about how the ideas changes over time, what are the factors on these change, whether all views are true or not, how the scientist builds new knowledge on the previous ones, and how they decides their mentioned ideas. Students' answers to changing nature of scientific knowledge were driven the samples from the story, for example; "People was thinking the arteries carries air, not blood, but now we know it does not" and "Malpighi observed capillaries by means of the development the microscope. With the new developed technology, we can also discover more about the circulatory system". Some students claimed there is nothing to discover in circulatory system anymore and claimed that our technology is enough to observe everything. They stated "We probably know everything there is to know about human body, MR imagining systems show everything in detail." However, others supported quite opposite idea and justified their answer saying "He (Harvey) also believed that he discovered everything about the circulatory system but he was wrong, so scientist may also discover new matters tomorrow that justify we were wrong or deficient today.". Considering the importance of experiments and observations they stated "They (Ibn-Nefis and Harvey) probably inspected many human bodies and maybe other living things to get the idea". The teacher described that Harvey's experiments and discoveries are more known than Ibn Nefis and asked the reason. They used elaboration strategy as they turned back to the story to seek the answer and figure out the importance of communication to declare the scientific discoveries. Moreover, when the students mentioned the developments in the science and technology about the circulatory system the teacher reminded the stethoscope which mentioned in the text. She distributed real stethoscopes to students to find the location of their heart and the best places to hear the sound of heart bumping. Students easily found the place of heart and tried their chest, neck, wrist and back to hear the pulse. This activity attempted to increase the interest and utility of the topic. Then the teacher prepared the students for next activity by questioning whether the heart beat is always at the same rate or not and how it changes.

Explore:

In the exploration part, the students were given an experimental situation, in which they investigated the effect of exercise and resting on the heartbeat. Another purpose of the activity was to develop science process skills on the students which were observing, inferring based on observations, hypothesizing, identifying variables, designing investigations, graphing the data, and communicating. Students activated their critical thinking during the design of the experiment and applied peer learning during the whole task.

At the outset of the activity, students' prior experiences were taken by showing a picture of two kids; one is resting and the other is running. Students were what they expect to realize if they listen to the heartbeat of these students. After taking their predictions, teacher formed groups of 3 students, and each group was given handouts, a stethoscope and a watch for the activity. In this activity, students were expected to design an experiment to explore how the physical exercise and resting affect the heartbeat. In their groups, each student was assigned a specific role as writer, counter, and experimenter; the role of the writer was to recode the data, counter's role was to observe and collect the data, and the experimenter's role was to exercise and rest to change heartbeat. Before the data collection process, they developed a hypothesis, listed the variables as dependent, independent and controlled variables, defined the materials and procedure and made predictions about the results. During this process, the teacher acted as a facilitator; investigated students' handouts, corrected their mistakes by challenging them with leading questions, and helped them on graphing their data. All of the groups hypothesized and predicted that the exercise is going to increase the heartbeat. They had difficulty to decide controlled variables. The teacher recommended them to think what they are not going to change while changing the physical activity or measuring the heartbeats to prevent its' possible effects on the result. The groups' decisions of the time periods to measure the beats varied from 10 seconds to 30 seconds. They were expected to multiply their data to calculate heartbeat per minute. The teacher suggested jumping as an exercise considering the convenience in the lab environment. Each group counted their heartbeats and calculated the hearth rate. After obtaining the relevant data, they filled the table provided on the handout and graphed their data. Then the teacher collected all data related with the hearth rates from each group and filled the table on the board. She initiated a whole class discussion with respect to variables, the experimenting process and directed students to derive a conclusion about how jumping and resting affects hearth rate based on the data on the board. When she was certain on the students get the related science process skills from the activity, she asked the reason of the increase on heart rate as they exercise and continue with the structure and function of heart with the next activity.

Students' responses to previous question were generally not scientifically acceptable such as "since our body uses all energy and needed more", "because we need to produce more blood", "since the body needs more food and the blood carries more food", " since more oxygen required and heart pumps more oxygenated blood". It was clear that students were aware of that heart pumps blood to all over the body. However, the answers revealed that they have misunderstandings such the heart produces blood and naïve ideas such as the blood only carries the required matters like food and oxygen but not the wastes or carbon dioxide. They were also unable to explain how the body converts energy from the substitutes of blood. Thereupon these answers, the teacher explained they will learn about structure and the function of heart by observing a dissected heart.

Before the activity, students were divided to form groups of five students and each student was given the worksheet. At the beginning of the activity, the teacher explained they were investigating a sheep heart since it is similar with the human heart as both are classified as mammalians. Because of the safety and hygiene concerns, the students were not allowed to dissect the heart but only to observe a full and opened hearts. However, before their investigations, the teacher demonstrated the dissection of a sample heart in front of all students. She showed the vessels on the top of the hearth without giving the names and cut the heart in half lengthwise starting from the aorta by a dissecting scissor. She showed the chambers of the heart and the valves to the students. Then each group was given a full heart and dissected heart in a pan to investigate. Students wore latex gloves during their investigations. They observed both outside and inside of the part and recorded their observations on the worksheet. They enjoyed to put their fingers in the vessels and to demonstrate the path of blood flowed inside the heart. To answer a question in the worksheet, students searched the names of the vessels on the heart from their book and tried to match the labels. The teacher oriented them at this point to figure out the aorta, pulmonary vein, pulmonary artery, and superior vena cava. During their observations and worksheet fill, the teacher guided them to realize the blood do not pass between right and left sides of the heart, rather it enters to the heart and leaves the heart through the vessels on the top. Once the students completed their observations and answering the questions on the worksheets the teacher initiated a discussion in the class to take their explanations in the next phase.

Explain:

The teacher encouraged students' to explain their observations and inferences while recording their answers to the questions on the worksheets and sharing them in class discussion. The teacher occasionally added more explanations about the constructs or asked additional questions to get deeper descriptions from students based on their answers. For example, concerning the structural difference between the ventricles and atrium, some of the students' inferences reflected misconceptions. She tried to help them with the guiding questions such as "How the blood enters and leaves the heart?” and “Which part of heart is responsible for pumping the blood”, In this way, the students realized ventricles have a more muscular structure compared to the atrium since they have to produce enough pressure to pump the blood out of the heart. Thereafter the teacher taught the parts of the heart again and drew a figure on the board to help students visualize the flow of blood inside the heart. She stressed the function of heart as to pump the blood through the body and the blood is not produced in the heart. She asked the organs responsible for producing blood cells and detailed the where the blood is produced in body based on students’ responses.

The next activity of explanation part involved demonstration of blood circulation through the body on a map drew on the floor (See pictures at Appendix M). The blood circulation floor map was inspired form the study of Monzack and Petersen (2010). It was aimed to help students visualize the pulmonary and systemic circulations to the extent possible and provide an environment that students can learn during game playing. For the activity, three big posters for heart, lungs, and body cells were prepared to put on the floor. The poster for heart consisted of a figure representing the chambers of heart and the vessels that connected to the chambers. The lung poster contained a figure of lungs and the poster for body cells had only the writing not any figure. The researcher set up the floor map as lungs poster at the top, heart poster in the middle, and finally blood cells poster to the bottom. The connections between the posters, which are arteries and veins have been drawn by chalk on the floor. The activity was planned to be implemented at the school garden however conducted in gym due to the rainy weather. To provide the stability of the poster on the floor they were fastened with tack-it.

All students in the class had a seat and sit as a circle around the map. At first, the teacher explained the materials and what they supposed to do during the game. Four volunteer students were requested to represent human body organs; brain, stomach, kidneys, and liver. They hold a paper that shows their name during the flow of blood and stood over the poster of body cells. Two students were assigned as lungs and waited on the poster of lungs. Finally, one student was selected to act as the blood. He hung two red cardboards in his front and back. The teacher stuck pink circles representing oxygen on his cardboards and introduced him to the class as oxygenated blood instead of clean blood, the unscientific term used by students.

The teacher explained the left side of the heart contains oxygenated blood and he (the oxygenated blood) is going to start his path from the left ventricle. The teacher asked what should happen to push the blood from outside the heart, they answered all together “the pump of heart” and he walked through Aorta to reach the body cells. The students representing body organs exchanged the circle shaped oxygen on the boards with the square shaped carbon dioxides and pretended like they are using the oxygen and producing new carbon dioxides. The teacher asked the name of the blood at this point and oriented student to use deoxygenated blood instead of dirty blood. The blood turned back to the heart through vena cava, entered to the right atrium and jumped to right ventricle. The teacher asked to student where should the deoxygenated blood need to go. After the students answered lungs, he left the blood from pulmonary artery to reach the lungs. The students represented the lungs exchanged the carbon dioxide with the oxygen and the oxygenated blood returned to the heart through pulmonary vein and walked in left atrium.

During this flow, the teacher specifically used the terms of the vessels, the chambers of the heart and oxygenated/deoxygenated bloods. She also indicated the function of capillaries during the exchanges at body cells and lungs. The students were asked to conduct the path again and this time the teacher did not provide any guidance. While leaving the heart the blood student took the wrong path and the students warned him to use aorta. This time the flown was pretended with other volunteer students. Then the teacher stressed the pulmonary and systemic circulations by showing on the floor and related the functions of two circulations through the probing questions. The closed system of the circulation and the function of the heart were pointed out again. She also guided the students with the questions to realize the veins and arteries entitled based on their purpose; to carry blood away from the heart and to collect the blood toward the heart, respectively. Students were given the opportunity to figure out the difference of pulmonary artery and pulmonary vein with the others.

After ensuring that students understood the related concept, the teacher asked if oxygen is enough for body organs to work. This question was aimed to focus students on food and waste transportation on the blood. When the expected answer received the teacher introduced the interrelationships among the organ systems: food digested by digestive system enters the blood and carried to the cells. Waste products produced by the cells enter the blood and carried away from the cells to be released from the body. Finally, the teacher encouraged the students to think about the previous activity in which they realized that the heart rate increases through the exercise. She asked them to discuss the possible reasons for this observation based on their explorations so far. Then, the teacher made a summary of students' responses and she explained that the heart beat is faster during the exercise since more oxygen and nutrient is needed by the muscles and the heart must quickly deliver blood to the related organs. Moreover, the blood needs to carry away the increasing waste and carbon dioxide in the muscles immediately. Therefore, the heart beats increases to meet the needs of muscles.

Elaborate:

The activities in the elaboration phase aimed to review what the students learned so far and to provide further experiences to apply the concept. This phase is appropriate to make students aware of their knowledge construction and the product of their own learning and effort. In this fashion this phase attempt to promote critical thinking, metacognitive self-regulation, self-efficacy, effort regulation, and control of learning beliefs. For this purpose, students firstly engaged in a coloring activity to demonstrate the path of oxygenated and deoxygenated blood through the pulmonary and systemic circulations. In this activity it was emphasized that the purpose of using different colors in the figures of circulatory systems is just to help students visualize the paths followed by oxygenated and deoxygenated blood. After warning students on this issue, they were asked the color oxygenated and deoxygenated blood in human body and were allowed to select any color to represent oxygenated and deoxygenated bloods. After finishing the painting they labeled the vessels and the chambers of the heart.

The teacher asked students what they have learned up to this point and listed their answers on the board to complete the last part of KWL chart. Students mentioned the terminology related with circulatory systems like names of the vessels and chambers of the heart, the muscular structure of the heart, the function of the heart and vessels, why the exercise increases heart rate and they distinguished pulmonary and systemic circulations.

Additionally, students were expected to develop a poster related to circulatory system. The teacher divided the students to form 6 groups, and stated that the posters need to be creative and present the accurate information, and also hand-writing is requisite but they can use pictures from other sources. 1-week period was allowed them to present their productions and the posters displayed on the walls of the class. During the poster development, students elaborated, organized and reconstructed the information related with the topic while working collaboratively, arranging their time schedule and study places, and receiving the helps when they required. Examples of students' posters can be seen at Appendix P.

Evaluate:

To evaluate students understanding of circulatory system the teacher assigned students to fill a roundhouse diagram. Students fill the diagrams by summarizing, categorizing and prioritizing the concepts after elaborating upon the circulatory system. This diagram is effective to foster self-efficacy and metacognitive skills such as reflecting and monitoring the amount of learning (Ward & Wandersee, 2002). The teacher examined the diagrams and gave feedbacks about students' misunderstandings (See Appendix O). For example, some students were still using clean and dirty blood terms with respect to oxygenated and deoxygenated blood. Students were recommended again to use more scientific terms in science.

Additionally, students’ conceptual understanding was determined through the related multiple-choice items of CSCI, administered at the end of instruction.

Extend:

In this part, the value, interest and importance of the task were promoted by following questions which were directed to transfer students’ learning to the new concept; constitutes of blood.

- What materials are transported by blood?
- How blood carries these materials?
- Why do you think doctors examine blood test result to diagnose certain illnesses?
- What is the structure of blood?
- How is the structure of blood related with its function?

Finally, the students were assigned to bring a blood test result to the next course. These blood tests were requested to investigate at the first phase of next 7E-LCI plan.

Table 3.10 Sequence, Purpose and Addressed Variable of Activities in 7E Learning Cycle Instruction Regarding Circulatory System – Blood

7E-LCI Phase	**Activities**	**Purpose**	**Addressed Variable**
Elicit	Questioning	• To recall students prior knowledge • To increase curiosity • To take students attention	• Conceptual Understanding • Critical Thinking • Task Value / Intrinsic Goal Orientation • Task Value
Engage	Blood Test Results	• To realize the blood has a complex structure • To realize there are different structures in the blood • To highlight the medical importance of blood in diagnoses	• Conceptual Understanding • Critical Thinking • Conceptual Understanding • Critical Thinking • Task Value
Explore	Blood cells	• To draw inference based on observation • To observe red and white blood cells in a prepared blood slide through a microscope • To realize the structural difference between blood cells	• Science Process Skills • Conceptual Understanding • Conceptual Understanding
Explain	Questioning	• To draw inference about blood structure from the observation	• Science Process Skills • Conceptual Understanding
	Function of Blood Constitutes	• To explain the function of plasma and cells	• Conceptual Understanding

Table 3.10 (Continued)

7E-LCI Phase	Activities	Purpose	Addressed Variable
	Questioning	• To realize the human blood types	• Conceptual Understanding • Critical Thinking • Task Value
		• To emphasize the blood transfusion	• Conceptual Understanding
	Blood Types	• To categorize the human blood types and infer compatibility	• Conceptual Understanding • Critical Thinking • Task Value
		• To facilitate the construction of meaning	• Conceptual Understanding
Elaborate	Rh Factor	• To draw a schema explaining blood transfusion considering Rh factor	• Conceptual Understanding • Elaboration Strategy / Organization Strategy
	Constituents of Blood Model	• To deepen students' understanding on structure of blood	• Conceptual Understanding
		• To apply the learned information in modeling	• Elaboration Strategy / Organization Strategy
		• To work collaboratively	• Peer Learning
Evaluate	Round-house diagram	• To provide a summary of what is learned	• Conceptual Understanding • Elaboration Strategy • Self-Efficacy • Control of Learning Beliefs
		• To uncover remained misconceptions	• Conceptual Understanding • Metacognitive Self-Regulation

Table 3.10 (Continued)

7E-LCI Phase	Activities	Purpose	Addressed Variable
		• To extract the main ideas of subject and sequence the important information • To interconnect the concepts of subject matter • To reflect the concepts in their own words and drawings • To help students reflecting and monitoring their own learning	• Organization Strategy • Elaboration Strategy • Elaboration Strategy • Metacognitive Self-Regulation • Self-Efficacy • Control of Learning Beliefs
Extend	Questioning	• To realize the protection process of body against the diseases • To connect the concept of lymphatic system and immune system	• Conceptual Understanding • Conceptual Understanding • Task Value

7E-LCI related with Blood:

Elicit:

The teacher started the instruction by questions aiming to determine students' prior knowledge, to increase curiosity about the blood, and to challenge critical thinking. She asked the importance of circulation of blood all over the body and the materials the blood transports. Most of the students were familiar with the terms of red blood cells and white blood cells while some of them mentioned also plasma and blood platelets. In this and next phases the teacher tried to emphasis the importance of topic for human life and set the learning goals to master the subject.

Engage:

Students' attention was focused on the subject matter with the investigation of blood test result that they brought to the class. Students were aimed to notice the complex structure of the blood and how the blood provides information about your health. In order to achieve this aim, the teacher initiated a discussion in the class.

Explore:

Prepared blood slides were provided to students to be observed under the microscope. They were asked to predict the names of the structures they explored in the blood. They were able to observe the red blood cells easily but only some students achieved to observe white blood cells. The students who were not able to observe disagreed the existence of white blood cells on the specimen and the teacher let them to view under high resolution of microscope. Then she asked the difference between the red blood cells and white blood cells. The answers were related the amount of the cells, their shapes and colors. The teacher also explained the white blood cells (leukocyte) contains nucleus while red blood cells (erythrocyte) does not. She let the student infer the blood is red because the amount of red blood cells. She challenged them by asking about how they not believed the existence of white blood cells without seeing on the slide and let them discuss if observing every constitutes in blood is possible. She emphasized direct observation is not the only way to reach scientific knowledge and added sometimes the scientists infer the ideas about the invisible matters. By this question, students realized they could not see the platelets but they may drive inferences about the existence of platelets.

Explain:

The teacher introduced the constituents of the blood and encouraged them to infer their functions. Students already learned the blood carries oxygen and carbon dioxide and the teacher let them discuss about which cell is responsible to carry these gases. When they made inferences based on their knowledge on the structure and amount of red blood cells the teacher gave them the activity sheet that requests to match the functions of all constitutes in the blood on a chart (See Appendix M). They studied on the chart with a peer. Once the students completed their matching the activity was repeated with whole class and further information related with the basic components of blood was presented by the teacher. The students were asked whether all people's blood is the same. Some of them agreed and verified their answer with the structure of the blood. Some other stated constitutes are same but their amounts are different and confirmed their idea with the blood test results. Then the teacher challenged them by asking "If we all have same blood, may I give my blood to any of you?". At that point, the students realized she is referring blood transportation and blood types. The teacher asked the blood types that they heard so far and listed them on the board.

Students were given the information about the blood types and the source of this categorization. Then they studied on blood transfusion chart with their peers to understand the compatibility of donor bloods for each blood type (See Appendix M). They were expected to write the blood types and complete the arrows to represent compatibility. Their final charts were discussed with whole class and the teacher repeated the chart on the board.

Elaborate:

To be able to apply their knowledge about the blood transfusion the teacher played a little game with the class. She said a few things about her own blood type and expected students to find her blood type. For example, she said “I do not have to know my donors’ blood type. I can get any type of blood.” Or “I can only donate to my group and receive only from them” Then students figured out she is universal receiver, AB type or other types. This short game was a repetition of their conception. Thereupon, the students were requested to search about Rh factor and bring a chart similar with they filled that represents the compatibility for transfusion. This task is promising the use of elaboration and organization learning strategies besides critical thinking. Their charts were discussed in the class.

In this phase, students also were provided with materials to extend newly learned concepts related to basic components of blood. They were requested to make a model of blood with the given materials and fill the work sheet (See Appendix M). Student formed groups and made a quick model of blood with white and red beads, transparent small beads, and a bottle of water dyed by yellow food paint representing red blood cells, white blood cells, platelets, and plasma, respectively. On the sheet they filled out the table related to the components represented by materials and the reason of their decision such as, plasma because it was yellow liquid. The teacher asked students answers on the sheet and discussed about structure of blood.

Evaluate:

Similar with the previous plans, students were requested to fill a roundhouse diagram to make their understanding concrete. During the development of diagram, student reviewed their learning, realize the existing deficiencies and put effort to reconstruct their knowledge. Additionally, they summarized the topic, separate the main ideas into interrelated segments and organized them in a sequence. That is, students' use of elaboration, organization and metacognitive self-regulation strategies were encouraged. Furthermore their self-efficacy and control of learning beliefs are promoted by emphasizing the improvement in their conception. The teacher gave feedback to students' diagrams and helped them correct their mistakes. Additional evaluation of concept learning was done by the items of CSCI administered at the end of the instruction.

Extend:

The extension of the concept was done for the lymphatic system and immune system of the body. The teacher and students made a discussion about the structure and the function of the lymphatic system and how it cooperates with the circulatory system. The protection against the diseases was discoursed and the immune system subject was instructed mostly based on students sharing of their experiences.

At the end of the circulatory system instructions, CSCI was implemented in experimental and comparison groups to determine students' conceptual understanding. At the same point, RSCI was administered before starting the following subject to get students' prior conceptual understanding of respiratory system. Additionally, after one-month interval of the implementation of CSCI, the students were administered again with the same test to investigate the retention of the concepts.

3.5.3 Instructions Related to Respiratory System

The curriculum oriented instruction with respect to respiratory system was carried out over 1 week in the comparison group. Firstly, the students were informed about what is going to be instructed in this subject. Similar with the previous instructions, students answered teacher-directed questions and read aloud the information in the textbook during the instruction. The content in the book got started with a story about divers to connect the subject with the daily life. The textbook suggested building a lung model through balloons, straws and bottle. A previously assigned student showed her model to the class and then explained what the materials used to build the model represent and how it works. Thereupon, the part of textbook that clarifies the organs of respiratory system and the inhalation and exhalation processes in the body was read aloud. The students were encouraged to focus on their own breathing process and how their chests move during it. One of the teachers has the students to watch a video including simulations about the respiratory system organs and breathing. The video also gave information about the respiration in the cells. The other one preferred to explain the subject herself; showed the lungs over the plastic torso model, used the board frequently to list the organs, and to summarize the function of them and draw the figures to explain the breathing. Both of the teachers asked direct-questions to evaluate the students' learning in the instructed concepts. The teachers discussed how to protect the respiratory system and emphasized to avoid smoking and inhaling the chemicals or harmful gases. At the end of the subject, students were assigned a game which provided them with an opportunity to make self-assessment. In the game, they were expected to decide if the given statements are true or false to follow a path and find the correct exit. Students were required to complete a flowchart after the class hour as homework. Moreover the teacher suggested them to examine the concept maps about skeletal, circulatory and respiratory systems that explain the functions and the related organs.

In the experimental group 7E-LCI with respect to respiratory system was completed in one and a half weeks, 6 lessons. A summary of the activities conducted in each phases and their purpose were given in Table 3.11 and explained in detail.

Table 3.11 Sequence, Purpose and Addressed Variable of Activities in 7E Learning Cycle Instruction Regarding Respiratory System

7E-LCI Phase	Activities	Purpose	Addressed Variable
Elicit	KWL Chart	• To recall students prior knowledge • To activate student interest and curiosity through collecting what they want to know	• Conceptual Understanding • Critical thinking • Task Value / Intrinsic Goal Orientation
	X-rays	• To activate students' curiosity • To observe x-rays of human lungs	• Task Value / Intrinsic Goal Orientation • Conceptual Understanding
	Questioning	• To increase curiosity • To take students attention	• Task Value / Critical thinking • Task Value
Engage	The Capacity of Lungs	• To warm up students to the content • To design a system to measure lung capacity • To take students attention • To explain that breathing is the process that moves air in and out of the lungs • To measure their expiratory capacity • To develop science process skills ○ Observing ○ Inferring based on observations ○ Measuring ○ Communicating	• Task Value • Critical thinking • Task Value • Conceptual Understanding • Conceptual Understanding • Science Process Skills

Table 3.11 (Continued)

7E-LCI Phase	Activities	Purpose	Addressed Variable
Explore (I)	What does Exhaled Air Contain?	• To explore the exhaled air contains carbon dioxide. • To stress to draw inference based on the observations	• Conceptual Understanding • Critical Thinking • Science Process Skills
Explain (I)	Questioning - Discussion	• To receive the explanations of students based on the concepts • To facilitate the construction of meaning about the respiration	• Critical Thinking • Metacognitive self-regulation • Conceptual Understanding • Control of Learning Beliefs
	Floor Map - Breathing and Respiration	• To realize the organs of human respiratory system • To visualize the process of respiration from inhalation to exhalation • To demonstrate the cellular respiration. • To distinguish the breathing and respiration concepts	• Conceptual Understanding • Conceptual Understanding • Critical Thinking / Control of Learning Beliefs • Conceptual Understanding • Conceptual Understanding • Critical Thinking
Elaborate (I)	Changing My Breath Rate	• To investigate the effect of exercise on breath rate • To work collaboratively • To develop science process skills ○ Observing ○ Inferring based on observations ○ Hypothesizing ○ Identifying variables ○ Designing Investigations ○ Graphing the Data ○ Communicating	• Conceptual Understanding • Critical Thinking • Peer learning / Help Seeking • Science Process Skills

Table 3.11 (Continued)

7E-LCI Phase	Activities	Purpose	Addressed Variable
Explore (II)	Lamb Lungs Exploration	• To observe the lungs taken from a lamb	• Conceptual Understanding • Task Value
		• To demonstrate how the lungs appear during inhalation and exhalation	• Conceptual Understanding
		• To work collaboratively	• Peer learning / Help Seeking
		• To draw inference based on observation	• Science Process Skills
Explain(II)	Questioning	• To receive the explanations of students based on the concepts	• Conceptual Understanding • Critical Thinking
		• To facilitate the construction of meaning on the process of inhalation and exhalation.	• Conceptual Understanding • Control of Learning Beliefs
Elaborate (II)	The Organs of Respiratory System	• To deepen students' understanding of respiratory system organs	• Conceptual Understanding
	Lungs Model	• To create a model of the lungs to describe inhalation and exhalation	• Conceptual Understanding • Critical Thinking
	KWL Chart	• To determine what the students have learned	• Conceptual Understanding
		• To provide students with self-monitoring for their learning	• Metacognitive Self-Regulation
Evaluation	Roundhouse Diagram	• To provide a summary of what is learned	• Conceptual Understanding • Elaboration Strategy • Self-Efficacy • Control of Learning Beliefs
		• To uncover remained misconceptions	• Conceptual Understanding • Metacognitive Self-Regulation

Table 3.11 (Continued)

7E-LCI Phase	Activities	Purpose	Addressed Variable
		• To extract the main ideas of subject and sequence the important information	• Organization Strategy
		• To interconnect the concepts of subject matter	• Elaboration Strategy
		• To reflect the concepts in their own words and drawings	• Elaboration Strategy
		• To help students reflecting and monitoring their own learning	• Metacognitive Self-Regulation • Self-Efficacy • Control of Learning Beliefs
Extend	Questioning	• To discuss about the relationship between the systems	• Conceptual Understanding • Task Value / Critical Thinking

7E-LCI related with Respiratory System:

Elicit:

The instruction was started with revealing students prior knowledge about the respiratory system. For that purpose the teacher divided the board into two parts to list what the students know and what they want to know, which are the first two parts of KWL chart are. Students appeared to be familiar with the organs of the Respiratory System but some of them, incorrectly, considered mouth and diaphragm as one of the respiratory organs. Their knowledge about inhaling oxygen and exhaling carbon dioxide was arisen but they were not able to put a sophisticated explanation to the cellular respiration. They explained the lungs exchanges oxygen and carbon dioxide from the capillaries and we need to breathe to be alive. They requested to learn more about the structure of organs, inhaling and exhaling processes, and respiration. Students were specifically asked if the breathing same with the respiration and most of them agreed with the idea. Nevertheless, the teacher added this matter to the list of 'what we need to learn' section to emphasize the issue and procreate a desire to learn. In this way, students were oriented to set intrinsic goals.

Then the teacher directed questions to elicit students' already formed conceptions. She asked how the circulatory and respiratory systems are related to each other, what the inhaled air and exhaled air include, and why the breathing is vital for humans. After getting students' answers, challenging their critical thinking, and increasing their curiosity on the topic, the teacher gave human lung x-rays to students.

Students were given human lung x-rays to increase their attention to the subject. They investigated the shape of lungs and noticed the difference between the size of right and left lungs. Students inferred that it is because of the existence of the heart at the left side. Moreover, they discussed if the appearance of the lungs would be same during inhalation and exhalation. Students answered as it would seem larger during the inhalation. The teacher guided them to think how much would the lungs extend and how much air can be inhaled and exhaled for the next activity.

Engage:

At this phase, the students were asked if they know how much air they exhale from their lungs. Later, their ideas about how to measure the capacity of their lungs were requested. One student stated blowing a balloon and measuring the size of it, another one proposed to measure the chest before and after inhalation. The teacher gave the clue of using water to determine the volume and they started to discuss how to hold the air in the water. After a small discussion about the design, the teacher gave the handouts to students with the required materials to conduct the activity (See Appendix N). The teacher oriented them on the experimental setup. As a first step, students were directed to breathe normally, then expel the air to the pipe in a normal fashion. For the next step, they were expected to breathe in and out normally, then expel the remaining air in to the pipe to measure. Finally, they were guided to breathe in normally but to expel all the air that is in the lungs. Students were enjoyed to measure the air that they exhale and also noticed they are not blowing out all the air that they inhaled. After the students recorded their measurement, the teacher explained it is not possible to eliminate all of the air from the lungs even they breathe out as much as they possibly can. The teacher challenged the students by asking the content of exhaled air. Most of the students appeared to know the exhaled carbon dioxide but a few of them mentioned about the nitrogen and water vapor, while none of them stated argon and oxygen. The teacher did not explain the content and continued to the next activity to explore the existence of carbon dioxide in the exhaled air.

Explore (I):

Students investigated the existence of carbon dioxide in their breath through an experimental situation. Firstly, students discussed how to realize a reaction occurs during the observation of a chemical experiment. After getting the answers like the change in the color, the change in the temperature, the production of gas, and the production of precipitation the teacher stressed the importance of observation through the five senses. Then she gave the materials to students with the information of the appearance in lime water turns from clear to milky when a certain amount of carbon dioxide passes through it. After the observations, the teacher put emphasis on how did they inferred the existence of the carbon dioxide in the exhaled air based on their observations. The students' attention was directed toward the source of this carbon dioxide and the importance of breathing to stay alive. In the next phase, students' explanations related with experiences that accumulated so far were taken.

Explain (I):

In this part, students reflected on their own experiences and tried to provide plausible responses to the questions of the teacher. The discussions and tasks performed in this phase influence students' various motivational aspects and strategy use; control of learning beliefs since the students realize the learning occurs by their own effort, critical thinking since they connect their prior knowledge to interpret the scientific phenomena, elaboration strategy since they express their interpretation of tasks by their own words, and metacognitive self-regulation since they reflect their own learning process and monitor the amount of knowledge.

At the beginning of the instruction students were aware of using oxygen to produce energy for the body. Moreover, they were aware of the carbon dioxide in the exhaled air is a product of body. Considering their prior knowledge and experiences on previous phases, the teacher asked more probing questions like "Is only oxygen enough to produce energy?", "Are there any other products from carbon dioxide and energy in energy production?", "What are the composition of inhaled and exhaled air?", "What the air in the lungs includes before the respiration and after the respiration?". After these questions, different answers emerged and a disagreement occurred among the students. Students were thinking the body also needs food to produce energy but could not explain the respiration process. Moreover, some of them were arguing only oxygen goes to the lungs during the inhalation. Students were also conflicted about the existence of gases other than carbon dioxide in the exhaled air. A group claimed that we send all the gases in the air to the lungs but the lungs filter it, but they were not clear if the lungs only take oxygen. All students were incorrectly sure the exhaled air does not contain oxygen. Some of them also thought that inhaled air does not contain carbon dioxide. During this discussion, the teacher encouraged a respective discussion between students and oriented them to explain more to support their claim. Then she presented scientifically content explanations for them through a floor map similar with the conducted in the previous content, Circulatory System.

Floor map for Respiratory System was prepared to demonstrate the breathing and respiration in the human body in a learning environment that help students learn by game playing. The activity consisted of posters representing respiratory passage to the lungs, lungs, hearth and mitochondria of body cells. The posters were arranged on the floor from top to the bottom. The lungs and heart posters were the same posters used in Circulatory System concept. However, another poster was added to the side of lungs to attract the attention on alveoli in the lungs as structures responsible for gas exchange. There were also two other posters one representing mitochondria another representing respiratory system organs other than lungs; nose, pharynx, larynx, and trachea. On the floor, a peace of trachea was drawn with the chalks to connect the poster with the lungs poster. Other connections between the lungs, hearth and mitochondria posters were also drawn by chalk on the floor as the arteries and veins. Capillaries were specified in the drawings on right and left sides of lungs and mitochondria posters.

All students in the class had a seat and sit as a circle around the map. At first, the teacher explained the materials and what they supposed to do during the game.

Two volunteer students were assigned as lungs, three of them assigned to show the respiration equation on the mitochondria, and one student selected to act as blood.

To demonstrate the air that we inhale the researcher prepared a box of carton pieces covering different colors and shapes for each gas on the air. The box was filled considering the percentages of gases on the air which means most of pieces were red rectangles for nitrogen. There were about eight pieces of pink circles for oxygen, and two yellow squares for carbon dioxide. Additionally, about two or three pieces of water vapor and other gases were included.

Two cycles were conducted during the experiment to distinguish the breathing and respiration concepts. In first cycle, students were expected to notice the gases that they breathe in and out. In second cycle, the teacher clarified the processes that take place in the cells of organisms to convert food and oxygen to energy, water and carbon dioxide.

At the first cycle, the teacher carried the box from the nose to the lungs by explaining the function of the organs that she moved through. Then she spilled the box in front of the students standing as the lungs. She asked the expectations of the observers as the next step and they explained the lungs need to take the oxygen and pass it to the blood. The lungs selected most of the oxygen from the gases and left some on the floor. Teacher mentioned the body does not use the all oxygen that inhaled. Selected oxygen cards were given to the blood from the lungs. While the students preforming this step, the teacher gave detailed information about the role of alveoli and capillaries during this exchange. The students acting as blood transported the oxygen to the hearth and then to the body cells. Students at the body cells exchanged the oxygen carried on the blood with the carbon dioxide. The blood returned to the hearth to pass through lungs. In the lungs, the carbon dioxide carried by blood was taken and added to the mix of gases. At this point, the teacher stated the role of alveoli again. Students representing lungs put all of the remained gases in a box and gave to the teacher to exhale. When the first circle completed, the teacher introduced the components of inhaled and exhaled gases during the breathing. She pointed out both the air we breathe in and out contains oxygen and carbon dioxide and other gases. However, the percentages of oxygen and carbon dioxides change during the breathing. In other words, exhaled air contains a lot more carbon dioxide from the inhaled air. Similarly, inhaled air covers more oxygen than exhaled air does. Following this explanations, the teacher let the student to repeat the concept on the floor by themselves.

As the second cycle, it was aimed to introduce the cellular respiration as the source of carbon dioxide in the exhaled air. The teacher repeated all the process covered in the first one until the oxygen reaches to the mitochondria. Then she asked again the requirements to produce energy. Students answered as nutrients and the teacher gave oxygen and nutrient cards to the students standing on mitochondria. Students were requested to say the products and the cards written carbon dioxide, water and energy were given to other student on the mitochondria. The teacher briefly expressed the process using nutrient and oxygen to produce energy. Then she asked the place that supplies the nutrients and carries away the waste products from the body to relate the other body systems. The collaborative work of circulatory, respiratory, digestive and excretory systems was discussed to conclude the activity. After the discussion, they were asked if they breathe in the same rate all the time or it changes to deal with another activity to elaborate their learning.

Elaborate (I):

This activity intended to investigate the effect of physical exercise on the breathing rate to perceive the relation of gas exchange with the energy production. Another purpose of the activity was to develop learning strategy use (eg. critical thinking, peer learning, and help seeking) and science process skills (namely; observing, inferring based on observations, hypothesizing, identifying variables, designing investigations, graphing the data, and communicating).

Students were familiar with the design of experiment from the previous subject (changing heartbeat). They formed groups of 3 people, and each group was given the hand outs and a watch for the activity (Appendix N). In this activity, again, students were expected to design an experiment to explore how the physical exercise and resting affect the rate of their breathing. In their groups, students attained a writer to note the data, a counter to observe and collect the data, and an experimental to conduct the physical activity to change his/her breathe rate. Before the data collection process, they developed a hypothesis, listed the variables as dependent, independent and controlled variables, defined the materials and procedure and made predictions about the results. During this process, the teacher acted as a facilitator; investigated students' handouts, corrected their mistakes by challenging them with leading questions, and helped them on graphing their data. All of the groups hypothesized and predicted that the exercise is going to increase the rate of breathing. Students decided the measurement period and then multiplied the results to calculate the breathing rate per minute. The groups preferred jumping, jumping jack and running as the physical exercise and performed their designs. After obtaining the relevant data, they filled the table provided on the handout and graphed their data. Then the teacher collected data from each group and filled the table on the board. She separated the data based on the performed physical activity and stated it as a variable that may cause a variation on the scores and cannot be considered as a controlling variable in whole class data.

She initiated a whole class discussion with respect to variables, the experimenting process and directed students to derive a conclusion about how physical exercises affect the breathing based on the data on the board. When she ensured the related science process skills were acquired, she asked the reason of the alteration in the rate of breathing as they exercise and rest. They explained the rate of breathing increases to supply the rising requirement of the body for oxygen as well as to remove the accrued carbon dioxide from the body.

At this point, the teacher conducted a discussion to associate the current conclusions with respect to breathing rate to results of the heartbeat activity. In this way, she let the students to accentuate the cooperation of Circulatory and Respiratory Systems.

Explore (II):

Once the students were informed about the breathing and respiration they were given opportunity to explore and observe the structure of lungs through full and dissected lamb lungs. Each student was given handouts to note their observations and answer the questions (See Appendix N). The indiscrete lamb lungs were shown by the teacher to demonstrate how the appearance of lungs changes when the air flows inside. The researcher previously prepared a set up by connecting a wide pipe to the end of trachea. At the outset of the activity, the teacher took students' observations with respect to indiscrete lamb lungs. They explained the shape, size, color, and the difference between right and left parts. After ensuring all the students are observing the demonstration, the teacher blew in the pipe to show the change in the size of lungs. Students were excited while observing the lungs getting larger with the air. Afterwards, the teacher stated the inhalation and exhalation processes are different from her demonstration and they will learn the details after their observations. She took students' predictions about the inside of the lungs and gave them the dissected lungs to observe it in their group. During their observation, the teacher stated scientist also conduct observations similar with them to understand how the human body works. She added that the development of the technology helped the scientist to discover further than their own observations. When the students completed the handouts, the questions were talked over with whole class.

Explain (II):

In this phase students reflected their knowledge that actively constructed in previous phases. Their control of learning beliefs and critical thinking skills are expected to be developed in this manner.

The teacher described the structure of the lungs, bronchi, and trachea based on the observations of students. Then she asked how the air enters to the lungs. Most of the students stated they suck the air inside from the nose. The teacher repeated her warning during the previous observation that the process is different from just blowing in the lungs. She pointed out sucking from nose is not the reason the inflation of lungs and started a discussion. She gave some clues like “There must be something to vacuum the air inside.”, and “Try to think converse, the air flown inflates the lungs or the air enters since the lungs inflate”. Students remembered the diaphragm helps to the breathing process and the teacher explained the inhalation and exhalation mechanism as the following:

During inhalation; the diaphragm contracts and moves downward, rib muscles also contracts to enlarge the chest cavity and these cause air to fill the lungs. Thus, as the lungs expand, air is sucked in through the nose or mouth.

During exhalation; diaphragm relaxes and moves upward and rib muscles also relax to reduce the space in the chest cavity and these cause to air to be pushed.

Elaborate (II):

This phase is aimed to deepen students’ understanding and to provide further experiences to apply the concept. In this purpose, students were firstly given a handout to label the organs of Respiratory System on a figure (See Appendix N). After the controlling their completed sheets, the teacher assigned them to conduct a model based on the handout to represent the inhalation and exhalation mechanism (Appendix N). Students brought their models to the class following lesson and explained the role of diaphragm during the breathing. They stated the balloons inside the bottle inflate and deflate because of the movement of the big balloon at the bottom, representing the diaphragm. The teacher listed the similarities and differences between model and the real mechanisms on the board to avoid the possible misunderstandings that may emerge because of the model.

To summarize and determine the learned concepts up to this point, the teacher completed last part of KWL chart on the board. Students stated the Respiratory system organs, the comparison of inhaled and exhaled air with respect to percentages of oxygen and carbon dioxide, the path of respiration and the equation of respiration, the exhalation and inhalation processes. This part is effective to help students to aware of their own effort and progress which facilitates metacognitive skills and self-regulation.

Evaluate:

Students' conceptual understanding was assessed through the implementation of SSCI. Moreover, students filled a roundhouse diagram to show their comprehension of concepts and summarize the Respiratory System subject (See Appendix O). Roundhouse diagram was an effective task to develop cognitive and metacognitive skills in students. Students summarized the topic, extracted the important ideas, associated the concepts, and realized their own learning progress which were facilitator factors for elaboration, organization and metacognitive self-regulation strategies. Students understanding of their own development may also promote their self-efficacy and control of learning beliefs. The diagrams were evaluated by both of the teacher and researcher but only the teacher gave feedbacks to the students.

Extend:

At the last phase of the plan, the teacher discussed with the students on the diseases of Respiratory System as well as how to provide the health of the Respiratory System. The importance of technologies in diagnosing and treatment of these diseases were addressed. Moreover, the teacher let the students to share their ideas about the cooperation of all systems in the body to allow a proper function. The teacher used the board to note the relation of systems.

At the turn of instructions related with Respiratory System in experimental and comparison groups, SSCI was implemented to determine students' conceptual understanding. The Respiratory System was the last concept of the treatment. Therefore, when their related instructions completed, the students of experimental and comparison groups were post tested through MSLQ, EBQ and SPST in order to measure their motivation and learning strategy use, scientific epistemological beliefs and science process skills.

Following one month period to the implementation of SSCI, the teacher instructed the next subject in the national curriculum through the curriculum based instructions. At the end of the interval, the students were again administered SSCI to evaluate the follow-up results.

3.6 Treatment Fidelity and Treatment Verification

Treatment fidelity and treatment verification are the concerns about the accuracy between the performed intervention and the intended implementation plan. In order to check if the treatment had been established as defined, the researcher previously clearly defined the lesson plan of 7E-LCI covering; the activities exist in each step, the objectives of lesson distinctively for each activity, the procedures to implement each steps, and probing questions to direct students. Detailed lesson plans were revised by two elementary science professors, three elementary science teachers and a medical doctor. The experts in elementary science commented on the age appropriateness and the coherence between the activities and objectives while the medical doctor scanned the accuracy of information that intended to teach with respect to his anatomical expertise. The final version of the lesson plans served as a protocol to follow during the intervention to the researcher as well as the teachers. To ensure the protocols are implemented as intended, the researcher trained the teachers before the application and conducted regular meetings at the beginning of each week. These meetings were aimed to explain the path to follow during their teaching in experimental group and to avoid the possible differences that may arise from the diverse implementer factor. Additionally, the experimental and comparison group classes were observed by the researcher to check; whether the experimental group classes instructed by two teachers received the same intervention based on the defined lesson plans, whether there was any teaching differences in comparison groups that may affect the study, and whether there were overlaps between the instructions received by experimental and comparison groups.

Treatment verification was maintained through the stated observations conducted in each lesson. During the observations in experimental group, the researcher checked if the defined protocol implemented as intended and took notes the details about the process. At the end of each lesson, teachers and researcher discussed if the instruction attained the objectives of lesson plan. The observations in comparison group classes were also documented in detail. There were a few activity suggested by curriculum that overlaps with the activities in 7E-LCI plans. After the implementations, the teacher and researcher was sure the application and objectives of these activities were different for each group. The implementations for each group were explained in detail at the treatment part of this chapter.

3.7 Ethical Concerns

The study was reviewed and approved with respect to ethical issues by the committees of Middle East Technical University and Ministry of National Education. The addressed issues were confidentiality, protection of students from any psychological or physical harm and avoidance from deception of subjects.

After taking all permissions for the study, the researcher requested the acceptance of the school administration and selected the teachers voluntarily. Moreover, the study was implemented to 6th grade students which are immature. To ensure the voluntary participations of the students, a brief description of the study was given to all students and a consent form explaining the study and providing the contact information of the researcher was sent to their parents. There was one student in the experimental group who was willing to participate the implemented activities but refusing to fill the administered instruments. This student was not involved to data collection process and had read his regular book during the administration of instruments. Students were also assured that the study is not going to affect their course grades and the researcher will be the only person who can access the data.

Since there were various instruments to be matched during the analysis, the students were requested to write their name but they were told that their names are not going to be decelerated on the final documents. Finally, the study has no concern to expose any psychological or physical harm for the subjects. The study was conducted in their regular school environment and neither the activities nor the instruments covered a potential danger for the students.

3.8 Analysis of Data

The general characteristics of the sample were described through descriptive statistics, means and standard deviations. Moreover, preliminary analyses were conducted to check whether the data violates the assumptions of analyses.

Three discrete Mixed between-within subjects ANOVAs were conducted to investigate the effects of 7E-LCI and COSI on students' conceptual understanding on three human body concepts as well as the continuous effects of these instructions on students' conceptual understanding. Two independent variables were time; Time 1, Time 2 and Time 3, and treatment; 7E-LCI and COSI. Dependent variable was conceptual understanding of students measured by CSCI, SSCI and RSCI.

Three separate Mixed between-within subjects MANOVAs were conducted to analyze the effect of treatment on students' motivational variables, learning strategy use, scientific epistemological beliefs, and science process skills in besides the effect of treatment on the development of collective variables. Two independent variables were time: Time 1 and Time 2, and treatment; 7E-LCI and COSI. Dependent variables for the first mixed-MANOVA were students' Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy, and Test Anxiety measured by the motivation Scales of MSLQ. Dependent variables for the second mixed-MANOVA were Rehearsal, Elaboration, Organization, Critical Thinking, Metacognitive Self-Regulation, Time and Study Environments, Effort Regulation, Peer Learning, and Help Seeking measured by the Learning Strategies scales of MSLQ. For the third mixed-MANOVA, dependent variables were Source, Certainty, Development and Justification which are measured by EBS.

Finally, a Mixed between-within subjects ANOVA was conducted to compare the effectiveness of 7E-LCI and COSI on students' science process skills that measured by SPST. Two independen variables were time: Time 1 and Time 2, and treatment: 7E-LCI and COSI. The dependent variable was students' scores gathered by SPST.

The sytaxes of each analysis were extended to answer the sub-research questions regarding comparing the groups separately in each administration time and investigating the change on the scores over time in each group of students. Sample syntaxes of the analyses can be seen in Appendix Q.

3.9 Validity of the Study

To minimalize the possible threats to external validity of study, the participants were selected from a regular public school which placed in a district has a population with middle level socioeconomic status. Moreover, the sample involved in the study was high as possible as for an experimental design to increase generalizability. The researcher described the profile of participants and teachers as well as the facilities of the school in detail.

Considering the internal validity threats the researcher took some precautions to avoid their possible effects to the results. However, there were also unpreventable threats that may influence the study.

Subject characteristics especially students' prior situations with respect to collective variables and gender were considered as a possible threat to the study. In order to remedy this problem, experimental and comparison group students were administered with the pre-tests and their scores were statistically compared. Since nonsignificant results were found for all variables this threat was not considered as a problem anymore. Additionally, there was a balanced ratio between the groups with respect to males and females.

In the present study the implementation threat is a possible threat because two different teachers implemented the treatment. To eliminate this effect, the classes were divided as experimental and comparison groups by assigning each teacher at least one experimental group class and one comparison group class. Moreover, to prevent the possible differences between the instructions of two teachers, which may affect the results, the researcher observed all the lessons applied in experimental and comparison groups by two of the teachers. The researcher also conducted meetings with the teachers at the beginning of each week during the study to achieve the resemblance between the instructions of teachers. A detailed description of instructions for both groups was presented under the Treatment part in this chapter.

Moreover, location is a threat to the study. Although the implementation conducted in the same school, the experimental group students received their instructions at the laboratory of the school while the comparison group students mostly used the laboratory but also resided in the class. Laboratory of the school was at the basement having a bit gloomy environment. The researcher arranged and cleaned the laboratory to prevent negative effect of studying in such environment.

Another important threat for the study is attitudinal treat which refers to the emerged improvements in the scores of experimental group due to a novel lecturing style while low scoring in comparison group due to perceived unfairness. In order to prevent this effect, the teachers were informed to conduct the experimental group implementations as a part of regular routine and avoid students to discern the difference between the implementations.

The repeated measurements in the study may cause a testing threat. To remedy this problem, the researcher put enough time between the applications of instruments. Additionally, all the instruments were implemented by the researcher to avoid the data collector bias, and same explanations were done to all classes during the application.

Finally, possible mortality threat was prevented by sampling high amount of students and attentively following the data collection process. During the administration of each test the researcher controlled the absent students and had filled the missed instrument next day. Nevertheless there were missing cases on the completed data and the listwise method was attended during the analysis.

CHAPTER IV

RESULTS

The present study aims to investigate six main research questions. The first one is to investigate the students' prior situations with respect to collective variables namely, conceptual understanding, motivation, learning strategy use, scientific epistemological beliefs, and science process skills. The results related with the first research question were discussed under the first section of this chapter: (1) Descriptive Statistics. That is, mean, standard deviation, minimum and maximum values of each variable were reported in that section. For the other five research questions, which address the effect of treatment on the variables, the data was analyzed through mixed between-within ANOVAs and mixed between-within MANOVAs. The assumption check and results of the conducted tests were discussed under the second section of this chapter: (2) Inferential Statistics. In detail, second section presents the results of three mixed-between within ANOVAs with respect to data obtained from Skeletal System Conceptual Inventory (SSCI), Circulatory System Conceptual Inventory (CSCI), and Respiratory System Conceptual Inventory (RSCI). Additionally, it reports the findings related with four distinct mixed between-within MANOVAs that conducted for data collected through Motivated Strategies for Learning Questionnaire (MSLQ), Epistemological Beliefs Questionnaire (EBQ). Finally, the findings of mixed-between within ANOVA regarding Science Process Skill Test (SPST) will be presented.

In this chapter, findings gathered from the above-mentioned questionnaires and tests were reported. First, the descriptive statistics results will be discussed.

4.1 Descriptive Statistics

The first research question stated in Chapter 1 was tested by descriptive statistics for each collective variable.

Q.1. *What are the relevant prior knowledge regarding human body systems, perceived motivation, perceived use of learning strategies, epistemological beliefs and science process skills of 6th grade students?*

Descriptive information related to conceptual inventories, MSLQ, EBQ, and SPST scores for both the experimental and the comparison groups are presented in Table 4.1 through Table 4.4. The sample sizes and the means of the groups may appear as different on inferential analysis results because the listwise method was conducted to deal with missing data.

First, descriptive statistics for implementations of three conceptual inventories about Skeletal System, Circulatory System and Respiratory System at before the instruction (Time1), after the instruction (Time2) and one-month later the instruction (Time3) were presented at the following table.

Table 4.1 Descriptive Statistics of Conceptual Inventories

	N		Mean		SD		Min		Max	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
SSCI-Time1[1]	86	92	2.43	2.93	1.74	1.64	0	0	7	8
SSCI-Time2	86	90	2.99	4.17	1.90	2.37	0	0	8	10
SSCI-Time3	82	85	3.16	3.90	2.11	2.10	0	0	8	8
CSCI-Time1[1]	84	94	1.48	1.92	1.22	1.48	0	0	5	6
CSCI-Time2	83	91	2.38	2.65	1.61	1.74	0	0	8	7
CSCI-Time3	81	82	2.16	3.01	1.66	1.85	0	0	6	8
RSCI-Time1[1]	84	91	1.68	1.93	1.54	1.66	0	0	6	7
RSCI-Time2	84	93	2.30	3.44	1.98	2.29	0	0	9	10
RSCI-Time3	84	86	2.36	3.27	1.89	2.34	0	0	8	9

Note: The scores of conceptual inventories range from 0 to 10
[1]SSCI= skeletal system conceptual inventory, CSCI= circulatory system conceptual inventory, RSCI= respiratory system conceptual inventory

At the Table 4.1, CG refers to comparison group while EG refers to experimental group. As seen from the table, the mean scores of both groups were pretty low. Considering the maximum value of the inventories is 10, the scores appeared to be even under the midpoint of the tests at all measures. On the other hand, the experimental group students appeared to have higher mean scores than the comparison group students at each time period. These between group differences seem to be increased from Time1 to Time3. What is more, experimental group students appeared to increase their scores in time more than the comparison groups. The statistical significance of these mean differences will be discussed in inferential statistics part. After reporting descriptive information about conceptual understanding variable, following table presents the descriptive statistics related with motivation and learning strategy use variables.

Table 4.2 Descriptive Statistics of Motivational Strategies and Learning Questionnaire

	N		Mean		SD		Min		Max	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
IGO-Pre-test[2]	87	91	5.68	5.84	0.96	0.88	3.00	3.25	7.00	7.00
IGO-Post-test	85	87	5.33	5.90	1.27	1.04	1.75	2.00	7.00	7.00
EGO-Pre-test[2]	87	91	5.92	6.13	1.16	1.04	1.00	2.00	7.00	7.00
EGO-Post-test	85	87	5.33	5.96	1.31	1.24	1.00	2.00	7.00	7.00
TV- Pre-test[2]	87	91	5.96	6.03	0.87	0.80	3.17	4.00	7.00	7.00
TV- Post-test	85	87	5.43	5.83	1.18	1.00	2.00	2.67	7.00	7.00
CLB- Pre-test[2]	87	91	6.03	5.88	0.88	0.95	3.75	3.25	7.00	7.00
CLB- Post-test	85	87	5.43	5.70	1.27	1.02	1.75	2.75	7.00	7.00
SE- Pre-test[2]	87	91	5.55	5.72	1.09	1.20	2.75	1.50	7.00	7.00
SE- Post-test	85	87	5.11	5.60	1.18	1.05	1.75	2.63	7.00	7.00
TA- Pre-test[2]	87	91	4.36	4.49	1.21	1.15	1.60	1.60	6.60	6.80
TA- Post-test	85	87	4.70	4.60	1.13	1.12	2.20	1.60	6.60	7.00
R- Pre-test[2]	87	91	4.93	4.99	1.37	1.46	1.50	0.50	7.00	7.00
R- Post-test	85	87	4.93	5.28	1.41	1.25	1.25	2.50	7.00	7.00
E- Pre-test[2]	87	91	5.07	5.29	1.20	1.26	1.67	1.83	7.00	7.00
E- Post-test	85	87	5.21	5.70	1.20	1.01	1.33	3.33	7.00	7.00
O- Pre-test[2]	87	91	4.68	4.93	1.41	1.30	0.75	2.00	7.00	7.00
O- Post-test	85	87	5.02	5.16	1.41	1.32	2.00	2.25	7.00	7.00
CT- Pre-test[2]	87	91	5.04	5.19	1.16	1.35	2.20	1.40	7.00	7.00
CT- Post-test	85	87	5.05	5.50	1.13	1.12	1.40	2.80	7.00	7.00
SR- Pre-test[2]	87	91	5.12	5.22	1.02	1.16	1.50	2.00	7.00	7.00
SR- Post-test	85	87	4.81	5.33	1.00	0.90	2.08	2.42	7.00	7.00
TSE- Pre-test[2]	87	91	5.11	5.12	0.92	1.19	3.25	1.13	7.00	7.00
TSE- Post-test	85	87	4.54	4.95	0.94	0.90	1.63	3.25	7.00	7.00
ER- Pre-test[2]	87	91	5.15	5.07	1.23	1.38	2.00	1.25	7.00	7.00
ER- Post-test	85	87	4.37	4.74	1.20	1.12	1.25	2.25	7.00	7.00
PL- Pre-test[2]	87	91	4.06	4.23	1.72	1.66	0.33	1.00	7.00	7.00
PL- Post-test	85	87	4.58	4.95	1.54	1.46	0.67	1.33	7.00	7.00
HS- Pre-test[2]	87	91	4.72	4.88	1.26	1.24	1.00	1.25	7.00	7.00
HS- Post-test	85	87	4.53	4.77	1.00	1.09	1.50	1.75	6.25	7.00

Note: The motivational variables range from 1 to 7.
[2]IGO= intrinsic goal orientation, EGO= extrinsic goal orientation, TV= task value, CLB=control of learning beliefs, SE=self-efficacy, TA= test anxiety R= rehearsal, E= elaboration, O=organization, CT= critical thinking, SR= self-regulation, TSE=time and study environment, ER= effort regulation, PL= peer learning, HS= help seeking.

Descriptive statistics for the subscales of MSLQ that implemented at the beginning of the study (pre-test) and at the end of the study (post-test) were displayed in Table 4.2 in detailed. As seen in the table, mean scores for the experimental and comparison groups were above the scales' midpoints indicating quite high levels of motivation and learning strategy use towards science learning. Considering Intrinsic Goal Orientation, both groups scored high at the beginning of the study but experimental group students' scores were increased while comparison group students' scores were decreased over time. Extrinsic Goal Orientation scores, on the other hand, showed a decrement for both groups. Task Value scores were also decreased but experimental group scores were higher than the comparison group before and after the instruction. All students reported high scores in Control of Learning Beliefs and Self Efficacy scales at the beginning of the study but their scores were lower at the end of the study. Test anxiety score was higher for experimental group students before the instruction however it was higher for comparison group students after the instruction. Experimental and comparison group students' scores for Rehearsal and Elaboration strategies were close at the beginning of the study while experimental group students reported higher scores at the end of the study. Considering Organization, experimental group students' score was higher than the comparison group students. Critical Thinking scores and Self-Regulation scores of experimental group students were increased over time, though the comparison group students' scores were decreased. Time and Study Environment scores were almost same for groups at the beginning of the study while it was slightly higher for experimental group at the end of the study. Effort Regulation scores were decreased for both groups over time however, it was slightly higher for comparison group students before the study while it was higher for experimental group students after the study. Peer Learning scores were increased to some degree for both groups over time. Help Seeking scores, on the other hand, were decreased slightly for both of the groups. The mean differences for between and within groups regarding all sub-scales of MSLQ will be discussed broadly in Inferential Statistics part. Following table presents the descriptive information with respect to scientific epistemological belief variable of the study.

Table 4.3 Descriptive Statistics of Epistemological Beliefs Questionnaire

	N		Mean		SD		Min		Max	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
Source- Pre-test	87	90	3.08	2.85	.88	.90	1.00	1.00	5.00	4.80
Source- Post-test	79	91	2.97	2.66	.79	.81	1.00	1.00	4.60	4.60
Certainty- Pre-test	87	90	3.44	3.35	.68	.74	1.33	1.33	4.67	4.83
Certainty- Post-test	79	91	3.15	3.00	.73	.73	1.50	1.17	4.67	4.50
Development- Pre-test	87	90	3.72	3.79	.62	.60	1.00	1.67	5.00	5.00
Development- Post-test	79	91	3.36	3.45	.83	.85	1.83	1.33	5.00	5.00
Justification- Pre-test	87	90	4.05	4.19	.66	.67	1.11	1.00	5.00	5.00
Justification- Post-test	79	91	3.52	3.66	.90	.94	1.22	1.11	5.00	5.00

Note: The epistemological belief dimensions range from 1 to 5.

Table 4.3 presents the descriptive statistics of EBQ that applied two times, at the beginning of the study (pre-test) and at the end of the study (post-test). As seen on the table, there was a decrease on the experimental and comparison group students' scores of Source and Certainty scales over time. Moreover, regarding Source and Certainty, comparison group students' both before the instruction scores and after the instruction scores were higher than the experimental group students. Additionally, experimental and comparison group students' scores related with Development and Justification were also decreased over time. Also, experimental group students scored slightly higher than the comparison group students before the instruction as well as after the instruction. Considering the descriptive results of scientific epistemological beliefs scores, experimental group students tend to hold more sophisticated beliefs since they had lower mean scores on source and certainty dimensions as well as higher scores on development and justification dimensions. Inferential results will be presented next part of this chapter. The descriptive information about the last variable of the study can be found in following table.

Table 4.4 Descriptive Statistics of Science Process Skills Test

	N		Mean		SD		Min		Max	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
SPST Pre-test	89	74	8.64	9.51	3.13	3.12	3	4	19	18
SPST Post-test	81	76	9.05	9.91	3.69	3.41	1	4	22	18

Note: The science process skills scores were calculated by calculating total scores so the scores range from 0 to 26.

Descriptive statistics related with two implementations of SPST were reported at Table 4.4. As seen at the table, students' science process skills scores in the experimental group were appeared to be slightly higher than the comparison group in both pre-test and post-tes implementations. Moreover, both group students appeared to slightly increase their scores over time.

After reporting the results of descriptive statistics regarding conceptual understanding, motivation, learning strategy use, scientific epistemological beliefs, and science process skills variables, the results of inferential statistics will be presented in the next part.

4.2 Inferential Statistics

Mixed between-within subjects analysis of variance (ANOVA) and mixed between-within subjects multivariate analysis of variance (MANOVA) was performed to investigate the relative effect of 7E Learning Cycle instruction (7E-LCI) and curriculum oriented science instruction (COSI) on students' conceptual understanding, motivation and learning strategy use, scientific epistemological beliefs, and science process skills. Additionally, the syntaxes of the analyses were extended to see a detailed result. The analyses through new syntaxes allow investigating the changes in the mean scores of above mentioned variables over time separately for each group. What is more, new syntaxes show the result of the mean difference between the groups separately at each implementation time period. Bonferroni adjustment was applied to control Type I Error across multiple tests conducted to compare the groups and variables. Before conducting the analyses, the assumptions were checked. Following parts firstly presents the results of assumptions for conceptual inventories, MSLQ, EBQ and SPST. Then, the results of mixed between-within ANOVAs for conceptual inventories and mixed between-within MANOVAs for MSLQ and EBQ, and then mixed between-within ANOVA for SPST were reported.

4.2.1 Preliminary Analyses of Data

This part covers the assumption check for variables of the study. For each of the variables, normality and outliers, linearity, homogeneity of variance-covariance matrices, and multicollinearity and singularity assumptions were investigated. Additionally, Sphericity assumption which required for repeated measures was checked for conceptual inventories. Before the explanation of assumptions for each variable separately it would be informative to mention about two general assumptions of mixed between-within subjects ANOVA and mixed between-within subjects MANOVA which are sample size and independence of observation.

4.2.1.1.1 Sample Size and Independence of Observation

Sample size of the study was enough to conduct analyses for each variable since the cases in each cell were greater than the number of dependent variables (Pallant, 2001).

Moreover, independence of observations assumption was obtained by ensuring the individually completed questionnaires. However, the group works during the implementation of treatment may cause the mutual understanding of concepts and dependence of subjects' scores which may affect this assumption. This situation is mentioned in the limitations of the study part.

In the following section, assumption analyses regarding the conceptual inventories were covered.

4.2.1.2 Assumption Check for Conceptual Inventories Scores

In this study, three conceptual inventories which are Skeletal System Conceptual Inventory (SSCI), Circulatory System Conceptual Inventory (CSCI), and Respiratory System Conceptual Inventory (RSCI) were implemented at three time points; at the beginning of the instruction (Time1), at the end of the instruction

(Time2), and one-month later the instruction (Time3). The assumptions for each conceptual inventory were analyzed separately but the results were presented in the following parts together.

4.2.1.2.1 Normality and Outliers

Univariate normality for three repeated implementation of conceptual inventories were examined through skewness and kurtosis values. As presented in the Table 4.5, the values vary between -2 and +2, which is acceptable range demonstrating univariate normality.

Table 4.5 Skewness and Kurtosis Values for the Conceptual Inventories across Groups

	N		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG
SSCI-Time1	86	92	0.55	0.58	-0.06	0.27
SSCI-Time2	86	90	0.58	0.29	-0.21	-0.50
SSCI-Time3	82	85	0.56	0.01	-0.35	-0.89
CSCI-Time1	84	94	0.78	0.72	-0.03	-0.06
CSCI-Time2	83	91	0.92	0.28	2.05	-0.56
CSCI-Time3	81	82	0.48	0.74	-0.47	-0.02
RSCI-Time1	84	91	0.93	0.77	0.28	0.38
RSCI-Time2	84	93	1.19	0.48	1.90	-0.41
RSCI-Time3	84	86	0.98	0.82	0.94	0.21

Note: SSCI= skeletal system conceptual inventory, CSCI= circulatory system conceptual inventory, RSCI= respiratory system conceptual inventory

Multivariate normality and outliers were examined by interpreting Mahalanobis Distance. The maximum values calculated for conceptual inventories across three implementations were 14.70, 12.86 and 14.14, respectively. The critical value in chi-square table for three dependent variables was found to be 16.26 (Pallant, 2001). Since the maximum Mahalanobis distances of sample was lower than the critical value, there was no need to remove any value from the data.

4.2.1.2.2 Linearity

The linearity assumption was assessed separately by generating scatterplots between each pair of the dependent variables for each group. Because of having two groups (experimental group and comparison group) and three dependent variables (Time1, Time2, and Time3) in each of three conceptual inventories (SSCI, CSCI, and RSCI), 18 scatterplots were generated. Although the scatterplots do not provide an indication of a perfect linearity, it can be assumed that there is no serious violation of this assumption (See Appendix Q).

4.2.1.2.3 Homogeneity of Variance-Covariance Matrices

Homogeneity of variance-covariance matrices assumption was checked by using Box's Test of Equality of Covariance Matrices. As seen in the Table 4.6, there was no violation of homogeneity of variance-covariance matrices assumption with Box's M significance values of SSCI, CSCI, and RSCI, $p > 0.001$ (Pallant, 2001).

Table 4.6 Box's Test of Equality of Covariance Matrices for Conceptual Inventories

	SCI	CCI	RCI
Box's M	8.86	7.28	16.39
F	1.44	1.19	2.67
df1	6	6	6
df2	172144.8	150480.3	174851.5
Sig.	.19	.31	.01

The significance of Levene's Test was also investigated to examine the homogeneity of variances between groups. As Table 4.7 shows, there was a violation of homogeneity of variance assumption only for one variable, RCI-Time3. Since the size of largest cell and lower cell is close in magnitude, homogeneity of variance is not considered as a treat for analysis of data (Stevens, 1996, p. 249).

Table 4.7 Levene's Test of Equality of Error Variances Conceptual Inventories

	F	df1	df2	Sig.
SSCI-Time1	3.87	1	155	.05
SSCI-Time2	3.71	1	155	.06
SSCI-Time3	.12	1	155	.73
CSCI-Time1	.08	1	147	.78
CSCI-Time2	.47	1	147	.49
CSCI-Time3	.06	1	147	.81
RSCI-Time1	.00	1	157	.96
RSCI-Time2	2.28	1	157	.13
RSCI-Time3	8.76	1	157	.00

4.2.1.2.4 Multicollinearity and Singularity

Multicollinearity and singularity assumption assess the relationships between the variables. Zero-order correlations were computed between three dependent variables across pre-tests, post-test and retention tests implementations. As depicted in the Appendix Q, there is not a strong relationship between the variables of concern ($r < .8$) (Pallant, 2001).

4.2.1.2.5 Sphericity Assumption

This assumption requires the equality of variances that calculated from difference scores between any of comparisons. This is assessed by Mauchly's Test of Sphericity. The assumption was violated on SSCI and CSCI scores (p= .00, p= .02) but it was met on RSCI with the significance values of, and p= .78, respectively. The results needed to be interpreted both via Multivariate Test in the case of violation, and via Tests of Within-Subjects Effects for the data having met the assumption. However, all of the analyses regarding SSCI, CSCI and RSCI were interpreted based on the Multivariate Test results to be consistent in the study.

In summary, there were no serious violation to conduct the mixed between-within ANOVAs for the data gathered from conceptual inventories. In the following part, assumptions regarding the data collected by MSLQ were discussed.

4.2.1.3 Assumption Check for Motivated Strategies for Learning Questionnaire (MSLQ) Scores

In this study MSLQ was implemented as pre-test and post-test. It comprises from two main sections as motivation and learning strategy use. These two sections were analyzed through two distinct mixed MANOVA analyses. For that reason, the assumptions were also investigated separately. However, combining results regarding the assumptions were presented in this part.

4.2.1.3.1 Normality and Outliers

To assess univariate normality, skewness and kurtosis values were generated. Table 4.8 presents skewness and kurtosis values of motivational variables and learning strategy variables implemented prior and after the treatment separately with respect to experimental and comparison groups. As it can be inferred from the table, skewness and kurtosis values were tolerable for all the dependent variables except for extrinsic goal orientation scores prior to the instruction. According to Tabachnick and Fidell (1996, p. 381), if the smallest cell has 20 participants the researcher should ensure robustness. In the present study, because the sample size in the smallest cell was higher than 20, the violation of normality is not expected to cause a serious problem to the validity of the results.

Table 4.8 Skewness and Kurtosis Values of Motivation Scales and Learning Strategies Scales

		N		Skewness		Kurtosis	
		CG	EG	CG	EG	CG	EG
Motivation Scales	Pre-IGO	87	91	-0.82	-0.78	0.07	0.24
	Post-IGO	85	87	-0.88	-1.19	0.18	1.42
	Pre-EGO	87	91	-1.72	-1.53	3.50	2.35
	Post-EGO	85	87	-0.71	-1.28	0.36	1.00
	Pre-TV	87	91	-0.85	-0.72	0.18	-0.48
	Post-TV	85	87	-1.03	-0.83	0.84	0.02
	Pre-CLB	87	91	-0.50	-0.67	-0.84	-0.24
	Post-CLB	85	87	-0.92	-0.71	0.53	-0.24
	Pre-SE	87	91	-0.60	-1.30	-0.42	1.30
	Post-SE	85	87	-0.68	-0.72	0.28	-0.27
	Pre-TA	87	91	-0.05	-0.37	-0.63	0.03
	Post-TA	85	87	-0.23	-0.28	-0.65	-0.20
Learning Strategies Scales	Pre-R	87	91	-0.54	-1.04	-0.34	1.04
	Post-R	85	87	-0.68	-0.28	-0.15	-1.00
	Pre-E	87	91	-0.52	-0.96	-0.42	0.36
	Post-E	85	87	-0.82	-0.52	0.60	-0.78
	Pre-O	87	91	-0.63	-0.45	-0.18	-0.56
	Post-O	85	87	-0.38	-0.37	-0.80	-0.80
	Pre-CT	87	91	-0.06	-0.91	-0.74	0.28
	Post-CT	85	87	-0.48	-0.47	0.40	-0.79
	Pre-SR	87	91	-0.56	-0.92	0.71	0.58
	Post-SR	85	87	-0.40	-0.42	0.36	0.36
	Pre-TSE	87	91	0.22	-0.44	-0.80	0.52
	Post-TSE	85	87	0.21	0.48	1.08	-0.32
	Pre-ER	87	91	-0.16	-0.44	-0.70	-0.27
	Post-ER	85	87	0.60	0.62	0.61	-0.23
	Pre-PL	87	91	-0.02	-0.41	-0.94	-0.84
	Post-PL	85	87	-0.44	-0.50	-0.42	-0.40
	Pre-HS	87	91	-0.52	-0.70	0.11	0.47
	Post-HS	85	87	-0.89	-0.61	0.73	0.26

Mahalanobis Distance values were generated for each of motivation scales and learning strategies scales to investigate multivariate normality and outliers. The maximum Mahalanobis Distance values of motivation scales was higher than 32.91, the critical value for 12 dependent variables reported on chi-square table. Moreover, the maximum values of learning strategy scales were also higher than 42.31, which is the critical limit for 18 dependent variables. This situation indicates the presence of multivariate outliers on the data. To control whether these cases are having any influence on the results of analyses, the Cook's Distance values were checked. According to Tabachnick and Fidell (2001, p. 69), cases with values larger than 1 indicate potential problem. The maximum values for Cook’s Distance 0.08 and 0.10 suggesting no major problems about the outliers.

4.2.1.3.2 Linearity

In order to examine the linearity assumption scatterplots between each pair of dependent variables were generated. The scatterplots were generated separately for experimental and comparison groups with respect to each of two mixed between-within MANOVA variables based on motivation scales and learning strategies scales. Considering two groups, two implementations, and six and nine dependent variables from each scale, 438 scatterplots were generated in total. The scatterplots in Appendix Q were interpreted according to general view and there seemed to be no serious violation of linearity assumption.

4.2.1.3.3 Homogeneity of Variance-Covariance Matrices

The significance of Box’s Test of Equality of Covariance Matrices were proceeded to examine whether the data meets the assumption of homogeneity of variance covariance matrices. As it can be deduced from Table 4.9, the data was not violated the assumption since the p values are not significant at .001 (Pallant, 2005).

Table 4.9 Box's Test of Equality of Covariance Matrices for MSLQ

	Motivation Scales	Learning Strategies Scales
Box’s M	110.38	210.60
F	1.38	1.09
df1	78	171
df2	84831.24	82458.356
Sig.	.04	.20

Additionally, the assumption of equality of variance was interpreted through the significance of variables on Levene’s Test of Equality of Error Variances. The test investigates the homogeneity of variances between groups for each variable assigned to the mixed between-within MANOVA analysis. As presented in Table 4.10, result of the test for each variable revealed no violation of this assumption.

Table 4.10 Levene's Test of Equality of Error Variances for MSLQ

	F	df1	df2	Sig.
Pre-IGO	1.76	1	164	.19
Pre-EGO	0.35	1	164	.56
Pre-TV	0.50	1	164	.48
Pre-CLB	0.05	1	164	.83
Pre-SE	0.02	1	164	.89
Pre-TA	1.03	1	164	.31
Post-IGO	2.09	1	164	.15
Post-EGO	1.08	1	164	.30
Post-TV	0.15	1	164	.70
Post-CLB	2.48	1	164	.12
Post-SE	0.42	1	164	.52
Post-TA	0.02	1	164	.89
Pre-R	0.33	1	164	.57
Pre-E	0.17	1	164	.68
Pre-O	0.88	1	164	.35
Pre-CT	0.98	1	164	.33
Pre-SR	0.57	1	164	.45
Pre-TSE	2.78	1	164	.10
Pre-ER	0.51	1	164	.48
Pre-PL	1.32	1	164	.25
Pre-HS	0.02	1	164	.89
Post-R	0.22	1	164	.64
Post-E	0.57	1	164	.45
Post-O	1.02	1	164	.31
Post-CT	0.31	1	164	.58
Post-SR	0.79	1	164	.37
Post-TSE	0.12	1	164	.73
Post-ER	0.19	1	164	.66
Post-PL	0.71	1	164	.40
Post-HS	1.28	1	164	.26

4.2.1.3.4 Multicollinearity and Singularity

Mixed between-within MANOVA requires a moderate correlation between dependent variables distinctly for each group. Pallant (2001) states it is safe to assume no violation on the absence of a correlation higher than 0.8. To check this assumption Zero-order Correlations were computed and the strength of the correlations among the motivational variables and learning strategy use variables are presented at Appendix Q. As it can be inferred from the tables the correlations between the variables did not exceed 0.8, which interpreted as no reason for concern about this assumption.

The preliminary analyses for motivation and learning strategy use variables showed that, there was no serious violation on the assumptions for mixed MANOVAs. The next variable of the study, scientific epistemological belief, was investigated with respect to assumptions of mixed MANOVA in the following part.

4.2.1.4 Assumption Check for Epistemological Beliefs Questionnaire (EBQ) Scores

EBQ was implemented two times during the study; at the beginning of the instruction (pre-test) and at the end of the instruction (post-test). In this part, the assumptions were checked to find out if the data has any violations to conduct the mixed MANOVA analysis regarding this variable.

4.2.1.4.1 Normality and Outliers

Skewness and kurtosis values were calculated as indicators of univariate normality while Mahalanobis Distance values were determined as to check multivariate normality and outliers. As presented at the Table 4.11, kurtosis values are very high for pre-development scores of comparison group as well as pre-justification scores for both of the experimental and comparison groups. Since the amount of participants in each groups are large enough it can be assumed that there is no serious violation of this assumption (Tabachnick & Fidell, 1996, p. 381).

Table 4.11 Skewness and Kurtosis Values for the EBQ Scales Across Groups

	N		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG
Pre-Source	87	90	-0.15	0.13	-0.11	-0.95
Post-Source	79	91	-0.38	0.24	0.11	-0.58
Pre-Certainty	87	90	-0.71	-0.09	0.31	-0.13
Post- Certainty	79	91	0.05	0.02	-0.66	-0.63
Pre-Development	87	90	-1.58	-0.30	4.88	0.77
Post-Development	79	91	0.10	-0.47	-0.75	-.009
Pre-Justification	87	90	-2.13	-1.80	6.81	5.60
Post-Justification	79	91	-0.41	-0.76	-0.48	-0.11

The maximum value of Mahalanobis Distance related with the data was 34.13 and there were two cases exceeding the critical value of 26.13, which is reported at chi-square table considering eight dependent variables. The maximum value of Cook's Distance was checked to decide if these cases had any undue effect on the analysis. Since the value is smaller than 1 these cases were not considered as potential problem (Tabachnick & Fidell, 2001).

4.2.1.4.2 Linearity

In order to check linearity assumption, the scatterplots were generated for each pairs of the dependent variables for prior and posterior implementations of EBQ scales with respect to experimental and comparison groups. These 24 scatterplots indicated that there was no violation of this assumption for mixed between-within subjects MANOVA analyses of EBQ (See Appendix Q).

4.2.1.4.3 Homogeneity of Variance-Covariance Matrices

This assumption was checked by Box's Test of Equality of Covariance Matrices. The results given in the Table 4.12 indicated no violation of this assumption for mixed between-within MANOVA analysis. Similarly, equality of variances between groups for each dependent variable was met since Levene's Test of Equality of Error Variances does not display significant results for any of variables.

Table 4.12 Box's Test of Equality of Covariance Matrices for EBQ Scales

	EBS Scales
Box's M	28.67
F	.76
df1	36
df2	85622.60
Sig.	.87

Table 4.13 Levene's Test of Equality of Error Variances for EBQ Scales

	F	df1	df2	Sig.
Pre-Source	1.87	1	162	.17
Post-Source	.15	1	162	.70
Pre-Certainty	.57	1	162	.45
Post- Certainty	.00	1	162	.99
Pre-Development	.96	1	162	.33
Post-Development	.32	1	162	.57
Pre-Justification	1.27	1	162	.26
Post-Justification	.01	1	162	.91

4.2.1.4.4 Multicollinearity and Singularity

Zero-order correlations between each of the variables were presented at related table in Appendix Q. As deduced from the table there is no variables that are highly related with each other. So there was no violation of the assumption related with scientific epistemological beliefs variables.

In general, the preliminary analyses for scientific epistemological belief variable indicated that the data can be assumed to meet all assumptions. The last variable of the study will be investigated with respect to assumptions of mixed MANOVA in the following part.

4.2.1.5 Assumption Check for Science Process Skill Test (SPST) Scores

In the present study, the SPST implemented as pre-test and post-test to investigate the effect of treatment on this variable. The data was analyzed to find out if there is a serious violation of the assumptions to conduct mixed MANOVA.

4.2.1.5.1 Normality and Outliers

Univariate normality was checked by investigating skewness and kurtosis values and the values were found in acceptable range of -2, +2 (See Table 4.14). The multivariate normality and outliers were examined through calculating Mahalanobis Distance value. Maximum Mahalanobis distance was found to be 13.76 which is lower than to the critical value of 13.82 from Chi-square table (Pallant, 2001) indicating the absence of outliers on the data set.

Table 4.14 Skewness and Kurtosis Values for the SPS Scales Across Groups

	N		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG
SPST Pre-test	89	74	0.58	0.48	0.55	0.20
SPST Post-test	81	76	0.89	0.68	1.68	-0.26

4.2.1.5.2 Linearity

Linearity assumption was checked through scatter plots. Considering two groups and two implementations of the test, two scatterplots were generated in total. The scatterplots presented in Appendix Q and there seemed to be no serious violation for this assumption.

4.2.1.5.3 Homogeneity of Variance-Covariance Matrices

The Box's Test of Equality of Covariance Matrices were proceeded to examine assumption of homogeneity of variance covariance matrices. As it can be deduced from Table 4.15, this assumption was satisfied $p > 0.001$.

Table 4.15 Box's Test of Equality of Covariance Matrices for SPS Scales

	SPS Scales
Box's M	5.061
F	1.66
df1	3
df2	26702831.72
Sig.	.17

Additionally, the assumption of equality of variance was checked with the Levene's Test of Equality of Error Variances. The test investigates the homogeneity of variances between groups for each variable assigned to the analysis. Results of the test for each variable revealed no violation of this assumption (See Table 4.16).

Table 4.16 Levene's Test of Equality of Error Variances for SPS Scales

	F	df1	df2	Sig.
SPST Pre-test	0.002	1	146	.96
SPST Post-test	0.133	1	146	.72

4.2.1.5.4 Multicollinearity and Singularity

The correlations between pre-test and post-test scores were interpreted for experimental and comparison groups separately in order to check this assumption. The correlation coefficients was .54 for experimental group and .26 for comparison groups indicating no violation of the assumption related with to science process skills variables for experimental group.

Overall, in this part the preliminary analyses regarding the data collected from conceptual inventories, MSLQ, EBQ and SPST were discussed. The results of assumptions indicated no serious violation for any of the variables. In the following section, the results of statistical analyses for above mentioned scales were presented respectively.

4.2.2 Statistical Analyses

The mixed between-within subjects ANOVA and mixed between-within subjects MANOVA were applied in order to determine the mean difference among groups with respect to students' conceptual understanding, motivation and learning strategies, scientific epistemological beliefs, and science process skills respectively. Moreover, the effect of treatment over time was investigated for each variable by extended syntax of analysis. Finally, the results will be explained separately for each variable on the following parts.

4.2.2.1 Statistical Analysis Regarding Conceptual Understanding

Three mixed between-within subjects ANOVAs were conducted separately for three intact conceptual inventories in human body system subject (Skeletal System Conceptual Inventory, Circulatory System Conceptual Inventory, and Respiratory System Conceptual Inventory) to determine whether there was a significant mean difference among students' conceptual understanding received 7E Learning Cycle instruction (7E-LCI) and curriculum oriented science instruction (COSI). In addition, if there was a change in students' human body concepts understanding after completion of the treatment was analyzed. The interaction between treatment and time variables was investigated as well.

More specifically, in this section, finding regarding the second main research question was discussed.

Q.2. *What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' understanding of human body systems concept (Skeletal System, Circulatory System, and Respiratory System)?*

This research question includes 12 sub-questions that address the interaction effect, between group differences and within group differences with respect to SSCI, CSCI and RSCI. First, the analysis of SSCI was presented in the following part.

4.2.2.1.1 Skeletal System Conceptual Inventory (SSCI)

There are four sub-questions addressed in this part which are,

Q.2.1.1. *Is there a significant interaction between treatment and time with respect to students' conceptual understanding of skeletal system concepts?*

Q.2.2.1. *Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' understanding of skeletal system concepts at before the treatment (Time1), after the treatment (Time2), and one-month later the treatment (Time3)?*

Q.2.3.1. *Is there a significant change in conceptual understanding of experimental group students who exposed to 7E learning cycle instruction with respect to skeletal system concepts across three time periods?*

Q.2.3.2. *Is there a significant change in conceptual understanding of comparison group students who exposed curriculum oriented science instruction with respect to skeletal system concepts across three time periods?*

A mixed between-within subjects ANOVA was performed to answer this all sub-questions which means to investigate the effect of 7E-LCI and COSI on students' conceptual understanding in Skeletal System. The dependent variables were students' scores on Skeletal System Conceptual Inventory that measured three times, before instruction of skeletal system concepts (Time1), after the instruction (Time2) and again one month later (Time3). The independent variable was the type of treatment: 7E-LCI for the experimental group versus COSI for the comparison group. The results were reported in Table 4.17.

Table 4.17 Mixed Between-Within Subjects ANOVA Results for SSCI

Effect	Wilks' λ	Df	F	Sig. (*p*)*	Partial η^2
Time	0.81	2	17.99	0.00*	0.19
Time X Treatment	0.94	2	4.91	0.01*	0.60

*Analysis was performed with the significance level of $\alpha = 0.05$

Sub-question Q.2.1.1 that stated at the beginning of this part was investigated through Table 4.17. The results revealed a statistically significant interaction effect between time and treatment Wilk's λ= 0.94, F(2, 154)= 4.91, p= 0.01. Significant interaction effect means that the changes in students' concept understanding scores over time for two groups (7E-LCI and COSI) were different. The multivariate partial η^2 value of interaction effect is 0.60 which is quite high based on the (Cohen, 1988). Moreover, there was a statistically significant mean difference across the three time periods, Wilk's λ= 0.81, F(2, 154)= 17.99, p= 0.00. The multivariate partial η^2 value is 0.19 indicating that 19% of multivariate variance of dependent variables was explained by time effect.

The main effect of treatment was also significant which means that there was a significant mean difference between groups F(1, 155)= 8.79, p= 0.00 (See Table 4.18). The partial η^2 value 0.05 indicating that 5% of multivariate variance of dependent variables was explained by treatment effect.

Table 4.18 Tests of Between-Subjects Effects Results for SSCI

Source	Type III SS	df	F	Sig. (p)*	Partial η^2	Obs. Power
Treatment	65.45	1	8.79	0.00	0.05	0.84

*Analysis was performed with the significance level of α = 0.05

After having statistically significant interaction effect, it is more explanatory to investigate between and within group comparisons through separating one based on the other. Because, the results related with tests of between groups and within subjects provide information about neither the mean difference between experimental and comparison group at each specific time nor the mean difference over three time periods for each specific group of students. To investigate these comparisons the syntax was extended. Additionally, Bonferroni Adjustment was requested on SPSS to decrease Type 1 error on multiple comparisons. Firstly, sub-question Q.2.2.1 which asks between group differences at each time point were investigated (See

Table 4.20). Previously, the mean of each group students at any time points were summarized in Table 4.19.

Table 4.19 Means of Groups with Respect to Time for SSCI

Time	Treatment	N	Mean	Std. Error
1	7E-LCI	81	2.94	0.18
	COSI	76	2.54	0.19
2	7E-LCI	81	4.41	0.24
	COSI	76	3.12	0.15
3	7E-LCI	81	3.84	0.23
	COSI	76	3.29	0.24

Table 4.20 Pairwise Comparisons of Groups by Time for SSCI

Time	Treatment I vs J	Mean Difference (I-J)	Std. Error	Sig. (*p*) [1]
1	7E-LCI vs COSI	0.40	0.26	0.14
2	7E-LCI vs COSI	1.29*	0.34	0.00
3	7E-LCI vs COSI	0.55	0.34	0.10

*Analysis was performed with the significance level of $\alpha = 0.05$
[1] Adjustment for multiple comparisons: Bonferronni

As shown in Table 4.20, at the beginning of the skeletal system instruction (Time1), there was no statistically significant mean difference between the two groups regarding students' concept understanding ($p > .05$) (See Table 4.19). At the end of the instruction (Time2) there was a significant mean difference between experimental group ($M = 4.41$) and comparison group ($M = 3.12$) ($p < .05$). The significant difference found between groups after the instruction aroused from treatment effect in favour of experimental group. However, one-month later (Time3) no significant mean difference between the two groups was observed. This finding implied that the retention of the knowledge was not significantly different between groups ($p > .05$). The mean scores at Time3, on the other hand, showed that experimental group students ($M = 3.84$) scored slightly higher than the comparison group students ($M = 3.29$). In other words, students exposed 7E-LCI retained the concepts better than students instructed with COSI although it did not contributed a significant difference. After having investigated the differences between groups, within group differences were investigated across the three time periods (Q.2.3.1 and Q.2.3.2) (See Table 4.21).

Table 4.21 Pairwise Comparisons of Time by Groups for SSCI

Treatment	Time I vs J	Mean Difference (I-J)	Std. Error	Sig. (*p*) [1]
7E-LCI	Time1 vs Time2	-1.47*	0.24	0.00
	Time2 vs Time3	0.57*	0.20	0.01
	Time1 vs Time3	-0.90*	0.25	0.00
COSI	Time1 vs Time2	-0.58	0.25	0.06
	Time2 vs Time3	-0.17	0.21	1.00
	Time1 vs Time3	-0.75*	0.26	0.01

*Analysis was performed with the significance level of $\alpha = 0.05$
1 Adjustment for multiple comparisons: Bonferronni

As shown in the Table 4.21, there was a significant change in experimental group students' conceptual understanding of skeletal system across time from Time1 (M= 2.94) to Time2 (M= 4.41) (p< .05), from Time2 to Time3 (M= 3.84) (p< .05), and from Time1 to Time3 (p< .05). In comparison group the mean difference in conceptual inventory scores was significant only from Time1 (M= 2.54) to Time3 (M= 3.29) (p< .05). This result indicates the continuous effect of treatment on experimental group was better than the comparison group. A clear picture of within group changes and between group differences can be inferred from Figure 4.1.

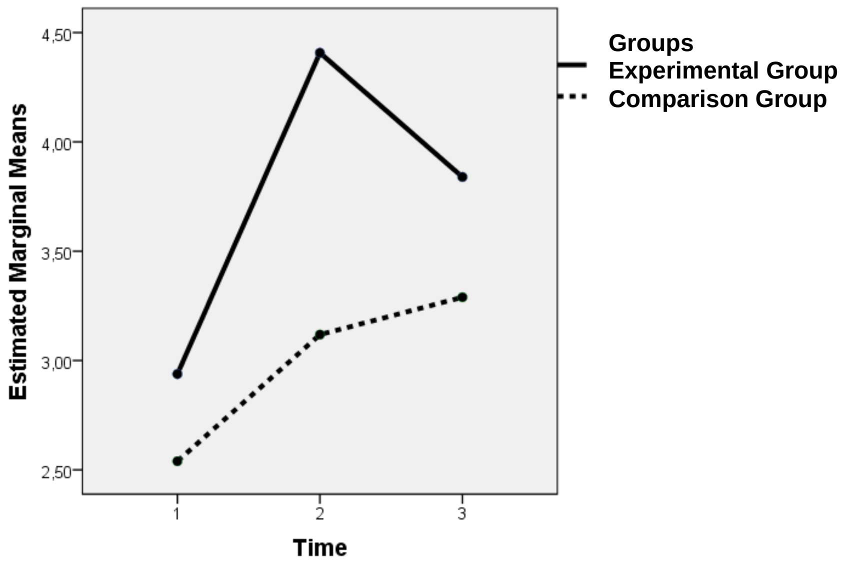

Figure 4.1 Estimated Marginal Means of Students' Conceptual Understanding on Skeletal System

Moreover, Figure 4.2 and Figure 4.3 shows the proportions of correct responses to each item of SSCI for the experimental and the comparison groups at Time2 and Time3, respectively. Analyzing the item responses indicated that, students in the experimental group were appeared to be more successful than the comparison group in both implementations. It reveals that 7E learning cycle provided more scientifically correct knowledge acquisition. For example, Item 1 was related to the perception of students regarding the bones; if the bones of a living organism are also living or nonliving. Experimental group students seemed to understand and retain that the bones are living and composed of cells better than the comparison group students. Similarly, students in experimental group outperformed in Item 7, which was about the difference between the skeleton of a human baby and adult. However, both group students reported similar and low scores in Item 2 at Time2 and Time3. The item was reflecting the confusion about the types of bones and joints. This result revealed that the instructions did not indicate a superiority to provide the understanding relative the type of bones and joints.

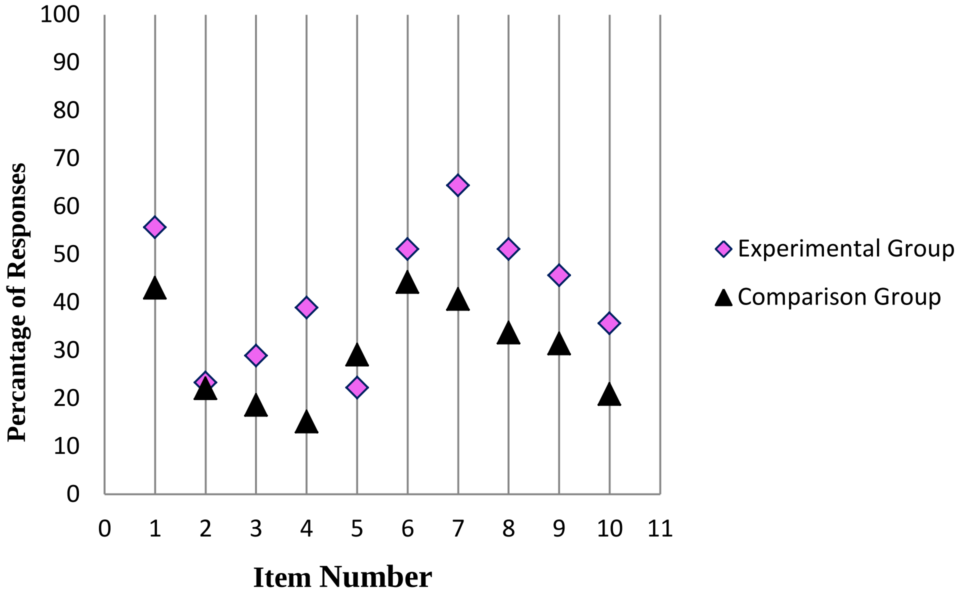

Figure 4.2 Comparison Between SSCI Time2 Scores of the Experimental and the Comparison Groups

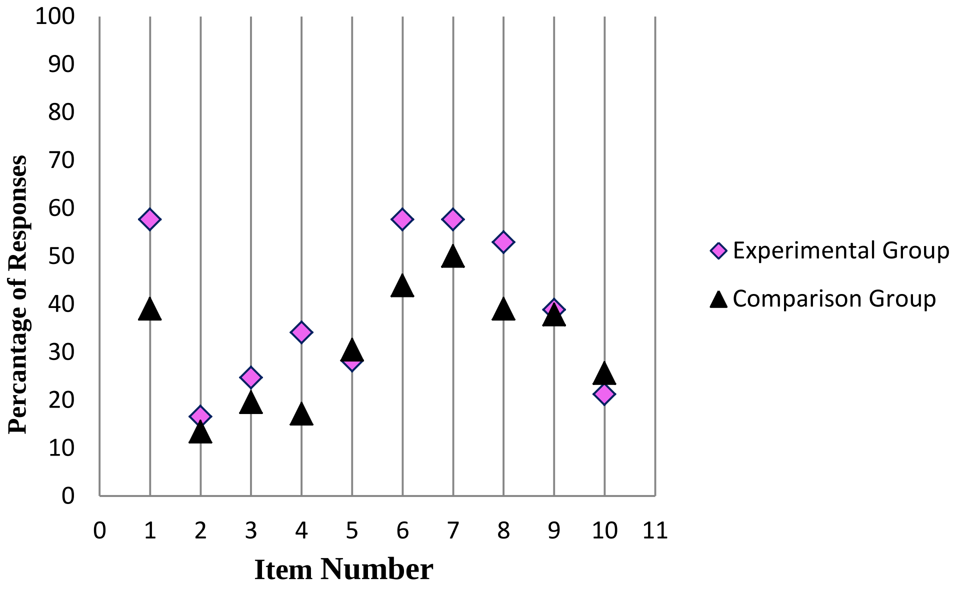

Figure 4.3 Comparison Between SSCI Time3 Scores of the Experimental and the Comparison Groups

Overall, as it can be inferred from Table 4.21 and Figure 4.1 experimental group students' conceptual understanding of Skeletal System improved after the treatment (Time2) and decreased to a degree later one-month period (Time3). On the other hand, comparison group students' performance on conceptual inventory appears to have actually improved slightly in the delayed post-test administered one month later. However, this increase in comparison group students' conceptual understanding was not statistically significant from Time2 to Time3. Moreover, in the experimental group, the increase in mean scores from Time1 to Time2 was higher than that of the comparison group. Additionally, the change in the mean scores from Time1 through Time3 was higher in the experimental group than the comparison group which indicates the effectiveness of 7E-LCI on understanding and long term retention of Skeletal System concepts over COSI. At Time2, experimental group students had the highest mean score and the mean difference between experimental and comparison groups was statistically significant. The two groups did not differ at Time1 and Time3 regarding mean concept understanding scores (See Table 4.20).

The results were indicated the effectiveness of 7E-LCI on students' understanding and long term retention of Skeletal System concepts. In the next part, the effect of treatment on the circulatory system conceptual understanding was discussed.

4.2.2.1.2 Circulatory System Conceptual Inventory (CSCI)

The four sub-questions of second main research question were addressed in this part as listed next.

Q.2.1.2. *Is there a significant interaction between treatment and time with respect to students' conceptual understanding of circulatory system concepts?*

Q.2.2.2. *Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' understanding of circulatory system concepts at before* *the treatment (Time1), after the treatment (Time2), and one-month later the treatment (Time3)?*

Q.2.3.3. *Is there a significant change in conceptual understanding of experimental group students who exposed to 7E learning cycle instruction with respect to circulatory system concepts across three time periods?*

Q.2.3.4. *Is there a significant change in conceptual understanding of comparison group students who exposed curriculum oriented science instruction with respect to circulatory system concepts across three time periods?*

These sub-questions were investigated through a mixed between-within subjects ANOVA that analyses the effect of 7E-LCI and COSI on students' conceptual understanding in Circulatory System concept. The independent variable was the type of treatment while the dependent variables were students' scores on prior, posterior and delayed implementations of Circulatory System Conceptual Inventory. The results of the multivariate test analysis were reported in Table 4.22.

Table 4.22 Mixed Between-Within Subjects ANOVA Results for CSCI

Effect	Wilks' λ	Df	F	Sig. (*p*)*	Partial η2
Time	0.77	2	21.77	0.00*	0.23
Time X Treatment	0.98	2	1.67	0.19	0.02

*Analysis was performed with the significance level of $\alpha = 0.05$

The results related with the interaction which addressed in sub-question Q.2.1.2 showed that there was not a statistically significant interaction effect between time and treatment Wilk's λ= 0.98, $F(2, 146)$= 1,67, $p > 0.05$. Also, there was a statistically significant mean difference across the time, Wilk's λ= 0.77, $F(2, 146)$= 21.77, $p < 0.05$, as indicated in Table 4.22. This significant mean difference implies that students' conceptual understanding changes over time. The multivariate partial η^2 value is 0.23 which is indicating 23% of multivariate variance of dependent variables were explained by time effect. Table 4.23 presents the pairwise comparisons of CSCI scores across time.

Table 4.23 Pairwise Comparisons for Main Effect of Time for CSCI

Time I vs J	Mean Difference (I-J)	Std. Error	Sig. (*p*)*
Time1 vs Time2	-0.93	0.15	0.00
Time2 vs Time3	0.04	0.14	0.77
Time1 vs Time3	-0.89	0.17	0.00

*Analysis was performed with the significance level of $\alpha = 0.05$

The pairwise analysis of time effect at Table 4.23 shows that there were significant mean differences between Time1 and Time2, and Time1 and Time3 ($p < 0.05$) while there was no significant mean difference between Time2 and Time3 ($p > 0.05$). Investigation of mean scores shows that the conceptual understanding of students increased over time. More specifically, their scores increased from Time1 to Time2 and from Time1 to Time3 but it decreased slightly from Time2 to Time3.

In addition, results revealed a significant main effect of treatment $F(1, 147) = 5.64$, $p = 0.02$ (See Table 4.24). This finding suggests that there was a significant mean difference between groups. The partial η^2 value is 0.04 indicating that 4% of multivariate variance of dependent variables was explained by treatment effect.

Table 4.24 Tests of Between-Subjects Effects Results for CSCI

Source	Type III SS	Df	F	Sig. (*p*)*	Partial η^2	Obs. Power
Treatment	24.96	1	5.64	0.02	0.04	0.66

*Analysis was performed with the significance level of $\alpha = 0.05$

The abovementioned results, on the other hand, reveal the mean differences by combining the students of two groups or by combining the three points of time periods (Time1, Time2, and Time3). Even though the interaction effect was not significant for CSCI scores, the extended syntax was ran to be able to investigate treatment effect on each group and on each time severally as addressed on the sub-questions Q.2.2.2, Q.2.3.3 and Q.2.3.4. Bonferronni Adjustment test was requested during the analysis to ensure a lower Type 1 error on multiple comparisons. Following tables present the results of pairwise comparisons of groups and time effects. Firstly, the mean scores of the groups at each time period were covered at Table 4.25. Later, the between group differences were reported and discussed (See Table 4.26).

Table 4.25 Means of Groups with Respect to Time for CSCI

Time	Treatment	N	Mean	Std. Error
1	7E-LCI	79	1.85	0.15
	COSI	70	1.54	0.16
2	7E-LCI	79	2.79	0.1
	COSI	70	2.47	0.20
3	7E-LCI	79	2.99	0.20
	COSI	70	2.19	0.21

Table 4.26 Pairwise Comparisons of Groups by Time for CSCI

Time	Treatment I vs J	Mean Difference (I-J)	Std. Error	Sig. (*p*) [1]
1	7E-LCI vs COSI	0.30	0.22	0.17
2	7E-LCI vs COSI	0.31	0.28	0.26
3	7E-LCI vs COSI	0.80*	0.29	0.00

*Analysis was performed with the significance level of $\alpha = 0.05$
1 Adjustment for multiple comparisons: Bonferronni

As seen at the Table 4.26, at the beginning of the Circulatory System instruction (Time1) there was not a significant mean difference between experimental (M=1.85) and comparison groups (M=1.54), $p > 0.05$. Similarly, there was not a significant mean difference between experimental (M= 2.79) and comparison groups (M= 2.47) after the instruction (Time2), $p > 0.05$. In other words, before the instruction students had similar concept understanding and right after the study, 7E-LCI did not have a significant contribution comparing COSI. In contrast, there was a statistically significant mean difference between experimental (M= 2.99) and comparison groups (M= 2.19) after one-month period (Time3), $p < 0.05$. That is, 7E-LCI is more effective at retention of acquired knowledge over time than COSI. After having investigated the differences between groups, within group differences were investigated across the three time periods and the results were presented at Table 4.27.

Table 4.27 Pairwise Comparisons of Time by Groups for CSCI

Treatment	Time I vs J	Mean Difference (I-J)	Std. Error	Sig. (*p*) [1]
7E-LCI	Time1 vs Time2	-0.94*	0.20	0.00
	Time2 vs Time3	-0.20	0.19	0.88
	Time1 vs Time3	-1.14*	0.23	0.00
COSI	Time1 vs Time2	-0.93*	0.21	0.00
	Time2 vs Time3	0.29	0.20	0.50
	Time1 vs Time3	-0.64*	0.24	0.03

*Analysis was performed with the significance level of $\alpha = 0.05$
1 Adjustment for multiple comparisons: Bonferroni

The continuous effect of treatment on student concept understanding can be inferred from Table 4.27. 7E-LCI students had a significant improvement in the conceptual understanding of Circulatory System from Time1 (M= 1.85) to Time2 (M= 2.79) (p< 0.05), and from Time1 to Time3 (M= 2.19) (p< 0.05). However, there were no significant change in their conceptual understanding from Time2 and Time3 (p> 0.05). These findings suggest that 7E-LCI did significantly promote the students' conceptual understanding about Circulatory System. What is more, the ongoing increase of the mean scores of experimental group students from Time1 through Time3 indicated that the continuous effect of 7E-LCI also existed.

Similarly, COSI students' scores on the conceptual inventory increased significantly from Time1 (M= 1.54) to Time2 (M= 2.47) (p< 0.05) and from Time1 (M= 1.54) to Time3 (M= 2.19) (p< 0.05). However, there was no significant change from Time2 to Time3 (p> 0.05). These findings suggest that COSI also contributed to students' Circulatory System concept understanding but lesser comparing to 7E-LCI. A visionary comparison for treatment can be depicted from following figure.

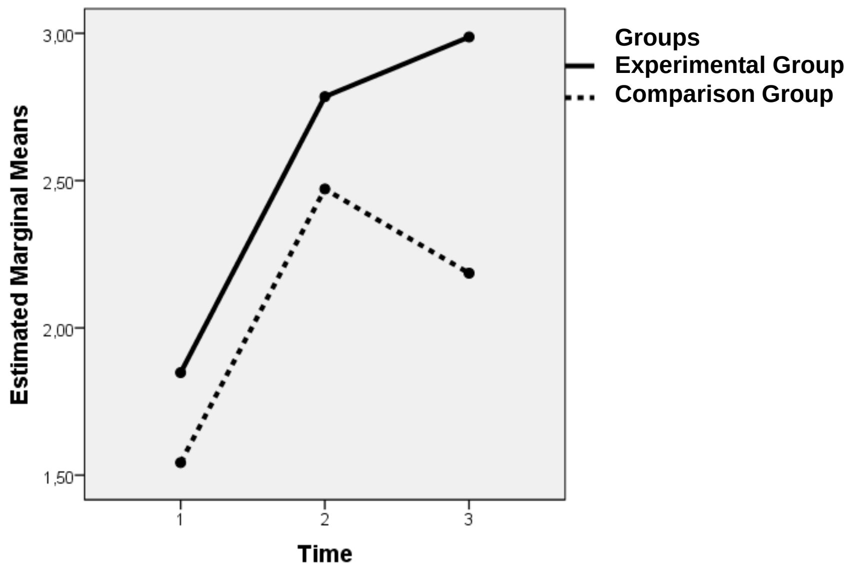

Figure 4.4 Estimated Marginal Means of Students' Conceptual Understanding on Circulatory System

Comparison of students' responses to every single item of CSCI at Time2 and Time3 are presented at Figure 4.5 and Figure 4.6. Accordingly, in Time2 scores, experimental group students appeared to perform slightly better than the comparison group students in most of the items. Time3 scores revealed the better retention of concepts related circulatory system in the students exposed 7E-LCI. The striking effect of 7E-LCI on Time2 and Time3 scores can be observed in Item 7 which was related to the structure of the heart. Moreover, students received 7E-LCI appeared to increase their scores over time in some items such as Item 6, which was addressing the effect of exercise on the heartbeat. However, experimental group students performed lower than the comparison group in the Item 1, indicating they hold unscientific conceptions related with the function of the heart more than the comparison group.

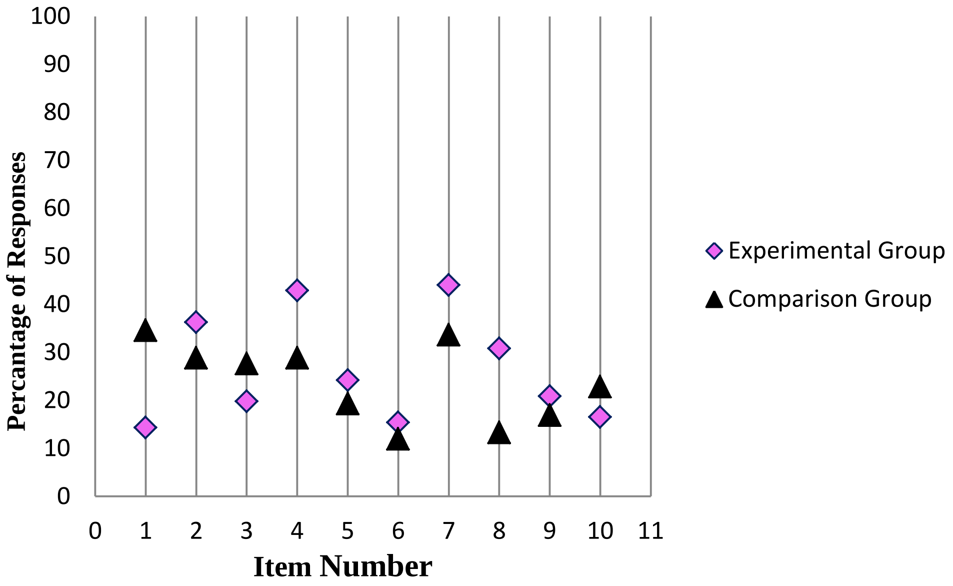

Figure 4.5 Comparison Between CSCI Time2 Scores of the experimental and the Comparison Groups

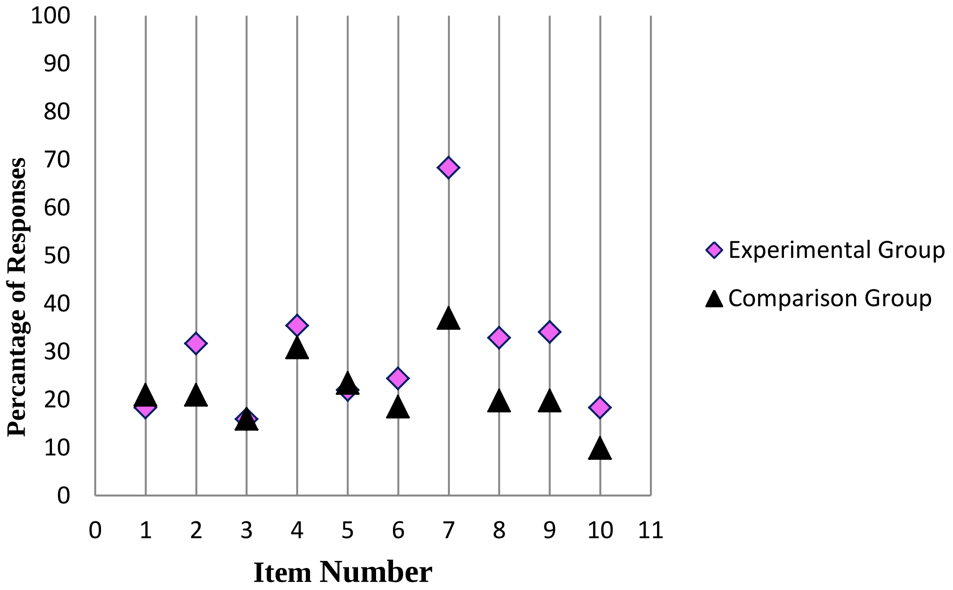

Figure 4.6 Comparison Between CSCI Time3 Scores of the Experimental and the Comparison Groups

Taken as a whole, it can be inferred from Table 4.27 and Figure 4.4 experimental group students' conceptual understanding of Circulatory System improved across time. On the other hand, comparison group students' conceptual understanding of Circulatory System improved only from Time1 to Time2. There was a decline in their conceptual understanding from Time2 to Time3. In both experimental and comparison groups, the improvement in students' conceptual understanding of Circulatory System concepts from Time1 to Time2 was statistically significant. This finding implies the contribution of both 7E-LCI and COSI on students' conceptual understanding related to Circulatory System. Before (Time1) and after the instruction (Time2) students in both groups had similar levels of conceptual understanding (See Table 4.26). On the other hand, significant mean difference between groups at Time3 suggests that after one-month period (Time3), experimental group students remembered the learned concept better than the comparison group students and continued to improve their understanding. The fact that the students had sustained their initial improvement indicates the maintaining effect of 7E-LCI on the following subject, Respiratory System.

4.2.2.1.3 Respiratory System Conceptual Inventory (RSCI)

In this part, four sub-questions were addressed with respect to conceptual understanding of Respiratory System (See Chapter 1).

Q.2.1.3. *Is there a significant interaction between treatment and time with respect to students' conceptual understanding of respiratory system concepts?*

Q.2.2.3. *Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' understanding of respiratory system concepts at before the treatment (Time1), after the treatment (Time2), and one-month later the treatment (Time3)?*

Q.2.3.5. *Is there a significant change in conceptual understanding of experimental group students who exposed to 7E learning cycle instruction with respect to respiratory system concepts across three time periods?*

Q.2.3.6. *Is there a significant change in conceptual understanding of comparison group students who exposed curriculum oriented science instruction with respect to respiratory system concepts across three time periods?*

A mixed between-within subjects ANOVA was conducted to examine these sub-questions that address the effect of 7E-LCI and COSI on students' conceptual understanding in Respiratory System. There were three dependent variables as the scores of students at three implementations of inventory and an independent variable as being instructed through 7E-LCI or COSI. The results are reported in Table 4.28.

Table 4.28 Mixed Between-Within Subjects ANOVA Results for RSCI

Effect	Wilks' λ	df	F	Sig. (*p*)*	Partial η2
Time	0.73	2	28.68	0.00*	0.27
Time X Treatment	0.92	2	6.39	0.00*	0.08

*Analysis was performed with the significance level of α = 0.05

The sub-question Q.2.1.3 which addresses the interaction effect was investigated firstly. The results showed a statistically significant interaction effect between time and treatment which indicates the change of scores over time were not similar for groups, Wilk's λ= 0.92, $F(2, 156)= 6.39$, $p< 0.05$. The multivariate partial η^2 value of interaction effect is 0.08 which is a moderate effect size (Cohen, 1988). It was also found that there was a significant time effect, Wilk's λ= 0.73, $F(2, 156)=$ 28.68 , $p< 0.05$ which contributed a high effect size with the multivariate partial η^2 value of 0.27.

Moreover, a significant treatment effect was revealed on the analysis, $F(1,157)= 12.09$, $p< 0.05$ (See Table 4.29). The partial η^2 value of treatment effect was middle based on the general accepted criteria.

Table 4.29 Tests of Between-Subjects Effects Results for CSCI

Source	Type III SS	df	F	Sig. (p)*	Partial η^2	Obs. Power
Treatment	86.39	1	12.09	0.00	0.07	0.93

*Analysis was performed with the significance level of α = 0.05

After having a statistically significant interaction effect, it is reasonable to investigate between group and within group comparisons through separating one based on the other. To explore these comparisons the extended syntax was run for data of Respiratory System Conceptual Inventory scores. During the analysis Bonferroni Adjustment was requested to decrease Type 1 error that occurs on multiple comparisons. Before the results, the mean of each group students at any time points were reported in the Table 4.30.

Table 4.30 Means of Groups With Respect to Time for RSCI

Time	Treatment	N	Mean	Std. Error
1	7E-LCI	83	2.00	0.18
	COSI	76	1.17	0.18
2	7E-LCI	83	3.59	0.23
	COSI	76	2.33	0.24
3	7E-LCI	83	3.37	0.22
	COSI	76	2.30	0.23

Table 4.31 Pairwise Comparisons of Groups by Time for RSCI

Time	Treatment I vs J	Mean Difference (I-J)	Std. Error	Sig. (p) [1]
1	7E-LCI vs COSI	0.22	0.26	0.38
2	7E-LCI vs COSI	1.26*	0.34	0.00
3	7E-LCI vs COSI	1.07*	0.31	0.00

*Analysis was performed with the significance level of α = 0.05
1 Adjustment for multiple comparisons: Bonferronni

The result given in the Table 4.31, referring to sub-question Q.2.2.3, indicate that there were not significant mean differences between groups before the Respiratory System instruction (Time1), $p > 0.05$. After the instruction (Time2), a significant mean difference was found between experimental ($M = 3.59$) and comparison group ($M = 2.33$), $p < 0.05$. Namely, at the beginning of instruction students had similar level of concept understanding about Respiratory System. However, after receiving the 7E-LCI, the groups differed significantly and experimental group students had higher conceptual understanding than comparison group students. Similarly, a statistically significant treatment effect was found in favour of experimental group one-month later the instruction (Time3), $p < 0.05$. This finding indicates that 7E-LCI ($M = 3.37$) is more effective than COSI ($M = 2.30$) in the retention of acquired knowledge in Respiratory System concepts. To have more information about how the instructions contributed each group students' understanding, within group differences were investigated in the following table (sub-questions Q.2.3.5 and Q.2.3.6).

Table 4.32 Pairwise Comparisons of Time by Groups for RSCI

Treatment	Time I vs J	Mean Difference (I-J)	Std. Error	Sig. (*p*) [1]
7E-LCI	Time1 vs Time2	-1.59*	0.21	0.00
	Time2 vs Time3	0.22	0.22	0.98
	Time1 vs Time3	-1.37*	0.22	0.00
COSI	Time1 vs Time2	-0.55*	0.22	0.04
	Time2 vs Time3	0.03	0.23	1.00
	Time1 vs Time3	-0.53	0.23	0.07

*Analysis was performed with the significance level of $\alpha = 0.05$
1 Adjustment for multiple comparisons: Bonferronni

According to Table 4.32, the 7E-LCI students demonstrated a significant improvement in their conceptual understanding of Respiratory System from Time1 ($M = 2.00$) to Time2 ($M = 3.29$) ($p < 0.05$), and Time1 to Time3 ($M = 3.37$) ($p < 0.05$). However, there was no significant change in their understanding from Time2 to Time3 ($p > 0.05$). The mean scores suggested that although experimental group students' conceptual understanding of Respiratory System increased after the implementation of 7E-LCI, their conceptual understanding declined one month after the implementation. However, this decline was not statistically significant. The significant change from Time1 through Time3 in the experimental group students' scores demonstrates long term retention of the knowledge. On the other hand, the only significant difference in COSI students' scores was between Time1 ($M = 1.78$) and Time2 ($M = 2.33$) ($p < 0.05$). There were no significant differences between Time1 and Time3 ($M = 2.30$), and between Time2 and Time3 ($p > 0.05$).

A clear picture about the contribution of 7E-LCI and COSI on students Respiratory System concepts understanding can be inferred from Figure 4.7. As shown in the figure, at the beginning of the instruction (Time1), students had similar level of conceptual understanding. However, a striking difference emerged after the instruction in favor of 7E-LCI students. Moreover the figure shows that 7E-LCI had better retention of Respiratory System concepts than COSI students.

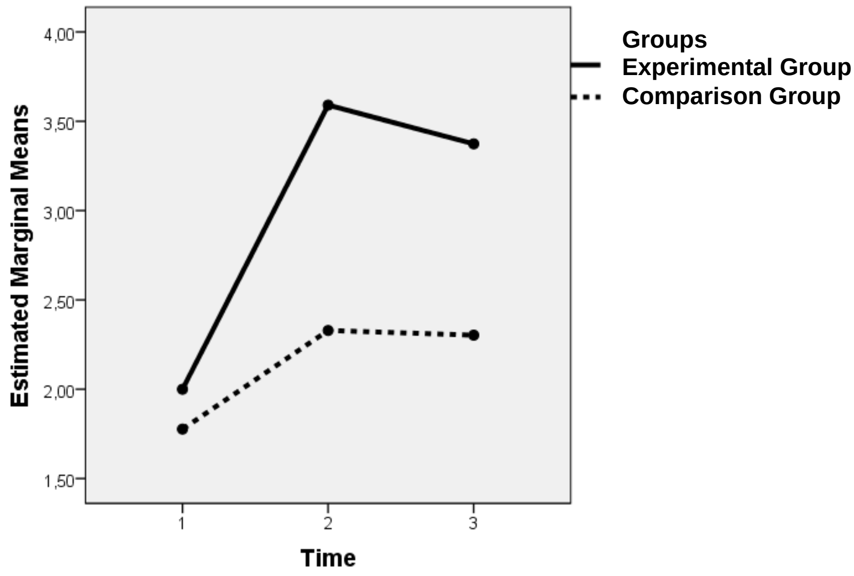

Figure 4.7 Estimated Marginal Means of Students' Conceptual Understanding on Respiratory System

In addition, Figure 4.8 and Figure 4.9 shows the proportions of correct responses to each item of RSCI for the experimental and the comparison groups at Time2 and Time3, respectively. Experimental group students appeared to perform higher than the comparison groups students in almost all items. For example, Item 5 and Item 8 were related with the function of the respiratory system organs and 7E-LCI seemed to provide a better understanding and retention of this concept. The group scores in the most of items at Time3 reveals the effectiveness of 7E-LCI on the retention of concepts over the COSI.

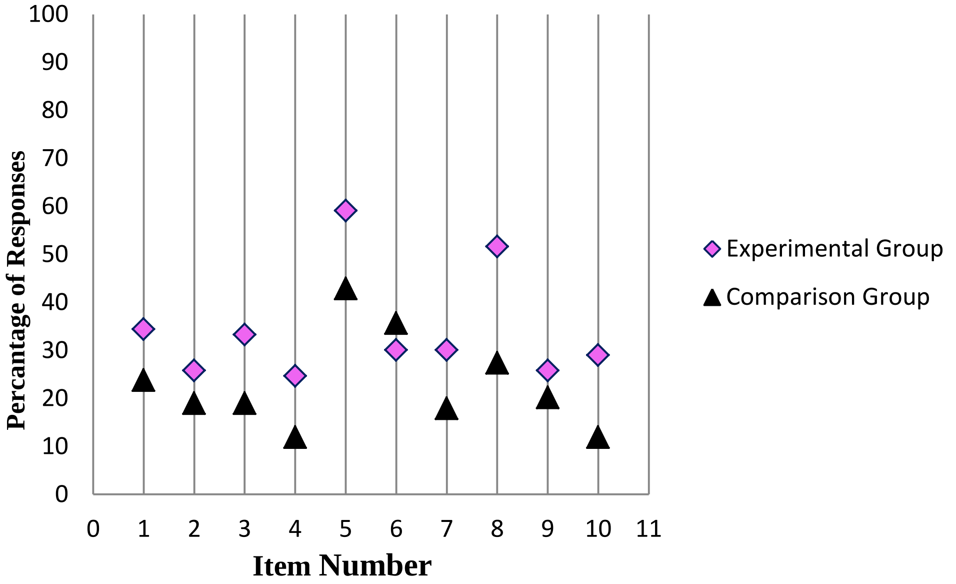

Figure 4.8 Comparison Between RSCI Time2 Scores of the Experimental and the Comparison Groups

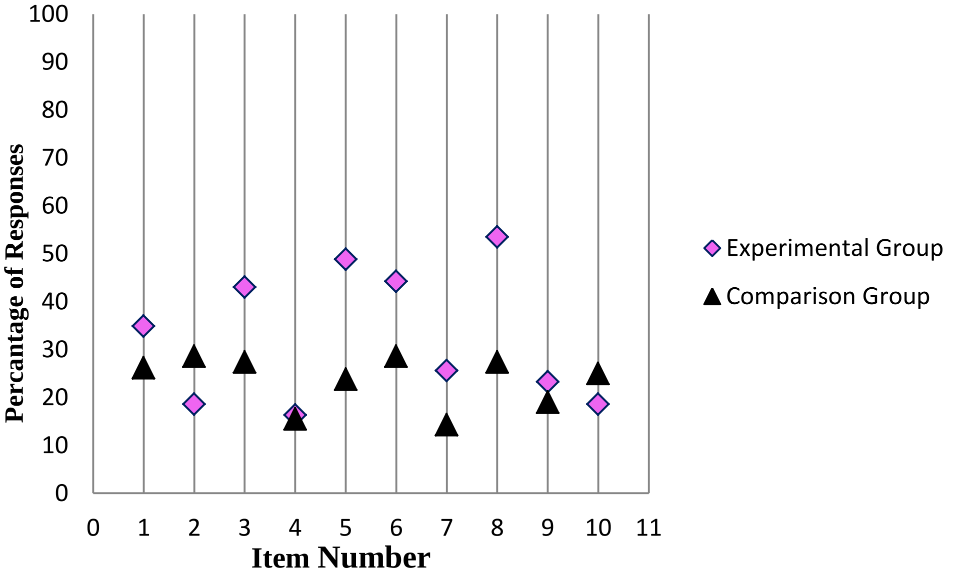

Figure 4.9 Comparison Between RSCI Time3 Scores of the Experimental and the Comparison Groups

To sum up, findings regarding the data from all three conceptual inventories (SSCI, CSCI, and RSCI) revealed that 7E-LCI is more effective than COSI to improve students' conceptual understanding related with human body systems. Moreover, superiority of 7E-LCI over COSI in the maintaining the acquired knowledge over time was observed. Figure 4.1, Figure 4.4 and Figure 4.7 show clear patterns of higher conceptual understanding for 7E-LCI students than COSI students after the instructions as well as the promotion in their knowledge from the beginning to the end of the study. The retention of learned human body systems concepts in 7E-LCI classes was also higher at all three analyses of conceptual inventories. In the following parts, the effect of treatment on motivation and then learning strategy use was investigated.

4.2.2.2 Statistical Analysis Regarding Self-Regulation

Students' self-regulations were assessed by Motivated Strategies for Learning Questionnaire which consists of two main sections as motivation section and learning strategy section. Motivation section covers six sub-scales while the learning strategy section covers nine sub-scales. Scores from sub-scales of two sections were analyzed through two mixed between-within subjects MANOVAs (1) to compare the effect of 7E-LCI and COSI on students' motivation and learning strategies, (2) to investigate the contribution of these instructions on the development of related variables over time, and (3) to examine the interaction between time and treatment variables. For this purpose, the scales were firstly implemented at the beginning of the study. After the completion of the treatment, the same scales were readministered to groups as post-test. The analysis of collected data was addressed third and fourth main research questions stated in Chapter 1, as following;

Q.3. *What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of*

Learning Beliefs, Self-Efficacy for Learning and Performance, and Test Anxiety)?

Q.4. *What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' perceived learning strategies (Rehearsal, Elaboration, Organization, Critical Thinking, and Metacognitive Self-Regulation)?*

The results will be presented under the following parts for motivation scales and then for learning strategies scales respectively.

4.2.2.2.1 Motivation Scales

A mixed between-within subjects MANOVA was conducted to investigate the effect of treatment on students motivational variables. More specifically, the following sub-questions were addressed during this analysis.

Q.3.1. *Is there a significant interaction between treatment and time with respect to students' perceived motivation?*

Q.3.2.1. *Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived motivation before the treatment?*

Q.3.2.2. *Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived motivation after the treatment?*

Q.3.3.1. *Is there a significant change in perceived motivation of experimental group students who exposed to 7E learning cycle instruction.*

Q.3.3.2. *Is there a significant change in perceived motivation of comparison group students who exposed to curriculum oriented science instruction.*

In detail, mixed between-within subjects MANOVA was applied to examine the effects of 7E-LCI and COSI on students' motivational variables towards science learning. Independent variables on the analysis were treatment and time while dependent variables were intrinsic goal orientation (IGO), extrinsic goal orientation (EGO), task value (TV), control of learning beliefs (CLB), self-efficacy (SE) and test anxiety (TA). The results revealed statistically significant treatment effect on the combined dependent variables as indicated in Table 4.33, Wilk's λ= 0.92, $F(6, 159)= 2.40$, $p< 0.05$. The multivariate partial η^2 value was 0.08 indicating that 8% of multivariate variance of dependent variables was explained by treatment effect. It was also found that there was a statistically significant time effect on combined dependent variables (See Table 4.33), Wilk's λ= 0.79, $F(6, 159)= 6.92$, $p< 0.05$. The partial η^2 value was 0.21 which is quite strong based on generally accepted criteria (Cohen, 1988). Furthermore, the results related with sub-question Q.3.1 showed that there was no significant interaction effect between time and treatment Wilk's λ= 0.93, $F(6, 159)= 1.86$, $p> 0.05$.

Table 4.33 Mixed-MANOVA Results on Motivational Variables by Treatment and Time

Effect	Wilks' λ	F	Sig. (*p*)	Partial η2
Treatment	0.92	2.40	0.03*	0.08
Time	0.79	6.92	0.00*	0.21
Time X Treatment	0.93	1.86	0.09	0.07

*Analysis was performed with the significance level of α = 0.05

After reaching statistically significant main effects for treatment and time, follow-up univariate analysis were conducted in order to determine on which dependent variables experimental and comparison groups differed and on which dependent variables the students' scores changed over time. The Bonferonni adjustment was used to reduce the chance of Type 1 error hence the significance level was addressed at the 0.008. As reported in the Table 4.34, univariate statistics revealed statistically significant treatment effect with respect to intrinsic goal orientation , $F(1,164)=8.90$, $p<0.008$, and extrinsic goal orientation, $F(1,164)=8.16$, $p<0.008$. Furthermore, there was a significant time effect for extrinsic goal orientation, $F(1,164)=12.08$, task value, $F(1,164)=16.92$, control of learning beliefs $F(1,164)=13.92$, and self-efficacy, $F(1,164)=11.82$, $p<0.008$.

Table 4.34 Follow-up Univariate Results of Motivation Variables

Sources	Dependent Variable	Type III Sum of Squares	df	*F*	Sig. (*p*)	Partial η2
Treatment	Intrinsic Goal Orientation	12.62	1	8.90	0.00*	0.05
	Extrinsic Goal Orientation	16.66	1	8.16	0.00*	0.05
	Task Value	4.94	1	4.02	0.04	0.02
	Control of Learning Beliefs	0.64	1	0.49	0.48	0.00
	Self-Efficacy	9.63	1	5.40	0.02	0.03
	Test Anxiety	0.06	1	0.03	0.85	0.00
Time	Intrinsic Goal Orientation	2.26	1	2.84	0.09	0.02
	Extrinsic Goal Orientation	9.83	1	12.08	0.00*	0.07
	Task Value	10.41	1	16.92	0.00*	0.09
	Control of Learning Beliefs	12.58	1	13.92	0.00*	0.08
	Self-Efficacy	8.43	1	11.82	0.00*	0.07
	Test Anxiety	3.74	1	3.93	0.04	0.02

*Analysis was performed with the significance level of $\alpha = 0.008$

The results of univariate analysis showed a significant treatment effect and time effect on some of the motivational variables. However, the interpretation of analysis is deficient to investigate the sub-questions Q.3.2 and Q.3.3 that mentioned at the first chapter. More specifically, it is not possible to interpret at which implementation period the groups differed as well as in which group the scores changed over time. Although not having a statistically significant interaction effect, it would be informative to investigate the time effect by separating groups and treatment effect on each implementation time period. The syntax of the model was extended for that purpose. Moreover, Bonferroni adjustment was requested in the syntax to reduce the Type 1 error chance on multiple comparisons. Following tables present the means and significance test results of multiple comparisons. The results for each motivational variable will be discussed distinctively after directing the general comments for the results on the next tables.

Firstly, experimental and comparison group students' mean scores at before (pre-test) and after the instruction (post-test) related with motivation scales are reported at Table 4.35.

Table 4.35 Means of Groups With Respect to Time for Motivation Variables

Dependent Variable	Treatment	Time	Mean	Std. Error
Intrinsic Goal Orientation	7E-LCI	Pre-test	5.87	0.10
		Post-test	5.90	0.13
	COSI	Pre-test	5.68	0.10
		Post-test	5.32	0.13
Extrinsic Goal Orientation	7E-LCI	Pre-test	6.15	0.12
		Post-test	5.99	014
	COSI	Pre-test	5.89	0.12
		Post-test	5.35	0.14
Task Value	7E-LCI	Pre-test	6.06	0.09
		Post-test	5.85	0.12
	COSI	Pre-test	5.96	0.09
		Post-test	5.46	0.12
Control of Learning Beliefs	7E-LCI	Pre-test	5.94	0.10
		Post-test	5.74	0.13
	COSI	Pre-test	6.04	0.10
		Post-test	5.46	0.13
Self-Efficacy	7E-LCI	Pre-test	5.78	0.12
		Post-test	5.60	0.12
	COSI	Pre-test	5.58	0.12
		Post-test	5.12	0.12
Test Anxiety	7E-LCI	Pre-test	4.50	0.13
		Post-test	4.60	0.12
	COSI	Pre-test	4.41	0.13
		Post-test	4.74	0.12

Table 4.36 presents the mean differences between groups at each time periods for all motivation scales separately as addressed in sub-questions Q.3.2.1 and Q.3.2.2. As seen at the table, there were significant mean differences between experimental and comparison groups' post-test scores with respect to intrinsic goal orientation, extrinsic goal orientation, task value, and self-efficacy ($p < .05$).

Table 4.36 Pairwise Comparisons of Groups by Time for Motivation Variables

Dependent Variable	Time	Treatment I vs J	Mean Difference (I-J)	Std. Error	Sig. (*p*) [1]
Intrinsic Goal Orientation	Pre-test	7E-LCI vs COSI	0.20	0.14	0.17
	Post-test	7E-LCI vs COSI	0.58*	0.18	0.00
Extrinsic Goal Orientation	Pre-test	7E-LCI vs COSI	0.26	0.18	0.14
	Post-test	7E-LCI vs COSI	0.64*	0.20	0.00
Task Value	Pre-test	7E-LCI vs COSI	0.10	0.13	0.43
	Post-test	7E-LCI vs COSI	0.39*	0.17	0.02
Control of Learning Beliefs	Pre-test	7E-LCI vs COSI	-0.11	0.14	0.45
	Post-test	7E-LCI vs COSI	0.28	0.18	0.12
Self-Efficacy	Pre-test	7E-LCI vs COSI	0.20	0.17	0.24
	Post-test	7E-LCI vs COSI	0.49*	0.17	0.01
Text Anxiety	Pre-test	7E-LCI vs COSI	0.10	0.18	0.61
	Post-test	7E-LCI vs COSI	-0.15	0.18	0.40

*Analysis was performed with the significance level of $\alpha = 0.05$
[1] Adjustment for multiple comparisons: Bonferronni

Additionally, the changes in experimental and comparison group students' scores over time which directed in sub-questions Q.3.3.1 and Q.3.3.2 were represented at Table 4.37. It was found that, comparison group students' scores on all scales were significantly changed across time ($p < .05$). The results will be interpreted for each variable separately in the following parts.

Table 4.37 Pairwise Comparisons of Time by Groups for Motivation Variables

Dependent Variable	Treatment	Time I vs J	Mean Difference (I-J)	Std. Error	Sig. (*p*) [1]
Intrinsic Goal Orientation	7E-LCI	Pre-test vs Post-test	-0.03	0.14	0.83
	COSI	Pre-test vs Post-test	0.36*	0.14	0.01
Extrinsic Goal Orientation	7E-LCI	Pre-test vs Post-test	0.15	0.14	0.27
	COSI	Pre-test vs Post-test	0.53*	0.14	0.00
Task Value	7E-LCI	Pre-test vs Post-test	0.21	0.12	0.08
	COSI	Pre-test vs Post-test	0.50*	0.12	0.00
Control of Learning Beliefs	7E-LCI	Pre-test vs Post-test	0.19	0.15	0.19
	COSI	Pre-test vs Post-test	0.58*	0.15	0.00
Self-Efficacy	7E-LCI	Pre-test vs Post-test	0.18	0.13	0.16
	COSI	Pre-test vs Post-test	0.45*	0.13	0.00
Text Anxiety	7E-LCI	Pre-test vs Post-test	-0.09	0.15	0.55
	COSI	Pre-test vs Post-test	-0.33*	0.15	0.03

*Analysis was performed with the significance level of $\alpha = 0.05$
[1] Adjustment for multiple comparisons: Bonferronni

4.2.2.2.1.1 Follow-Up Analysis of Intrinsic Goal Orientation (IGO)

As it can be inferred from Table 4.36 the groups did not differ on intrinsic goal orientation before the instructions (pre-test), $p > 0.05$. Regarding after instruction scores (post-test), statistically significant mean difference was found between experimental ($M= 5.90$) and comparison group ($M= 5.32$), $p < 0.05$. An inspection of the mean scores indicated that students in 7E-LCI classes reported slightly higher levels of intrinsic goal orientation compared to students in COSI classes. Table 4.38 displays the percentages of agreement with the selected items in the IGO (item 16 and item 22). As seen in the table, the total percentage of agreement of students responding 5, 6 and 7 with item 16, “In a class like this, I prefer course material that arouses my curiosity even if it is difficult to learn” was 83.9% for experimental group while it was 71.1% for comparison group. In addition, the percentage of agreement of students in item 22, “the most satisfying thing for me in this course is trying to understand the content as thoroughly as possible” was 85% for experimental group and 74.8% for comparison group. In other words, it could be said that experimental group students participated in the science lesson to mastery the subject and satisfy their curiosity.

Table 4.38 Percentages of Responses to Selected Items of the Post-IGO, Between Groups

Item No	Groups	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
16	EG	1.1	1.1	6.9	6.9	13.8	13.8	56.3
	CG	7.2	2.4	4.8	14.5	8.4	22.9	39.8
22	EG	1.1	1.1	3.4	9.2	9.2	21.8	54.0
	CG	4.8	1.2	7.2	12.0	15.7	20.5	38.6

Considering the change of intrinsic goal orientation over time, the significant mean difference was only found in comparison group scores (See Table 4.37) The means of the pre-test ($M= 5.68$) and post-test ($M= 5.32$) scores in the comparison group indicates a decrease over time. On the other hand, there was not a substantial alteration on experimental groups students’ scores from pre-test ($M= 5.87$) to post-test ($M= 5.90$). Table 4.39 presents the percentages of comparison groups students’ responses for selected items of IGO scale (item 16 and item 22). The percentage of total agreement of students responding 5, 6 and 7 in the comparison group with item 16 was 81.5% at the before instructing with COSI while it decreased to 74.8% after the instruction. Similarly, the percentage of agreement was decreased from 85% to 74.8% for the item 24. Students in the comparison group appeared to be less to adopt IGO in science lessons.

The change on intrinsic goal orientation of students from two groups over time can also be interpreted from Figure 4.1. The figure and the mean differences between and within groups implied that experimental group students tend to engage science learning task for reasons such as challenge, curiosity, and mastery more than the comparison group students. Moreover, COSI had a negative effect on students' intrinsic goal orientation because a decrease was occurred on the mean scores of comparison group over time.

Table 4.39 Percentages of Responses to Selected Items of the IGO, Within Comparison Group

Item No	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
16	Pre-Test	4.6	1.1	2.3	10.3	12.6	17.2	51.7
	Post-Test	7.2	2.4	4.8	14.5	8.4	22.9	39.8
22	Pre-Test	0	3.4	1.1	9.2	13.8	17.2	54.0
	Post-Test	4.8	1.2	7.2	12.0	15.7	20.5	38.6

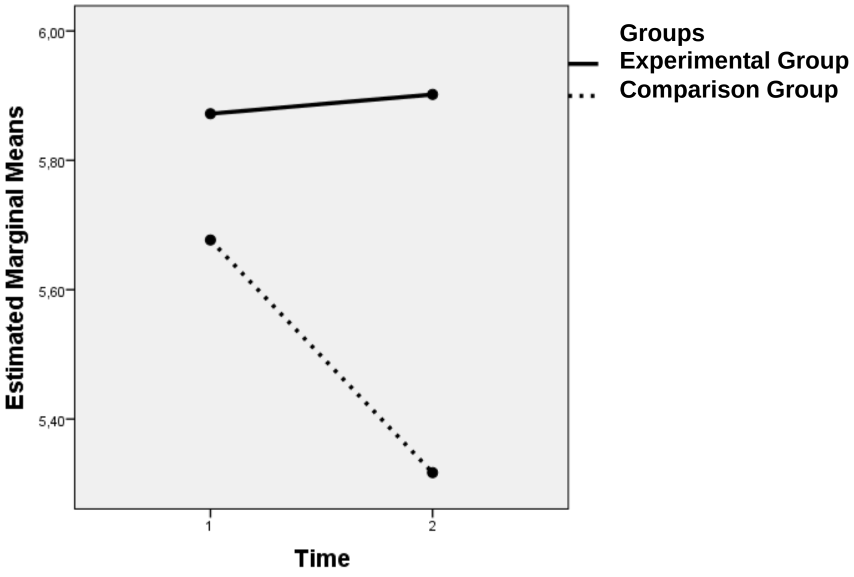

Figure 4.10 Estimated Marginal Means of Students' IGO

4.2.2.2.1.2 <u>Follow-Up Analysis of Extrinsic Goal Orientation (EGO)</u>

Concerning extrinsic goal orientation, the results revealed a statistically significant mean difference between experimental (M=5.99) and comparison group (M=5.35) after the instruction (post-test), p< 0.05 (See Table 4.36). An examination of the mean scores indicated that students in 7E-LCI classes reported slightly higher level of extrinsic goal orientation compared to students in COSI classes indicating that experimental group students perceived themselves more extrinsically goal oriented. Both group students' percentage of responses to sample items of EGO scale after the instruction can be seen at Table 4.40. The percentage of total agreement of students (selecting 5, 6, and 7) with the statement of "Getting a good grade in this class is the most satisfying thing for me right now" (item 7) was 83.9% for experimental group students and 64.7% for comparison group students. Similarly, experimental group students reported 87.4% of agreement with the statement of "If I can, I want to get better grades in this class than most of the other students" (item 13) while the comparison group reported 74.1% agreement. Thus, the students in the experimental group perceived themselves to attain the science class for getting better grades more than the students in the comparison group.

Table 4.40 Percentages of Responses to Selected Items of the Post-EGO, Between Groups

Item No	Groups	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
7	EG	4.6	2.3	2.3	6.9	9.2	11.5	63.2
	CG	7.1	5.9	7.1	14.1	11.8	17.6	35.3
13	EG	2.3	1.1	3.4	5.7	9.2	13.8	64.4
	CG	1.2	4.7	8.2	10.6	10.6	14.1	49.4

Moreover, inspection of time effect on students extrinsic goal orientation scores shows that there was a significant mean difference between pre-test (M= 5.88) and post-test (M= 5.35) scores of comparison groups students (p< 0.05) (See Table 4.37). On the other hand, there was no significant mean difference between pre-test (M= 6.15) and post-test (M= 5.99) for experimental group students, p> 0.05. As seen at the Table 4.41, comparison group students' agreement with the sample items of EGO decreases over time. At the beginning of the study, they reported a total agreement of 86.1% with the statement in the item 11 "The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade" while they reported lower percentage of agreement (74.1%) at the end of instruction. Additionally, their agreement with the item 13 was 93.1% at the beginning while at the end of the study, this percentage was decreased to 75.3%.

As also seen on the Figure 4.11, there is a clear pattern of higher extrinsic goal orientation for 7E-LCI than COSI and a clear pattern of a decrease in extrinsic goal orientation from the beginning of the study to the end of the study for both groups.

Table 4.41 Percentages of Responses to Selected Items of the EGO, Within Comparison Group

Item No	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
11	Pre-Test	3.4	1.1	1.1	8.0	12.6	21.8	51.7
	Post-Test	2.4	2.4	14.1	7.1	15.3	17.6	41.2
13	Pre-Test	1.1	0	0	5.7	11.5	13.8	67.8
	Post-Test	1.2	4.7	8.2	10.6	10.6	15.3	49.4

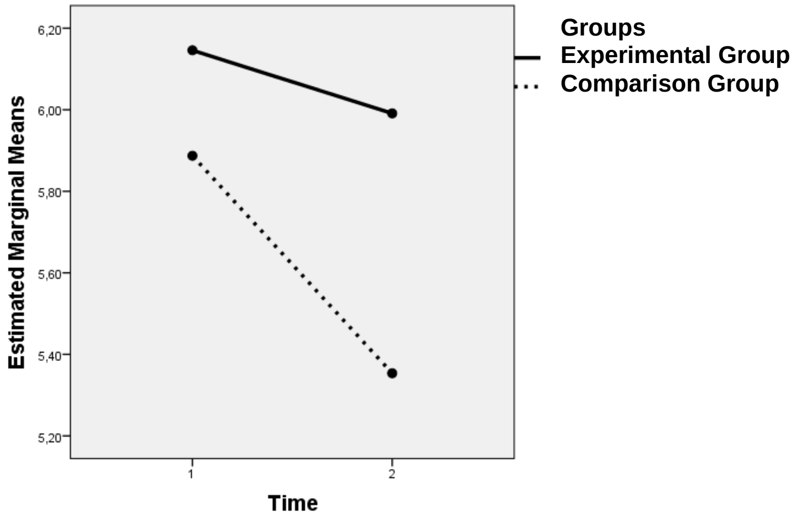

Figure 4.11 Estimated Marginal Means of Students' EGO

4.2.2.2.1.3 Follow-Up Analysis of Task Value (TV)

Regarding task value, the findings revealed that the difference between experimental (*M*= 6.06) and comparison group (*M*= 5.96) was not significant at the beginning of the study (pre-test), ($p > 0.05$) (See Table 4.36). However, a statistically significant mean difference was found between experimental (*M*= 5.85) and comparison group (*M*= 5.46) at the end of the study (post-test), $p < 0.05$. These findings indicate that students thought by 7E-LCI appeared to perceive science as interesting, important and useful more than students in COSI classes. For instance, 82.7% of the students in the experimental group rated themselves on the item 17, "I am very interested in the content area of this course” as 5,6 and 7 while the rate of the students in the comparison group was 71,7% (See Table 4.42). Similarly, considering the perception about the usefulness of the content, 86.2% of the experimental group students rated over 5 on the item 23, “I think the course material in this class is useful for me to learn” while the same rate of the students in the comparison group was 75.2%.

Table 4.42 Percentages of Responses to Selected Items of the Post-TV, Between Groups

Item No	Groups	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
17	EG	2.3	1.1	3.4	10.3	10.3	20.7	51.7
	CG	7.1	2.4	7.1	11.8	17.6	18.8	35.5
23	EG	1.1	3.4	3.4	5.7	5.7	16.1	64.4
	CG	3.5	3.5	8.2	8.2	9.4	17.6	48.2

Considering the time effect on the groups, the only significant mean difference was found on comparison group students (See Table 4.37). An investigation of mean scores reveals a decrease on the task value of students in COSI classes from pre-test (M= 5.96) to post-test (M= 5.46), p< 0.05. Actually, the scores of students in 7E-LCI also decrease from pre-test (M= 6.06) to post-test (M=5.85), despite it did not contribute a significant difference, p> 0.05. For example, at the outset of the study, 94.2% of comparison group students rate themselves on the item 23 as 5, 6 and 7 while this percentile decreased to 76.4% after the instruction. In a similar manner, comparison group students the percentage of students who rate themselves on the item 27, “Understanding the subject matter of this course is very important to me” as 5, 6 and 7 was 88.5% before the instruction and 73% after the instruction.

Table 4.43 Percentages of Responses to Selected Items of the TV, Within Comparison Group

Item No	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
23	Pre-Test	0	0	1.1	4.6	9.2	14.9	70.1
	Post-Test	3.5	3.5	8.2	8.2	9.4	17.6	49.4
27	Pre-Test	1.1	0	1.1	8.0	9.2	9.2	70.1
	Post-Test	2.4	1.2	8.2	15.3	5.9	16.5	50.6

These findings about the difference between groups and change on the scores over time can be clearly seen from Figure 4.12. After the instructions, task value of students in both groups decreased. However, COSI caused a steeper decline in the mean task value scores from the beginning to the end of the study compared to 7E-LCI.

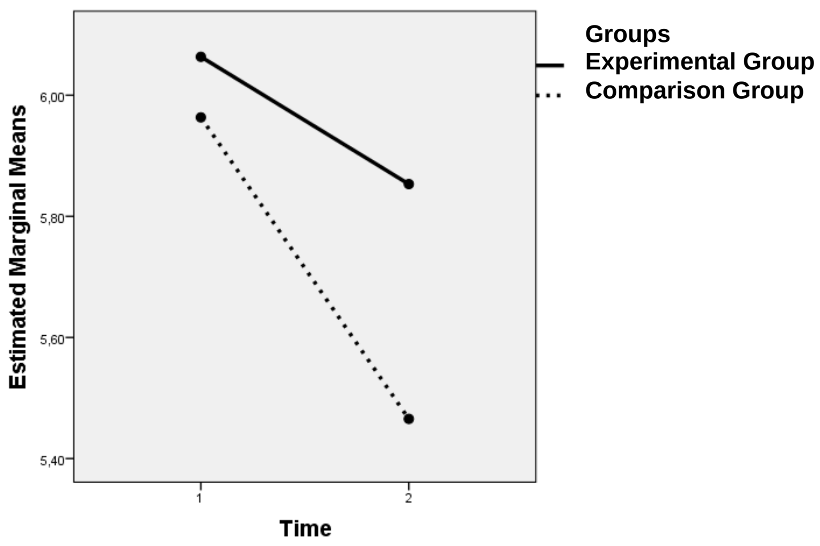

Figure 4.12 Estimated Marginal Means of Students' TV

4.2.2.2.1.4 Follow-Up Analysis of Control of Learning Beliefs (CLB)

Considering control of learning beliefs variable, no significant mean difference was found between groups at neither before the instruction nor after the instruction, $p > 0.05$. This finding implied that, before and after the instruction, both group had similar levels of the belief that their efforts to learn science leads to positive outcomes (See Table 4.36). On the other hand, when the change in the students' beliefs across time was examined, results revealed the superiority of 7E-LCI on the improvement of control of learning beliefs. As seen on the Figure 4.13, there was a decrease in the mean scores from pre-test to post-test for both groups. However the decline in the mean scores from pre-test to post-test was significant only for the COSI students (See Table 4.37).

Thus, when COSI students' before and after the instruction scores of control of learning beliefs was compared, it appeared that they become less likely to feel that they can control their performance in science after the instruction. The percentages of responses given by COSI students to sample items of CBL scale can be seen at Table 4.44. The percentage of total agreement of students with item 9, "It is my fault if I don't learn the material in this course" was 73.9% before the instruction, while it became 61.6% after the instruction.

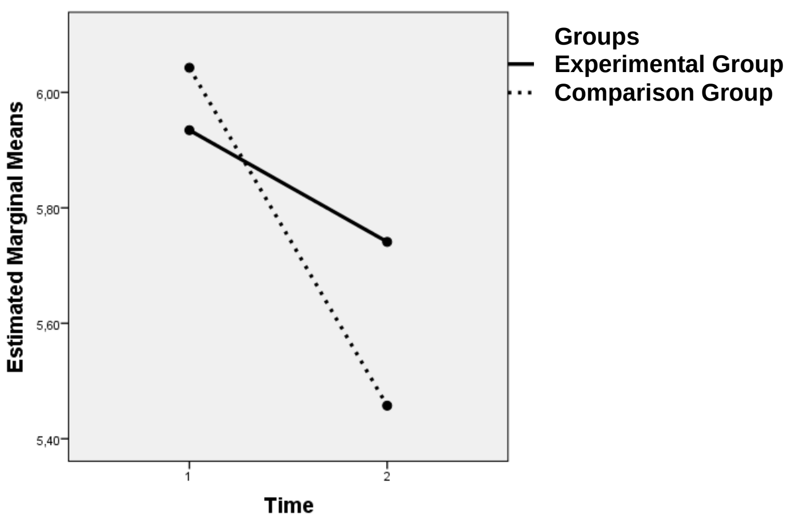

Figure 4.13 Estimated Marginal Means of Students' CLB

Table 4.44 Percentages of Responses to Selected Items of the CBL, Within Comparison Group

Item No	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
9	Pre-Test	4.5	4.5	9.1	8.0	10.2	11.4	52.3
	Post-Test	8.1	4.7	5.8	18.6	15.1	7.0	39.5
18	Pre-Test	0	0	0	2.3	1.1	15.9	80.7
	Post-Test	3.5	7.0	7.0	5.8	9.3	18.6	48.8

4.2.2.2.1.5 Follow-Up Analysis of Self-Efficacy (SE)

As seen in the Table 4.36, self-efficacy of students from two groups was not significantly different before the instructions (pre-test), $p > 0.05$. Regarding after the instructions scores (post-test), statistically significant mean difference was found between experimental group ($M = 5.60$) and comparison group ($M = 5.12$), $p < 0.05$. That is, compared to COSI classes, students in 7E-LCI classes were more likely to have stronger beliefs about their ability to perform science learning tasks well. For instance, 78.1% of the students in the experimental group rated themselves on the item 5, "I believe I will receive an excellent grade in this class." as 5, 6 and 7 while the 64.8% of the students in the comparison group rated over 5 (See Table 4.45). Similarly, 85% of the experimental group rated from 5 to 7 on the item 29, "I am certain I can master the skills being taught in this class." while the corresponding percentage in the comparison group was 72.9%.

Table 4.45 Percentages of Responses to Selected Items of the Post-SE, Between Groups

Item No	Groups	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
5	EG	1.1	1.1	6.9	11.5	21.8	25.3	31.0
	CG	8.2	4.7	7.1	12.9	27.1	15.3	22.4
29	EG	0	2.3	3.4	9.2	14.9	14.9	55.2
	CG	5.9	4.7	4.7	11.8	25.9	8.2	38.8

Respecting the time effect, a similar pattern with task value variable was also seen on this variable (See Figure 4.14). Investigation of mean scores with respect to their change over time shows a decline from pre-test to post-test for both groups. However, the difference between the mean scores of pre-test ($M = 5.58$) and post-test ($M = 5.12$) is statistically significant only in the comparison group, $p < 0.05$. Experimental group students' scores also decreased from pre-test ($M = 5.78$) to post-test ($M = 5.60$) but that change did not contributed a significant difference, $p > 0.05$. The decrease on the scores also seen in the percentages of comparison group students' responses to items of SE scale (See Table 4.46). The percentage of total agreement reported by comparison group students with item 5 was 78.1% at the beginning of the study while the corresponding percentage decreased to 64.8% at the end of the study. Moreover, students' agreement with item 21, "I expect to do well in this class." decreased from 86.2% to 70.6% over the course of COSI implementation.

Table 4.46 Percentages of Responses to Selected Items of the SE, Within Comparison Group

Item No	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
5	Pre-Test	1.1	3.4	5.7	9.2	16.1	26.4	35.6
	Post-Test	8.2	4.7	7.1	12.9	27.1	15.3	22.4
21	Pre-Test	0	1.1	2.3	10.3	20.7	24.1	41.4
	Post-Test	8.2	0	5.9	15.3	11.8	20.0	38.8

As it can be deduced from these results, experimental group students perceive themselves to be more self-efficacious in their science learning since they reported slightly higher levels of self-efficacy.

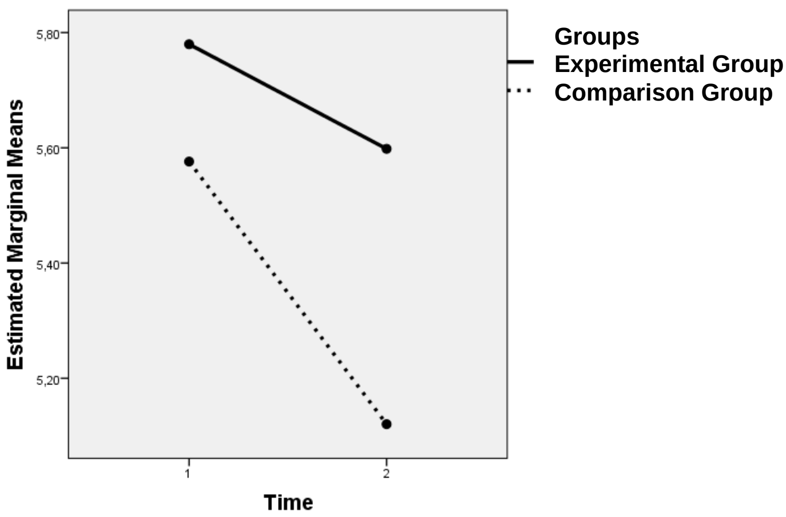

Figure 4.14 Estimated Marginal Means of Students' SE

4.2.2.2.1.6 Follow-Up Analysis of Test Anxiety (TA)

The analysis with respect to test anxiety scores indicated that there were no statistically significant mean differences between groups both at the beginning of the study (pre-test), and at the end of the study (post-test) ($p > 0.05$) (See Table 4.36).

Moreover, investigation of mean scores reports an undesirable increment for both groups over time. There was a significant change on the scores of comparison group students from pre-test (*M*= 4.41) to post-test (*M*= 4.74) ($p< 0.05$) (See Table 4.37). On the other hand, there was not a statistically significant change on the scores of experimental group students from pre-test (*M*= 4.50) to post-test (*M*= 4.60), $p> 0.05$. Actually, the statement of “I have an uneasy, upset feeling when I take an exam.” (item 19) was agreed by 25.2% of comparison group students before the instruction (rated 5, 6 or 7), whereas the percentage of students increased to 49.4% after the instruction (See Table 4.47). Similarly, the statement of “When I take a test I think about items on other parts of the test I can’t answer.” (item 8) was agreed by 51.7% of students before exposed to COSI while the corresponding percentage increased to 61.1% after instructed with COSI

Table 4.47 Percentages of Responses to Selected Items of the TA, Within Comparison Group

Item No	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
19	Pre-Test	41.4	16.1	3.4	13.8	11.5	8.0	5.7
	Post-Test	23.5	9.4	5.9	11.8	12.9	9.4	27.1
8	Pre-Test	13.8	9.2	6.9	18.4	9.2	11.5	31.0
	Post-Test	10.6	4.7	5.9	16.5	18.8	14.1	28.2

Figure 4.15 shows a clear pattern of an increase in test anxiety from pre-test to post-test for both groups. The figure also presents a clear pattern of higher test anxiety on COSI students after the instruction. That is, students’ perceived worry or anxiety during a test did not differ between groups but increased after the instruction against for comparison group students.

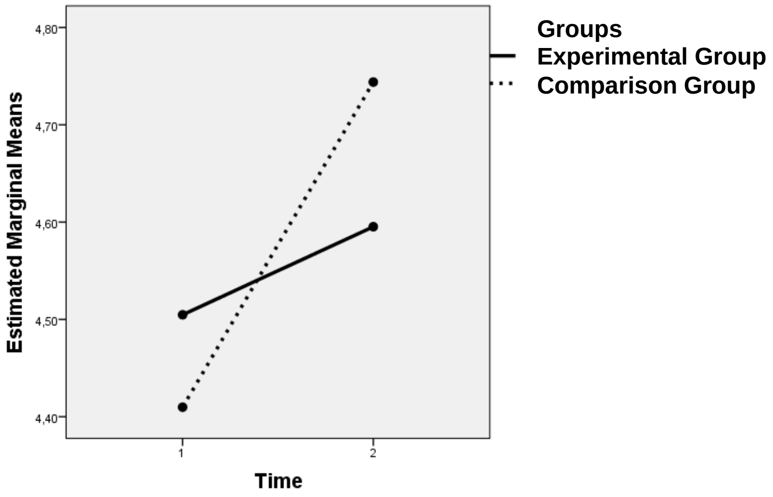

Figure 4.15 Estimated Marginal Means of Students' TA

Overall, experimental and comparison groups were not significantly different before the instructions (pre-test) with respect to all motivational variables as seen at Table 4.36.

On the other hand, significant differences were found between two instruction groups after the instructions (post-test) with respect to students' intrinsic goal orientation, extrinsic goal orientation, task value, and self-efficacy variables. The investigation of mean scores indicates that the mean scores differ in the favor of experimental group for all of the motivation variables. Between groups analyses showed that students instructed through learning cycle perceived themselves to be more intrinsically and extrinsically goal oriented. Additionally, they perceived science learning as interesting, important and useful more than comparison group students. They also reported higher self-efficacy in their science learning compared with comparison group students.

Moreover, considering the time effect on the variables there is a tendency to decrease on the scores from pre-test to post-test measures (See Table 4.37). These changes on scores were significant for all of the variables for COSI students.

However, 7E-LCI did not contribute a significant mean difference over time. These results implied that students' motivation towards science learning tends to decrease across time and the COSI has an undesirable effect on this situation. Yet, 7E-LCI did not contribute a significant effect on the change observed within group comparisons. After investigating the motivational variables with respect to between and within differences, learning strategies variables will be analyzed with the same analysis pattern under next heading.

4.2.2.2.2 Learning Strategies Scales

Learning strategies scales were consist of nine scales which implemented as pre-test and post-test. The analyses of the data were conducted to address the sub-questions of fourth main questions, as follows;

Q.4.1. *Is there a significant interaction between treatment and time with respect to students' perceived learning strategies?*

Q.4.2.1. *Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived learning strategies before the treatment?*

Q.4.2.2. *Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived learning strategies after the treatment?*

Q.4.3.1. *Is there a significant change in perceived learning strategies of experimental group students who exposed to 7E learning cycle instruction.*

Q.4.3.2. *Is there a significant change in perceived learning strategies of comparison group students who exposed to curriculum oriented science instruction.*

To investigate abovementioned sub-questions, the effect of 7E-LCI and COSI on students' learning strategies during science learning was examined through the analysis of mixed between-within subjects MANOVA. The independent variables were treatment and time effect while the dependent variables were rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, peer learning, and help seeking. The findings reported at Table 4.48 revealed a significant effect of time on the combined variables Wilk's λ= 0.72, $F(9, 156)= 6.70$, $p< 0.05$. The multivariate partial η^2 was quite high with the value of 0.28, indicating that 28% of variance of dependent variables was explained by time effect. On the other hand, treatment effect found to be not significant referring there was no statistically significant mean difference between groups with respect to collective variables, Wilk's λ= 0.95, $F(9, 156)= 0.94$, $p> 0.05$. Moreover, the interaction between time and treatment which directed in sub-question Q.4.1 was investigated and it was found to be not statistically significant, Wilk's λ= 0.92, $F(9, 156)= 1.43$, $p> 0.05$.

Table 4.48 Mixed-MANOVA Results on Learning Strategies Variables by Treatment and Time

Effect	Wilks' λ	F	Sig. (*p*)	Partial η2
Treatment	0.95	0.94	0.49	0.05
Time	0.72	6.70	0.00*	0.28
Time X Treatment	0.92	1.43	0.18	0.07

*Analysis was performed with the significance level of $\alpha = 0.05$

After reaching statistically significant main effect for time, follow-up univariate analysis were conducted in order to determine on which dependent variables the scores changed over time. The analyses were assessed with a smaller significance level calculated by Bonferroni adjustment to reduce Type 1 error. As seen at Table 4.49, there was a significant time effect with respect to variables of time and study environment, $F(1,164)= 21.57$, effort regulation, $F(1,164)=23.80$, and peer learning, $F(1,164)= 16.17$, $p<0.008$.

Table 4.49 Follow-up Univariate Results of Learning Strategies Variables

Sources	Dependent Variable	Type III Sum of Squares	df	*F*	Sig. (*p*)	Partial η2
Time	Rehearsal	1.73	1	1.39	0.24	0.01
	Elaboration	5.55	1	7.08	0.01	0.04
	Organization	7.19	1	6.51	0.01	0.04
	Critical Thinking	1.73	1	1.87	0.17	0.01
	Self-Regulation	0.84	1	1.35	0.25	0.01
	Time and Study Environment	10.42	1	21.57	0.00*	0.12
	Effort Regulation	24.61	1	23.80	0.00*	0.13
	Peer Learning	30.54	1	16.17	0.00*	0.09
	Help Seeking	0.80	1	0.84	0.36	0.01

*Analysis was performed with the significance level of $\alpha = 0.005$

At this point, more information on the development of learning strategy use within groups can be obtained by extending the syntax. Although, no significant interaction was found, investigation of mean change between and within groups separately may be informative to investigate the sub-questions stated at the beginning of this part and to compare the effects of 7E-LCI and COSI with respect to learning strategies. Bonferroni adjustment was also requested during the analysis to reduce type 1 error risk on univariate comparisons. Following tables show the mean scores and results of between and within group analysis results.

Table 4.50 reports the mean scores of experimental and comparison group students at before (pre-test) and after the instruction (post-test) related with learning strategies scales.

Table 4.50 Means of Groups with Respect to Time for Learning Strategies Variables

Dependent Variable	Treatment	Time	Mean	Std. Error
Rehearsal	7E-LCI	Pre-test	5.01	0.16
		Post-test	5.30	0.14
	COSI	Pre-test	4.95	0.16
		Post-test	4.95	0.15
Elaboration	7E-LCI	Pre-test	5.33	0.13
		Post-test	5.71	0.12
	COSI	Pre-test	5.08	0.14
		Post-test	5.22	0.12
Organization	7E-LCI	Pre-test	4.94	0.15
		Post-test	5.18	0.15
	COSI	Pre-test	4.69	0.15
		Post-test	5.04	0.15
Critical Thinking	7E-LCI	Pre-test	5.23	0.14
		Post-test	5.50	0.12
	COSI	Pre-test	5.05	0.14
		Post-test	5.07	0.12
Self-Regulation	7E-LCI	Pre-test	5.24	0.12
		Post-test	5.33	0.10
	COSI	Pre-test	5.12	0.12
		Post-test	4.83	0.11
Time and Study Environment	7E-LCI	Pre-test	5.16	0.12
		Post-test	4.97	0.10
	COSI	Pre-test	5.08	0.12
		Post-test	4.56	0.10
Effort Regulation	7E-LCI	Pre-test	5.08	0.14
		Post-test	4.74	0.13
	COSI	Pre-test	5.10	0.15
		Post-test	4.36	0.13
Peer Learning	7E-LCI	Pre-test	4.23	0.18
		Post-test	4.98	0.16
	COSI	Pre-test	4.12	0.19
		Post-test	4.57	0.16
Help Seeking	7E-LCI	Pre-test	4.84	0.14
		Post-test	4.77	0.12
	COSI	Pre-test	4.66	0.14
		Post-test	4.53	0.12

The results for the sub-questions Q.4.2.1 and Q.4.2.2 which ask the mean differences between groups at each time periods for all learning strategies scales were presented at Table 4.51. As seen at the table, there were significant mean differences between experimental and comparison groups' post-test scores with respect to elaboration, critical thinking, self-regulation, time and study environment, and effort regulation. Detailed interpretations will be presented for each scale later.

Table 4.51 Pairwise Comparisons of Groups by Time for Learning Strategies Variables

Dependent Variable	Time	Treatment I vs J	Mean Difference (I-J)	Std. Error	Sig. (*p*) [1]
Rehearsal	Pre-test	7E-LCI vs COSI	0.06	0.22	0.78
	Post-test	7E-LCI vs COSI	0.34	0.21	0.10
Elaboration	Pre-test	7E-LCI vs COSI	0.25	0.19	0.20
	Post-test	7E-LCI vs COSI	0.48*	0.17	0.00
Organization	Pre-test	7E-LCI vs COSI	0.24	0.21	0.24
	Post-test	7E-LCI vs COSI	0.14	0.21	0.49
Critical Thinking	Pre-test	7E-LCI vs COSI	0.17	0.19	0.36
	Post-test	7E-LCI vs COSI	0.44*	0.18	0.01
Self-Regulation	Pre-test	7E-LCI vs COSI	0.12	0.17	0.46
	Post-test	7E-LCI vs COSI	0.50*	0.15	0.00
Time and Study Environment	Pre-test	7E-LCI vs COSI	0.08	0.16	0.61
	Post-test	7E-LCI vs COSI	0.41*	0.14	0.00
Effort Regulation	Pre-test	7E-LCI vs COSI	0.02	0.20	0.92
	Post-test	7E-LCI vs COSI	0.38*	0.18	0.04
Peer Learning	Pre-test	7E-LCI vs COSI	0.11	0.26	0.68
	Post-test	7E-LCI vs COSI	0.41	0.23	0.08
Help Seeking	Pre-test	7E-LCI vs COSI	0.18	0.20	0.35
	Post-test	7E-LCI vs COSI	0.24	0.16	0.15

*Analysis was performed with the significance level of $\alpha = 0.05$
1 Adjustment for multiple comparisons: Bonferronni

Moreover, the changes in experimental and comparison group students' learning strategies scores over time that addressed in sub-questions Q.4.3.1 and Q.4.3.2 were represented at Table 4.52. It was found that, there were significant changes over time in the experimental group students' scores of elaboration, effort regulation and peer learning and the comparison group students' scores of organization, self-regulation, time and study environment, effort regulation, and peer learning. The results related with each learning strategy variables will be investigated and interpreted separately on the next parts.

Table 4.52 Pairwise Comparisons of Time by Groups for Learning Strategies Variables

Dependent Variable	Treatment	Time I vs J	Mean Difference (I-J)	Std. Error	Sig. (*p*) [1]
Rehearsal	7E-LCI	Pre-test vs Post-test	-0.29	0.17	0.10
	COSI	Pre-test vs Post-test	0.00	0.17	0.99
Elaboration	7E-LCI	Pre-test vs Post-test	-0.38*	0.14	0.00
	COSI	Pre-test vs Post-test	-0.14	0.14	0.31
Organization	7E-LCI	Pre-test vs Post-test	-0.24	0.16	0.13
	COSI	Pre-test vs Post-test	0.34*	0.16	0.04
Critical Thinking	7E-LCI	Pre-test vs Post-test	-0.27	0.15	0.07
	COSI	Pre-test vs Post-test	-0.02	0.15	0.92
Self-Regulation	7E-LCI	Pre-test vs Post-test	-0.09	0.12	0.47
	COSI	Pre-test vs Post-test	0.29*	0.12	0.02
Time and Study Environment	7E-LCI	Pre-test vs Post-test	0.19	0.11	0.08
	COSI	Pre-test vs Post-test	0.52*	0.11	0.00
Effort Regulation	7E-LCI	Pre-test vs Post-test	0.34*	0.16	0.03
	COSI	Pre-test vs Post-test	0.74*	0.16	0.00
Peer Learning	7E-LCI	Pre-test vs Post-test	-0.76*	0.21	0.00
	COSI	Pre-test vs Post-test	-0.46*	0.22	0.04
Help Seeking	7E-LCI	Pre-test vs Post-test	0.07	0.15	0.64
	COSI	Pre-test vs Post-test	0.12	0.15	0.41

*Analysis was performed with the significance level of $\alpha = 0.05$
[1] Adjustment for multiple comparisons: Bonferronni

4.2.2.2.2.1 Follow-Up Analysis of Rehearsal (R)

Regarding rehearsal, the results revealed that there was no statistically significant mean difference between groups before the instructions (pre-test) as well as after the instructions (post-test) ($p > 0.05$) (See Table 4.51).

Investigation of mean scores indicates that after the instruction, experimental group students ($M = 5.30$) perceived themselves as using rehearsal strategy a little more than the comparison group students ($M = 4.95$). Furthermore, significant mean differences were not found on the continuous effect of instructions indicating that there is no statistically significant mean difference between pre-test ($M = 5.01$) and post-test ($M = 5.30$) scores with respect to experimental group students and there is no statistically significant mean difference between pre-test ($M = 4.95$) and post-test ($M = 4.95$) scores with respect to comparison group students, $p > 0.05$ (See Table 4.52).

The change on the mean scores and Figure 4.16 implies that 7E-LCI contributed an unsignificant increase to students' perception on rehearsal strategy use while COSI did not affect students' use of rehearsal strategy use.

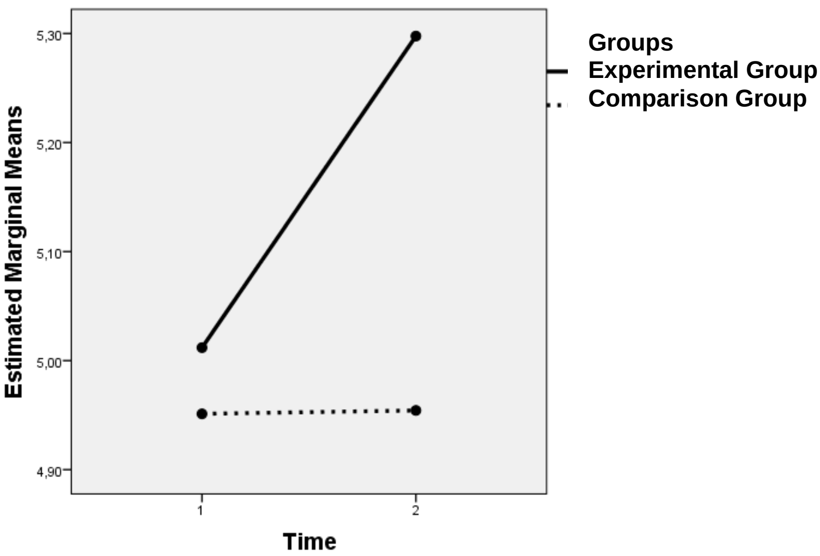

Figure 4.16 Estimated Marginal Means of Students' R

4.2.2.2.2.2 Follow-Up Analysis of Elaboration (E)

As presented at Table 4.51, there was not a statistically significant mean difference between groups at the beginning of the study (pre-test), $p > 0.05$. However, a statistically significant mean difference was found between experimental ($M = 5.71$) and comparison groups ($M = 5.22$) at the end of the study (post-test), $p < 0.05$. An examination of mean scores indicates that students instructed by 7E-LCI reported the use of elaboration strategies like paraphrasing, summarizing, creating analogies and generative note-taking at higher levels compared to the students instructed by COSI. For example, 80.5% of the students in the experimental group rated themselves on the item 64, "When reading for this class, I try to relate the material to what I already know." as 5 or more (See Table 4.53). Corresponding percentage in the comparison group was 67.9%. Moreover, 82.8% of the students in the experimental group agreed with the statement of item 67, "When I study for this course, I write brief summaries of the main ideas from the readings and the concepts from the lectures." while the percentage of students that agree this statement was 67.9%.

Table 4.53 Percentages of Responses to Selected Items of the Post-E, Between Groups

Item No	Groups	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
64	EG	0	1.1	8.0	10.3	14.9	16.1	49.4
	CG	6.0	8.3	10.7	7.1	16.7	23.8	27.4
67	EG	1.1	2.3	8.0	5.7	16.1	19.5	47.1
	CG	4.8	2.4	14.3	10.7	16.7	19.0	32.1

Concerning the within group changes reported Table 4.52, a significant change was found in the mean scores from pre-test (M= 5.33) to post-test (M= 5.71) only in experimental group, $p < 0.05$. After the instruction, experimental group students instructed by 7E-LCI appeared to use elaboration strategies such as integrating and connecting new knowledge with the previous ones at higher levels. For instance, the total percentage of agreement (rated 5, 6 or 7) with the statement in item 67 of experimental group students was 73.3% before the instruction while it increased to 82.8% after the instruction (See Table 4.54). Similarly, in experimental group students, an increase on the total percentage of agreement from 70% towards 79.3% was observed over time with the item 81, stating "I try to apply ideas from course readings in other class activities such as lecture and discussion.".

Table 4.54 Percentages of Responses to Selected Items of the E, Within Experimental Group

Item No	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
9	Pre-Test	4.5	4.5	9.1	8.0	10.2	11.4	52.3
	Post-Test	8.1	4.7	5.8	18.6	15.1	7.0	39.5
18	Pre-Test	0	0	0	2.3	1.1	15.9	80.7
	Post-Test	3.5	7.0	7.0	5.8	9.3	18.6	48.8

Overall, results suggested that 7E-LCI promoted the students' use of such strategies in their learning process while COSI did not induce a significant contribution to students' using elaborations strategy. Figure 4.17 shows the change on the scores of students before and after the instructions clearly.

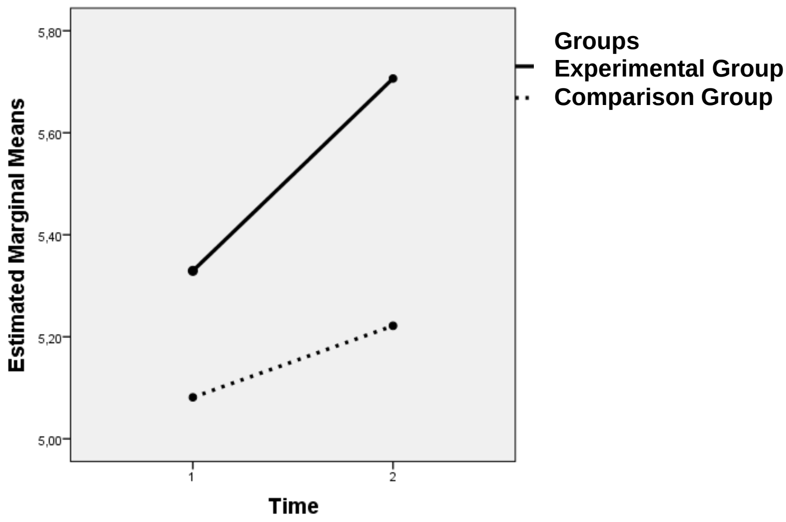

Figure 4.17 Estimated Marginal Means of Students' E

4.2.2.2.2.3 <u>Follow-Up Analysis of Organization (O)</u>

As presented at Table 4.51, there was no statistically significant mean difference between groups before (pre-test) and after (post-test) the instructions with respect to their organization strategy use, $p > 0.05$. Before the instruction, experimental group students' mean scores ($M = 4.94$) were higher than the comparison group students' mean scores ($M = 4.69$). Similarly, experimental group students reported higher mean scores ($M = 5.18$) than comparison group students ($M = 5.04$) after the instruction. That is, students exposed 7E-LCI perceived themselves using organization as a strategy to learn science concepts at higher levels than COSI students.

However, the investigation of within-subjects effects at Table 4.52 reveals a significant contribution of COSI to comparison group students indicating that there was a statistically significant mean difference between their pre-test scores (*M*= 4.69) and post-test scores (*M*= 5.04), $p < 0.05$. Comparison group students' agreement with the sample items of organization scale supports this result (See Table 4.55). For example, in item 32, the statement; "When I study the readings for this course, I outline the material to help me organize my thoughts." was rated as 5, 6, and 7 by 57% of comparison group students before the instruction while their percentage increased 66.3% after the instruction. Moreover, the comparison group students' percentage of agreement with item 63, "When I study for this course, I go over my class notes and make an outline of important concepts.", was 51.2% at the beginning of the COSI while it was 68.3% after the COSI. On the other hand, although there was an increase in the mean scores from pre-test (M= 4.94) to post-test scores (M= 5.18), 7E-LCI did not provide a significant contribution to students' organization strategy use.

Table 4.55 Percentages of Responses to Selected Items of the O, Within Comparison Group

Item No	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
32	Pre-Test	11.6	4.7	8.1	18.6	14.0	15.1	27.9
	Post-Test	9.6	3.6	8.4	12.0	18.1	12.0	36.1
63	Pre-Test	12.8	7.0	5.8	23.3	12.8	12.8	25.6
	Post-Test	9.6	2.4	6.0	13.3	15.7	12.0	39.8

Figure 4.18 presents the pattern of increase on the scores for both groups with respect to students' perceptions towards organization strategy use.

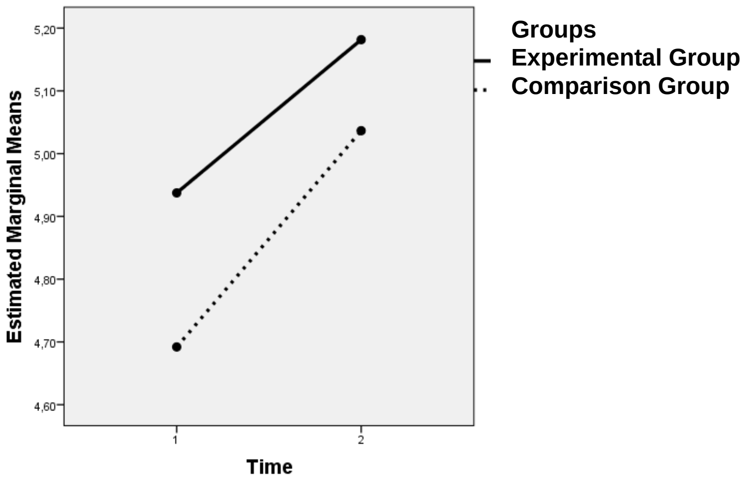

Figure 4.18 Estimated Marginal Means of Students' O

4.2.2.2.2.4 Follow-Up Analysis of Critical Thinking (CT)

Considering critical thinking, between group comparisons reveal that there was no statistically significant mean difference between experimental (*M*= 5.23) and comparison groups (*M*= 5.05) before the instructions (pre-test) ($p > 0.05$) (See Table 4.51. On the other hand, a statistically significant mean difference was found between the groups after the instructions (post-test), $p < 0.05$. The investigation of mean scores indicates that after having instructed through 7E-LCI, students in the experimental group (*M*= 5.50) appeared to use strategies to apply prior knowledge to new situations for the purpose of solving the problems, reaching decisions, or performing critical evaluations more than the students in the comparison group students (*M*= 5.07). For example, the statement of "I often find myself questioning things I hear or read in this course to decide if I find them convincing." (item 38) was rated as 5 and more by 73.6% of experimental group students whereas this percentage was 59% in comparison group students. Moreover, 75.9% of the students in the experimental group agreed with the statement of "When a theory, interpretation, or conclusion is presented in class or in readings, I try to decide if there is good supporting evidence" (item 47) while the agreement percentage was 63.9% for the students in the comparison group.

Table 4.56 Percentages of Responses to Selected Items of the Post-CT, Between Groups

Item No	Groups	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
38	EG	2.3	4.6	2.3	17.2	17.2	17.2	39.1
	CG	9.6	7.2	10.8	13.3	20.5	15.7	22.9
47	EG	4.6	1.1	5.7	12.6	20.7	20.7	34.5
	CG	6.0	6.0	8.4	15.7	16.9	21.7	25.3

Additionally, within-subject comparisons at Table 4.52 implied that there was not any significant contribution of 7E-LCI and COSI on students' critical thinking strategy use, $p > 0.05$. However, there was a positive change in the experimental group students' scores from pre-test ($M = 5.23$) to post-test ($M = 5.50$). The increase on the mean scores after the 7E-LCI specifies the contribution of 7E-LCI on students' scores. Conversely, no statistically striking change was found between comparison groups students' mean scores from pre-test ($M = 5.05$) to post-test ($M = 5.07$). The change on the mean scores for both groups during the study can be clearly seen at Figure 4.19.

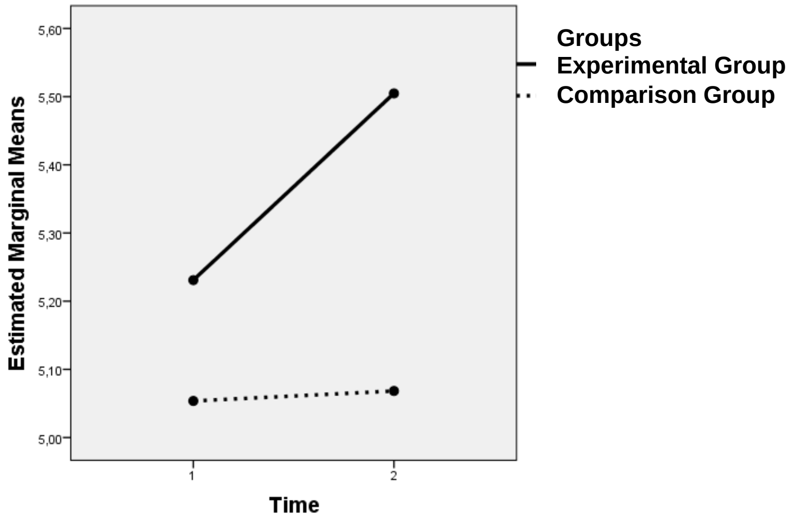

Figure 4.19 Estimated Marginal Means of Students' CT

4.2.2.2.2.5 Follow-Up Analysis of Metacognitive Self-Regulation (SR)

Regarding self-regulation strategy, there was no statistically significant mean difference between experimental (*M*= 5.24) and control (*M*= 5.13) groups at the beginning of the study (pre-test) (*p*> 0.05) (See Table 4.51). On the other hand, the findings revealed a statistically significant treatment effect at the end of the study (post-test), *p*< 0.05. Investigation of the mean scores revealed that experimental group students (*M*= 5.33) reported higher level of self-regulation strategies than comparison group students (*M*= 4.83). These findings implied that students exposed 7E-LCI appeared to use self-regulatory activities such as planning, monitoring and regulating more than students exposed TSDI. For instance, percentage of rating the statement of "When I become confused about something I'm reading for this class, I go back and try to figure it out." (item 41), as 5, 6 and 7 was 86% in the experimental group, while it was 72.8% in the comparison group (See Table 4.57). Similarly, percentage of rating the statement of "If I get confused taking notes in class, I make sure I sort it out afterwards." (item 79), as 5, 6 and 7 was 80.5% in the experimental group while it was 66.7% in the comparison group.

Table 4.57 Percentages of Responses to Selected Items of the Post-SR, Between Groups

Item No	Groups	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
41	EG	2.3	1.1	3.4	6.9	16.1	16.1	52.9
	CG	4.9	7.4	7.4	7.4	18.5	17.3	37
79	EG	2.3	2.3	5.7	9.2	11.5	26.4	42.5
	CG	7.4	0	7.4	18.5	22.2	19.8	24.7

Moreover, within-group comparisons at Table 4.52 indicated that there was no statistically significant change from pre-test (M= 5.24) to post-test (M= 5.33) scores of experimental group students, p> 0.05. However, the investigation of mean scores reveals a slight increase in their using of self-regulation strategies after the 7E-LCI. On the other hand, a statistically significant change was found from pre-test (M= 5.13) to post-test (M= 4.83) scores of comparison group students, p< 0.05. After the instruction, students in COSI classes reported lower levels of self-regulation strategies. The total percentage of agreement (rated 5, 6 and 7) of students in the comparison group with item 41 was decreased from 87.2% to 72.8% in the course of the study. Similarly, their agreement with item 61, "I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying." was 81.4% at the beginning of the study while it decreased to 68.8% at the end of the study.

Table 4.58 Percentages of Responses to Selected Items of the SR, Within Comparison Group

Item No	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
41	Pre-Test	0	3.5	2.3	7.0	11.6	18.6	57.0
	Post-Test	4.9	7.4	7.4	7.4	18.5	17.3	37.0
61	Pre-Test	1.2	2.3	3.5	11.6	15.1	20.9	45.3
	Post-Test	3.7	2.5	8.6	16.0	16.0	13.6	38.3

In addition, Figure 4.20 summarizes the difference between groups and the change on the mean SR scores of students at before and after the instruction.

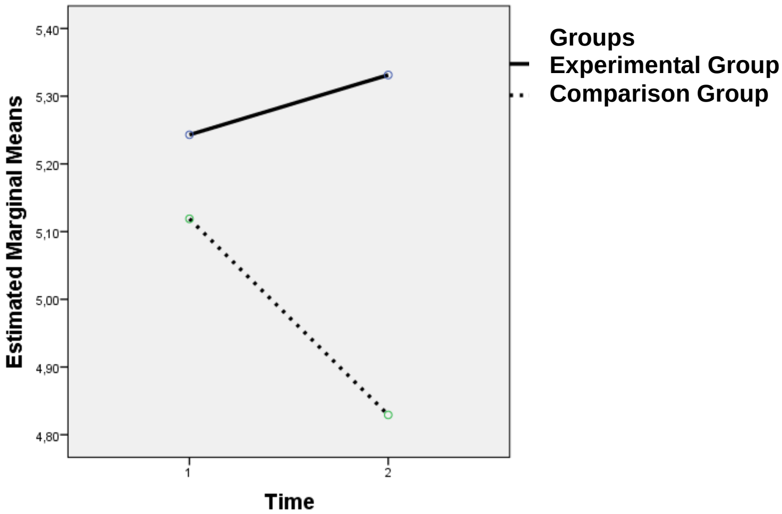

Figure 4.20 Estimated Marginal Means of Students' SR

4.2.2.2.2.6 Follow-Up Analysis of Time and Study Environment (TSE)

Students' time and study environment scores were not significantly different before the instruction indicating there was no statistically significant mean difference between experimental (*M*= 5.16) and control (*M*= 5.08) groups before the instruction (pre-test) ($p > 0.05$) (See Table 4.51). However, a statistically significant mean difference between groups was found with respect to time and study environment scores after the instruction (post-test), $p < 0.05$. After receiving the treatment, experimental group students (*M*= 4.94) reported themselves as being able to manage and regulate their time and study environments more than comparison group students (*M*= 4.56). For example, 80.5% of students in the experimental groups rated 5 or over in the agreement of item 43, "I make good use of my study time for this course." while the corresponding percentage was 69% in the comparison group (See Table 4.59). In addition, 81.6% of the students in the experimental group reported an agreement with the statement in the item 70, "I make sure I keep up with the weekly readings and assignments for this course." whereas 72.3% of students in the comparison group agreed with this item.

Table 4.59 Percentages of Responses to Selected Items of the Post-TSE, Between Groups

Item No	Groups	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
43	EG	1.1	0	3.4	14.9	11.5	24.1	44.8
	CG	6.0	2.4	10.7	11.9	15.5	17.9	35.7
70	EG	2.3	0	5.7	10.3	14.9	17.2	49.4
	CG	1.2	4.0	4.0	14.3	10.7	26.2	34.5

Considering the change of scores over time, a statistically significant mean difference was found between pre-test (*M*= 5.08) and post-test (*M*= 4.56) scores with respect to COSI classes, $p< 0.05$ (See Table 4.52). On the other hand, there was no statistically significant mean difference between pre-test (*M*= 5.16) and post-test (*M*= 4.97) scores of students in 7E-LCI classes, $p> 0.05$. The total percentage of agreement (rated 5, 6 and 7) of students in the comparison group with the statement of “I usually study in a place where I can concentrate on my course work” (item 35) was decreased from 92.9% to 81% in the course of the study. Similarly, their agreement with item 70 was 81.4 % at the beginning of the study while it decreased to 72.3% at the end of the study.

Table 4.60 Percentages of Responses to Selected Items of the TSE, Within Comparison Group

Item No	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
35	Pre-Test	0	0	0	7.0	10.5	16.3	65.1
	Post-Test	4.8	3.6	6.0	7.1	11.9	25.0	41.7
70	Pre-Test	1.2	2.3	7.0	8.1	14.0	23.3	44.2
	Post-Test	1.2	6.0	6.0	14.3	10.7	26.2	34.5

As seen on the Figure 4.21, there was a tendency to decrease on both group students’ perception of using time and study environment strategies in science class. However, COSI caused a significant decline in this strategy use while 7E-LCI did not seem to induce a substantial effect.

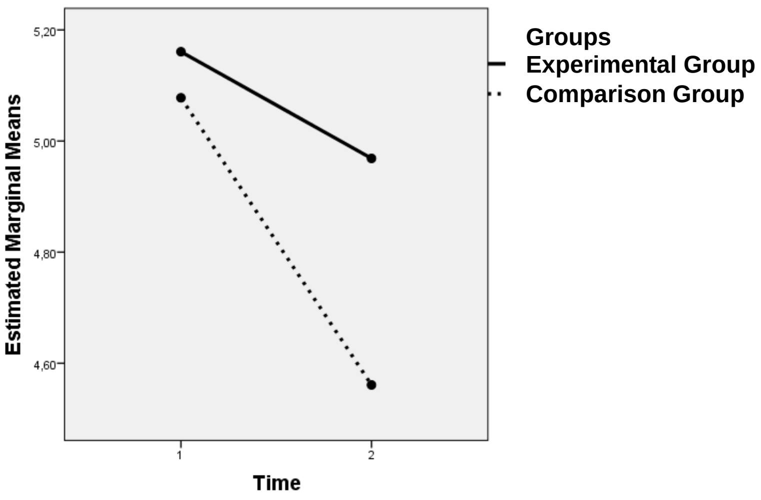

Figure 4.21 Estimated Marginal Means of Students' TSE

4.2.2.2.2.7 <u>Follow-Up Analysis of Effort Regulation (ER)</u>

As presented at Table 4.51, there was no statistically significant mean difference between students' effort regulation scores before the instructions (pre-test), $p > 0.05$. On the other hand, a statistically significant mean difference was found between experimental ($M = 4.74$) and comparison groups ($M = 4.36$) with respect to their effort regulation scores after the instructions (post-test), $p < 0.05$. The investigation of mean scores indicated that students instructed through 7E-LCI reported higher mean scores than students exposed COSI. The total percentage of agreement (rated 5, 6 and 7) with the reversed item 37, "I often feel so lazy or bored when I study for this class that I quit before I finish what I planned to do." was 41.4% for experimental group students whereas it was 35.7 for comparison group students (See Table 4.61). However, there was a slight difference between groups in terms of the percentage of total agreement with item 74, "Even when course materials are dull and uninteresting, I manage to keep working until I finish." indicating 74.4% for experimental group students and 73.5% for comparison group students.

Table 4.61 Percentages of Responses to Selected Items of the Post-ER, Between Groups

Item No	Groups	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
37*	EG	17.2	11.5	11.5	18.4	11.5	6.9	23.0
	CG	22.4	16.5	17.6	7.1	14.1	4.7	16.5
74	EG	2.3	5.7	9.2	8.0	13.8	11.5	48.3
	CG	3.5	3.5	8.2	10.6	16.5	20.0	35.3

* Reversed

However, the within-subject effect analysis for both group indicated a decrease on the mean scores (See Table 4.52). There was a statistically significant mean difference between pre-test (M= 5.08) and post-test (M= 4.71) scores of experimental group scores, $p < 0.05$. Similarly, a statistically significant mean difference between pre-test (M= 5.10) and post-test (M= 4.36) was found with respect to comparison group scores, $p < 0.05$. Students' total agreement (Rated 5, 6 and 7) with item 37 was decreased from 55.7% to 41.4% in experimental group whereas it was decreased from 50% to 35.7% in comparison group (See Table 4.62). Similarly, the percentages of total agreement with statement of "I work hard to do well in this class even if I don't like what we are doing." were decreased from 81.8% to 75.9% in experimental groups and from 84.9% to 77.1% in comparison group.

Table 4.62 Percentages of Responses to Selected Items of the ER, Within Experimental and Comparison Group

Item No	Groups	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
37*	EG	Pre-Test	17.0	10.2	6.8	10.2	8.0	12.5	35.2
		Post-Test	17.2	11.5	11.5	18.4	11.5	6.9	23.0
	CG	Pre-Test	8.1	12.8	15.1	14.0	9.3	7.0	33.7
		Post-Test	22.4	16.5	17.6	7.1	14.1	4.7	16.5
48	EG	Pre-Test	19.3	8.0	6.8	9.1	9.1	9.1	38.6
		Post-Test	17.2	11.5	11.5	18.4	11.5	6.9	23.0
	CG	Pre-Test	15.1	8.1	11.6	9.3	4.7	9.3	41.9
		Post-Test	22.4	16.5	17.6	7.1	14.1	4.7	16.5

* Reversed

As inspected in Figure 4.22, the mean scores of groups were close at the beginning of the study but decreased after the instructions. Furthermore, the decline in effort regulation scores was higher for comparison group as compared to experimental group indicating students in COSI classes reported lower commitment to complete a task when they face with difficulties or distractions.

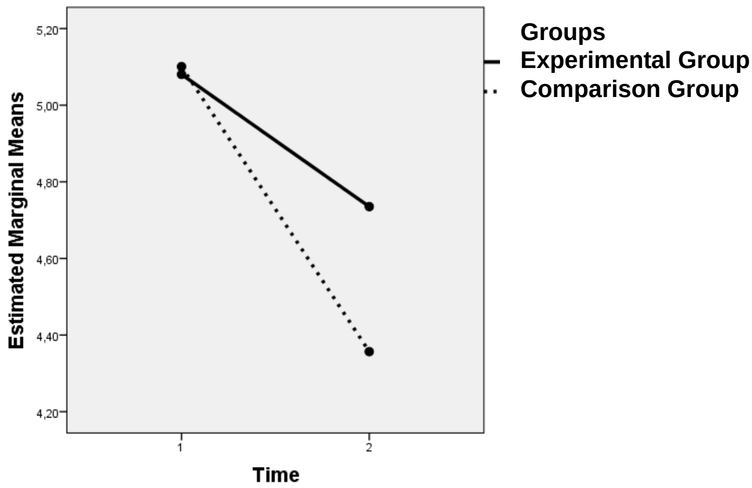

Figure 4.22 Estimated Marginal Means of Students' ER

4.2.2.2.2.8 Follow-Up Analysis of Peer Learning (PL)

The mean peer learning scores of students were the same at pre-test scores indicating there was no statistically significant mean difference between experimental (*M*= 4.23) and comparison group (*M*= 4.98) before the instructions, $p > 0.05$ (See Table 4.51). After the instruction, (post-test) there was a statistically significant mean difference between the groups, $p < 0.05$. Moreover, the mean scores on peer learning was found to be higher for experimental group students (*M*= 4.98) than comparison group students (*M*= 4.57). Besides, the change in the mean scores over time indicated an increase for both groups. There was a statistically significant change in experimental group students' mean scores from pre-test (*M*= 4.23) to post-test 2 (*M*= 4.98), $p < 0.05$ (See Table 4.52). Similarly, a statistically significant change was found in comparison group students' mean scores from pre-test (*M*= 4.12) to post-test (*M*= 4.57), $p < 0.05$. The percentages of students' responses to the sample items of PL scale can be seen at Table 4.63. In the course of the study, the total percentage of agreement with statement "I try to work with other students from this class to complete the course assignments." (item 45) was increased from 47.7% to 64.4% for experimental group, while it increased from 47.7% to 54.2% for comparison group. Moreover, the total percentage of agreement with statement "When studying for this course, I often set aside time to discuss the course material with a group of students from the class." (item 50) was increased from 45.5% to 64.4% for experimental group, whereas it increased from 41.2% to 58.5% for comparison group.

Table 4.63 Percentages of Responses to Selected Items of the PL, Within Experimental and Comparison Group

Item No	Groups	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)
45	EG	Pre-Test	17.0	8.0	9.1	18.2	10.2	19.3	18.2
		Post-Test	6.9	5.7	6.9	16.1	20.7	16.1	27.6
	CG	Pre-Test	12.8	14.0	14.0	11.6	14.0	15.1	18.6
		Post-Test	10.8	7.2	10.8	16.9	12.0	15.7	26.5
50	EG	Pre-Test	12.5	13.6	13.6	14.8	15.9	18.2	11.4
		Post-Test	11.5	6.9	8.0	9.2	13.8	17.2	33.3
	CG	Pre-Test	19.8	15.1	11.6	11.6	14.0	12.8	14.0
		Post-Test	12.0	10.8	7.2	10.8	19.3	15.7	22.9

As clearly seen in the Figure 4.23, the mean scores of groups were close at the beginning of the study but increased after receiving the instructions. Furthermore, the improvement in peer learning score was higher for experimental group indicating that student thought by 7E-LCI appeared to collaborate with their peers during their learning more than the students in COSI classes.

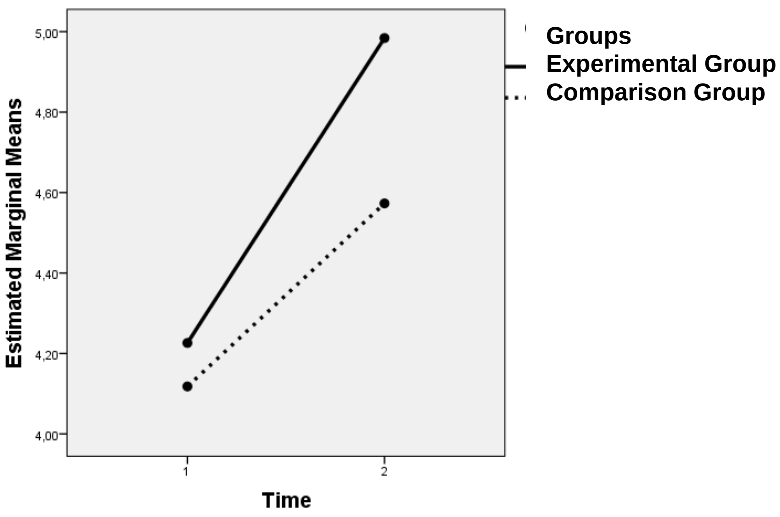

Figure 4.23 Estimated Marginal Means of Students' PL

4.2.2.2.2.9 Follow-Up Analysis of Help Seeking (HS)

Help seeking was the only variable on which no statistically significant mean differences were found between groups as well as within groups. As seen at Table 4.51, before the instruction (pre-test), there was no statistically significant mean difference between experimental (*M*= 4.84) and comparison groups (*M*= 4.66), $p>$ 0.05. Similarly, there was no statistically significant mean difference between experimental (*M*= 4.77) and comparison groups (*M*= 4.53) after the instruction (post-test), $p>$ 0.05. However, the investigation of mean scores reveals that experimental group students' scores were higher than comparison group students' scores at each time. Furthermore, there was not a statistically significant change from pre-test to post-test concerning both groups' scores (See Table 4.52). As also presented in Figure 4.24, there was a slight decrease on the scores of both groups from pre-test to post-test and the lines are approximately parallel. That is, although the students in 7E-LCI classes were perceived themselves to realize their knowledge deficiency and able to get assistance from other more than the students in COSI classes, there was a tendency to decrease on this strategy use for both groups across time.

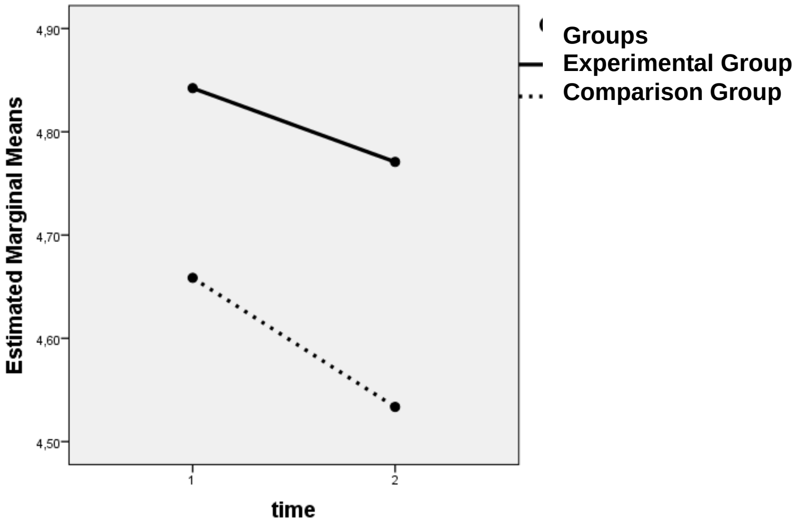

Figure 4.24 Estimated Marginal Means of Students' HS

In summary, as presented in Table 4.51, the between group comparisons before receiving the 7E-LCI and COSI (pre-test) showed that the learning strategies variables were same for both groups indicating there was not a statistically significant mean difference between experimental and comparison groups with respect to collective dependent variables. Moreover, statistically significant mean differences were found after the instructions (post-test) between groups with respect to variables of elaboration, critical thinking, self-regulation, time and study environment, and effort regulation. When the mean scores given in the Table 4.50 were examined, it was found that students in the experimental group had higher mean scores on these dependent measures than students in the comparison group. Therefore, students in 7E-LCI classes appeared to use elaboration, critical thinking, and metacognitive self-regulation strategies at higher levels during their learning process. Additionally, they perceived themselves as to manage their time and study environment and their own effort more than students in TSDI classes.

In contrast to these findings, no statistically significant mean difference was found after the instructions (post-test) with respect to variables of rehearsal, organization, peer learning, and help seeking. However, the investigation of mean scores of groups presented in Table 4.50 reveals that the students in the experimental group had higher scores than the students in the comparison group on related scales. That is, students exposed 7E-LCI appeared to use rehearsal and organization strategies on their science learning. Also, they were more likely to collaborate with their peers and to identify people to provide them with assistance.

Moreover, as seen in the Table 4.52 the results related with the change on the scores of groups over time indicated statistically significant change for the variables of elaboration, effort regulation, and peer learning with respect to experimental group scores while there were statistically significant change on the scales of organization, self-regulation, time and study environment, effort regulation, and peer learning with respect to comparison group scores. In the experimental group, students perceived themselves as using elaboration and peer learning strategies more after they are instructed with 7E-LCI than before. On the other hand, they reported lower effort regulation after the treatment. At this point it is important to mention that investigation of the change on comparison group students' mean scores also shows a decline over two time measures. Therefore, students' in both groups have a tendency to lower to control their effort and attention when there are distractions or difficulties, but the decrease on the COSI classes is more striking. Also, after the instruction, comparison group students' self-regulation and time and study environment scores decreased. Comparing with the experimental groups' scores, the difference in time and study environment scores appeared to be higher on comparison group students. What is more, self-regulation scores of experimental group increased although it did not contribute a significant change. Organization and peer learning scores of comparison group significantly increased after the instruction. The increase in the mean organization score was not significant for experimental group students.

Indeed, no statistically significant mean difference was found between before and after instruction scores of experimental group with respect to rehearsal, organization, critical thinking, self-regulation, time and study environment, and help seeking. Concerning mean scores, there was a general incline in students' rehearsal, organization, critical thinking, and self-regulation scores while this situation is reverse in the scores of help seeking and time and study environment variables. Regarding the comparison group, rehearsal, elaboration, critical thinking and help seeking were the variables which did not contributed a significant change from before to after receiving COSI measures. Among these variables, rehearsal and critical thinking scores showed indistinctive change over time while elaboration slightly increased and help seeking slightly decreased.

In general, experimental group students appeared to use learning strategies more than the comparison group students. Besides, after having instructed by 7E-LCI, students' most of the learning strategy variables increased while the direction of change in the scores of students in COSI classes varied.

In the next part, findings related with scientific epistemological beliefs will be presented.

4.2.2.3 Statistical Analysis Regarding Scientific Epistemological Beliefs

EBQ used to assess students' scientific epistemological beliefs consists of four dimensions and implemented as pre-test and post-test in this study. The collected data was analyzed addressing the fifth main research question stated in Chapter 1 in this section.

Q.5. *What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' perceived epistemological beliefs (Source, Certainty, Development, and Justification)?*

More specifically, the sub-questions that investigated in the analysis of scientific epistemological beliefs data are as follows.

Q.5.1. *Is there a significant interaction between treatment and time with respect to students' perceived epistemological beliefs?*

Q.5.2.1. *Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived epistemological beliefs before the treatment?*

Q.5.2.2. *Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' perceived epistemological beliefs after the treatment?*

Q.5.3.1. *Is there a significant change in perceived epistemological beliefs of experimental group students who exposed to 7E learning cycle instruction.*

Q.5.3.1. *Is there a significant change in perceived epistemological beliefs of comparison group students who exposed to curriculum oriented science instruction.*

Mixed between-within subjects MANOVA was performed to determine (1) whether there was a significant mean difference between students who received 7E-LCI and COSI with respect to their scientific epistemological beliefs (i.e. source, certainty, development, and justification), (2) whether there was a change in students' scientific epistemological beliefs dimensions following their participation in 7E-LCI and COSI, and (3) whether there was an interaction between time and treatment variables.

Independent variables on the analysis were treatment and time while dependent variables were source, certainty, development and justification. The results revealed that there was no statistically significant treatment effect on the combined dependent variables as presented in Table 4.64, Wilk's $\lambda = 0.96$, $F(4, 159) = 1.75$, $p > 0.05$. The multivariate partial η^2 value is 0.04 representing a small effect size. It was also found that there was a statistically significant time effect on combined dependent variables (See Table 4.64), Wilk's $\lambda = 0.75$, $F(4, 159) = 13.53$, $p < 0.05$. The partial η^2 value was 0.25 which is quite strong based on generally accepted criteria (Cohen, 1988).

Furthermore, interaction between time and treatment that stated in the sub-question Q.5.1 was investigated. The results showed that there was no significant interaction effect between time and treatment Wilk's λ= 0.99, $F(4, 159)$= 0.21, p> 0.05.

Table 4.64 Mixed-MANOVA Results on Epistemological Beliefs Variables by Treatment and Time

Effect	Wilks' λ	F	Sig. (*p*)	Partial η2
Treatment	0.96	1.75	0.14	0.04
Time	0.75	13.53	0.00*	0.25
Time X Treatment	0.99	0.21	0.93	0.00

*Analysis was performed with the significance level of α = 0.05

In order to investigate the epistemological beliefs dimensions in which there was a change across the two time periods (before the instruction and after the instruction), follow-up univariate analyses of variance were conducted. The significance level was tested according to Bonferroni method to lower the Type 1 error. In this analysis, the alpha level of 0.0125 was found by dividing the original alpha level by number of dependent variables (i.e., 0.05/4=0.0125). The results of univariate analyses were interpreted based on this calculated alpha level. As reported in the Table 4.65, univariate statistics revealed statistically significant time effect with respect to certainty, $F(1,162)$= 6.67, p< 0.0125, development, $F(1,162)$= 10.21, p< 0.0125, and justification, $F(1,162)$= 21.30, p< 0.0125. The partial η^2 values for variables were 0.10, 0.13 and 0.21 respectively. These results suggested a medium effect size for certainty and development dimensions and a large effect size for the justification dimensions. On the other hand, no statistically significant time effect was found with respect to source dimension, $F(1,162)$= 1.09, p> 0.0125.

Table 4.65 Follow-up Univariate Results of Epistemological Belief Dimensions

Sources	Dependent Variable	Type III Sum of Squares	df	*F*	Sig. (*p*)	Partial η2
Time	Source	1.09	1	2.42	0.12	0.02
	Certainty	6.67	1	18.73	0.00*	0.10
	Development	10.21	1	23.51	0.00*	0.13
	Justification	21.30	1	43.62	0.00*	0.21

*Analysis was performed with the significance level of $\alpha = 0.0125$

Thus, the results revealed statistically significant change in the mean scores on three dimensions of scientific epistemological beliefs across time. However, based on these results, it is not possible to determine whether these observed changes occurred in both groups or in one of the groups. Although interaction effect was not statistically significant, investigating the time effect by separating the groups would be informative to discuss the effectiveness of treatment over time for each group. The syntax of the model was extended for that purpose. Moreover, Bonferroni adjustment was requested in the syntax to reduce the Type 1 error that increase on multiple comparisons. The mean scores and significance test results of multiple comparisons are presented at following tables. Then, the findings will be investigated thoughtfully for each dimension one by one.

Firstly, experimental and comparison group students' mean scores at before and after the instruction can be found at Table 4.66.

Table 4.66 Means of Groups With Respect to Time for Epistemological Belief Dimensions

Dependent Variable	Treatment	Time	Mean	Std. Error
Source	7E-LCI	Pre-test	2.84	0.09
		Post-test	2.67	0.09
	COSI	Pre-test	3.03	0.10
		Post-test	2.98	0.09
Certainty	7E-LCI	Pre-test	3.35	0.08
		Post-test	3.03	0.08
	COSI	Pre-test	3.41	0.08
		Post-test	3.16	0.08
Development	7E-LCI	Pre-test	3.79	0.06
		Post-test	3.47	0.09
	COSI	Pre-test	3.76	0.07
		Post-test	3.38	0.09
Justification	7E-LCI	Pre-test	4.19	0.07
		Post-test	3.69	0.10
	COSI	Pre-test	4.05	0.07
		Post-test	3.53	0.10

Table 4.67 presents the between group differences at each of two time periods as addressed in sub-questions Q.5.2.1 and Q.5.2.2 that stated at the beginning of this part. As seen at the table, there was a statistically significant mean difference between experimental and comparison groups with respect to only source dimension at the end of the study (post-test).

Table 4.67 Pairwise Comparisons of Groups by Time for Epistemological Belief Dimensions

Dependent Variable	Time	Treatment I vs J	Mean Difference (I-J)	Std. Error	Sig. (p) [1]
Source	Pre-test	7E-LCI vs COSI	-0.19	0.14	0.17
	Post-test	7E-LCI vs COSI	-0.30*	0.13	0.02
Certainty	Pre-test	7E-LCI vs COSI	-0.06	0.11	0.58
	Post-test	7E-LCI vs COSI	-0.13	0.12	0.27
Development	Pre-test	7E-LCI vs COSI	0.03	0.09	0.76
	Post-test	7E-LCI vs COSI	0.09	0.13	0.49
Justification	Pre-test	7E-LCI vs COSI	0.14	0.10	0.15
	Post-test	7E-LCI vs COSI	0.15	0.14	0.28

*Analysis was performed with the significance level of $\alpha = 0.05$
1 Adjustment for multiple comparisons: Bonferronni

Within group differences that referred in sub-questions Q.5.3.1 and Q.5.3.2 were reported at Table 4.68. The results show that experimental group students' mean scores significantly changed from before to after the instruction with respect to certainty, development and justification dimensions while comparison group students' mean scores significantly changed in development and justification dimensions. These results will be interpreted separately for each variable in the following sections.

Table 4.68 Pairwise Comparisons of Time by Groups for Epistemological Belief Dimensions

Dependent Variable	Treatment	Time I vs J	Mean Difference (I-J)	Std. Error	Sig. (p) [1]
Source	7E-LCI	Pre-test vs Post-test	0.17	0.10	0.10
	COSI	Pre-test vs Post-test	0.06	0.11	0.60
Certainty	7E-LCI	Pre-test vs Post-test	0.32*	0.09	0.01
	COSI	Pre-test vs Post-test	0.25	0.10	0.09
Development	7E-LCI	Pre-test vs Post-test	0.32*	0.10	0.02
	COSI	Pre-test vs Post-test	0.38*	0.11	0.00
Justification	7E-LCI	Pre-test vs Post-test	-0.51*	0.11	0.00
	COSI	Pre-test vs Post-test	-0.52*	0.11	0.00

*Analysis was performed with the significance level of $\alpha = 0.05$
1 Adjustment for multiple comparisons: Bonferronni

4.2.2.3.1 Follow-Up Analysis of Source Dimension

As it can be inferred form Table 4.67, there was not a statistically significant mean difference between experimental and comparison groups before the implementation (pre-test), $p > 0.05$. However, a significant mean difference was observed after the instruction (post-test) indicating there was a statistically significant mean difference between experimental ($M = 2.84$) and comparison groups ($M = 3.03$), $p < 0.05$. The mean scores revealed that experimental group students reported lower mean score compared to comparison group students. Therefore, experimental group students appeared less to believe that the knowledge origins from the authority compared to comparison group students. For example, the total percentage of agreement (rated 4 and 5) with item 6, "Whatever the teacher says in science class is true." experimental group students was 24.2% whereas the corresponding percentage was 37.9% for comparison group students (See Table 4.25). Similarly, the percentage of agreement with item 10, "In science, you have to believe what the science books say about stuff." was lower in experimental group, 28.6%, than the comparison group, 40.5%.

Table 4.69 Percentages of Responses to Selected Items of the Post-Source, Between Groups

Item No	Groups	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)
6	EG	29.7	26.4	19.8	7.7	16.5
	CG	22.8	11.4	25.3	21.4	16.5
10	EG	24.2	25.3	22.0	17.6	11.0
	CG	16.5	16.5	26.6	29.1	11.4

On the other hand, the development of their beliefs over time did not contribute a significant difference, indicating that there was no statistically significant change from pre-test to post-test scores, $p > 0.05$ (See Table 4.68). Similarly, the change in comparison group students' mean scores on the source dimension was not statistically significant, $p > 0.05$. That is, no statistically significant mean change was found for both groups. However, as also seen in Figure 4.25, the mean scores indicate a decline on beliefs of students while this change is higher for experimental group than comparison group. These results reveal that there was a decrease on both group students' tendency to rely on authority, such as teachers or textbooks as the source of the knowledge after the instructions.

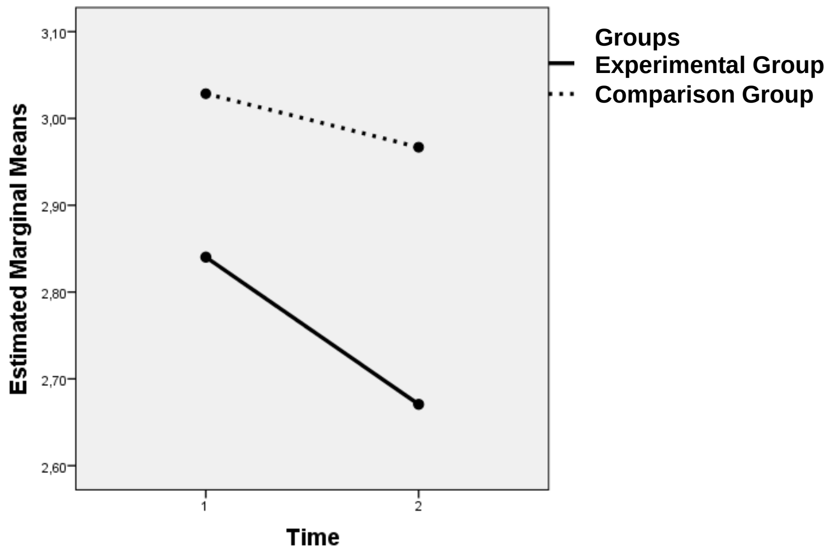

Figure 4.25 Estimated Marginal Means of Students' Beliefs on Source of Knowledge

4.2.2.3.2 Follow-Up Analysis of Certainty Dimension

Regarding certainty, there was no statistically significant mean difference between experimental and comparison group before the instruction and also after the instruction, $p > 0.05$ (See Table 4.67). However, the mean difference between groups was found to be slightly increased after receiving 7E-LCI and COSI (See Table 4.20). Additionally, experimental group students ($M = 3.03$) reported lower beliefs about the certainty of knowledge comparing to comparison group students ($M = 3.16$) only this difference was not significant. Furthermore, considering within group change over time presented in Table 4.68 there was a statistically significant mean difference between pre-test ($M = 3.35$) and post-test ($M = 3.03$) for experimental group students, $p < 0.05$. On the other hand, no statistically significant mean difference was found between pre-test ($M = 3.41$) and post-test ($M = 3.16$) scores of comparison group students, $p > 0.05$. The change of the experimental group students' certainty beliefs over time was also clear on the percentage of their rate on the sample items of scale (See Table 4.70). Before the instruction 57.7% of experimental group students rated 4 or 5 to the statement in item 2, "All questions in science have one right answer." while the percentage of students decreased to 36.3% after the instruction. Likewise, the percentage of agreement rated by experimental group students with item 12, "Scientists pretty much know everything about science; there is not much more to know." decreased from 85.6% to 66% in the course of 7E-LCI instruction.

Table 4.70 Percentages of Responses to Selected Items of the Certainty, Within Experimental Group

Item No	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)
2	Pre-Test	6.7	12.2	23.3	23.3	34.4
	Post-Test	15.4	24.2	24.2	17.6	18.7
12	Pre-Test	27.8	25.6	15.6	20.0	11.1
	Post-Test	41.8	20.9	16.5	15.4	5.5

Figure 4.26 represent a clear pattern of decline on students' mean scores. That is, students begun the study with fairly high beliefs about that the knowledge is certain but after the treatment their beliefs become lower. Moreover, students in 7E-LCI classes appeared to be more tended to believe that knowledge is not certain and there may be more than one answer to solve complex problems after they received the instructions.

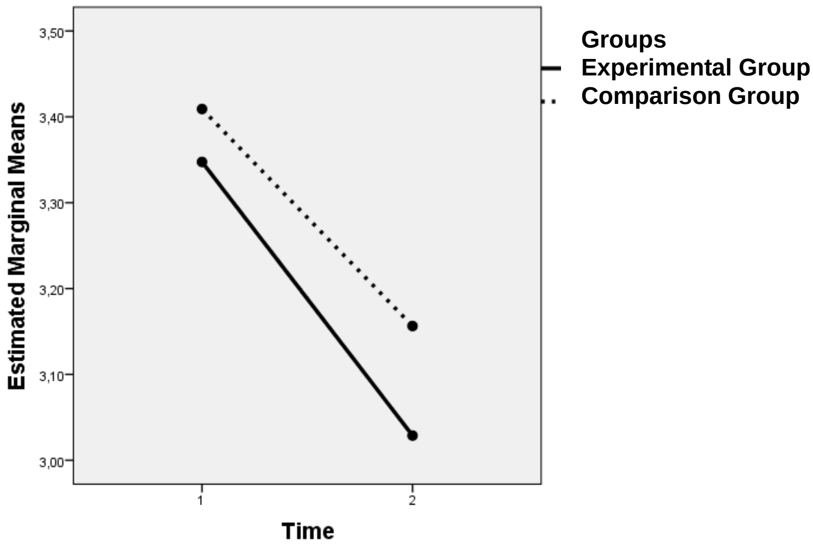

Figure 4.26 Estimated Marginal Means of Students' Belief on Certainty of Knowledge

4.2.2.3.3 Follow-Up Analysis of Development Dimension

Considering the students beliefs on development of knowledge, there was no statistically significant mean difference between experimental and comparison group before and after the instruction, $p > 0.05$ (See Table 4.67). The mean scores of students were almost same at each of the measurement. On the other hand, the change of scores over time was significant for both groups (See Table 4.68).

That is, there was a statistically significant mean difference between pre-test ($M = 3.80$) and post-test ($M = 3.47$) scores of experimental group students, $p < 0.05$. Also, there was a statistically significant mean difference between pre-test ($M = 3.76$) and post-test ($M = 3.38$) scores of comparison group students, $p < 0.05$. The decrease on the scores of both groups can also be investigated through the percentage of agreement (rated 4 and 5) on sample items of scale (Table 4.71). For example, the total percentage of agreement of students with item 4, "Some ideas in science today are different than what scientists used to think." decreased from 55.6% to 50.5% for experimental group, while it decreased from 58.6% to 45.6 for comparison group over time. Similarly, experimental group students' percentage of agreement with item 17 "Ideas in science sometimes change." changed from 71.1% to 54.9 while comparison group students' percentages changed from 66.5% to 51.9%.

Table 4.71 Percentages of Responses to Selected Items of the Development, Within Experimental and Comparison Group

Item No	Groups	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)
4	EG	Pre-Test	3.3	4.4	36.7	34.4	21.1
		Post-Test	7.7	9.9	31.9	28.6	22.0
	CG	Pre-Test	5.7	6.9	28.7	35.6	23.0
		Post-Test	5.1	19.0	30.4	27.8	17.7
17	EG	Pre-Test	6.7	3.3	18.9	48.9	22.2
		Post-Test	5.5	17.6	22.0	26.4	28.6
	CG	Pre-Test	9.2	4.6	20.7	42.5	23.0
		Post-Test	8.9	7.6	31.6	27.8	24.1

As also seen at Figure 4.27, the change of the scores showed a similar pattern for both groups which is a decline on the mean scores from before to after the instruction measures. This unexpected result indicates that, experimental and comparison group students' became less likely to believe that science is a tentative, evolving and changing subject.

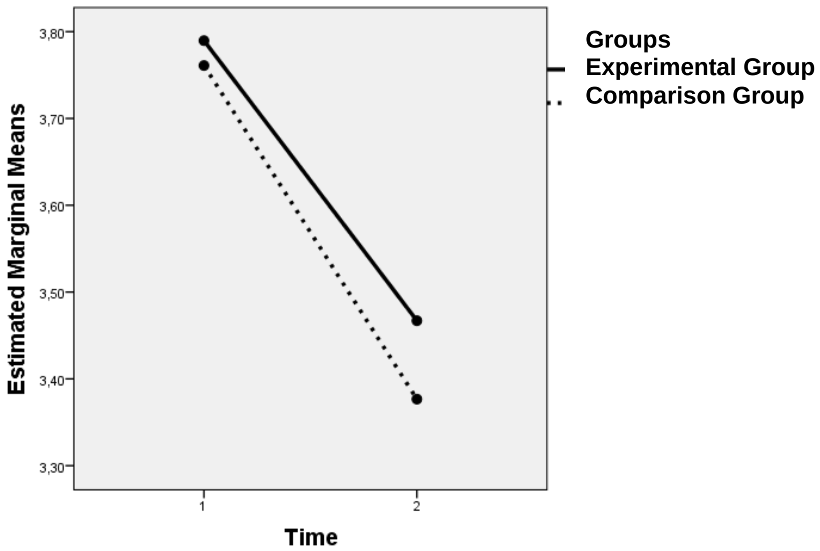

Figure 4.27 Estimated Marginal Means of Students' Belief on Development of Knowledge

4.2.2.3.4 Follow-Up Analysis of Justification Dimension

A similar pattern with development dimension was also observed for justification dimension. There was no statistically significant mean difference between groups neither at pre-test scores nor at post-test scores, $p > 0.05$ (See Table 4.67). However, significant mean differences were found on within group changes. There was a statistically significant mean change from pre-test (M= 4.19) to post-test (M= 3.69) scores of experimental group students, $p < 0.05$ (See Table 4.68). Similarly, a statistically significant mean change was found from pre-test (M= 4.05) to post-test (M= 3.53) scores of comparison group students, $p < 0.05$. Therefore students became to hold less sophisticated ideas towards the role of reasoning and experiments on scientific knowledge construction. For instance, the total percentages of agreement (rated 4 or 5) with statement of "Ideas about science experiments come from being curious and thinking about how things work." (item 3) decreased from 83.3% to 61.5% in experimental group students whereas the change was from 78.2% to 50.6% in comparison group students. Likewise, the percentages of students' agreement with statement of “A good way to know if something is true is to do an experiment.” (item 26) decreased from 86.7% to 68.1% in experimental group and decreased from 86.2% to 57% in comparison group.

Table 4.72 Percentages of Responses to Selected Items of the Justification, Within Experimental and Comparison Group

Item No	Groups	Test	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)
3	EG	Pre-Test	2.2	3.3	11.1	33.3	50.0
		Post-Test	7.7	12.1	18.7	27.5	34.1
	CG	Pre-Test	2.3	2.3	17.2	32.2	46.0
		Post-Test	6.3	11.4	31.6	25.3	25.3
26	EG	Pre-Test	2.2	2.2	8.9	22.2	64.4
		Post-Test	12.1	8.8	11.0	12.1	56.0
	CG	Pre-Test	5.7	1.1	6.9	21.8	64.4
		Post-Test	40.5	16.5	22.8	7.6	12.7

As inspected in Figure 4.28, there was a striking decline on the mean scores of both groups over time. The lines on the figure are almost parallel, indicating the effect of 7E-LCI and COSI on students was not different with respect to their belief about necessity of experiments and using data on constructing knowledge.

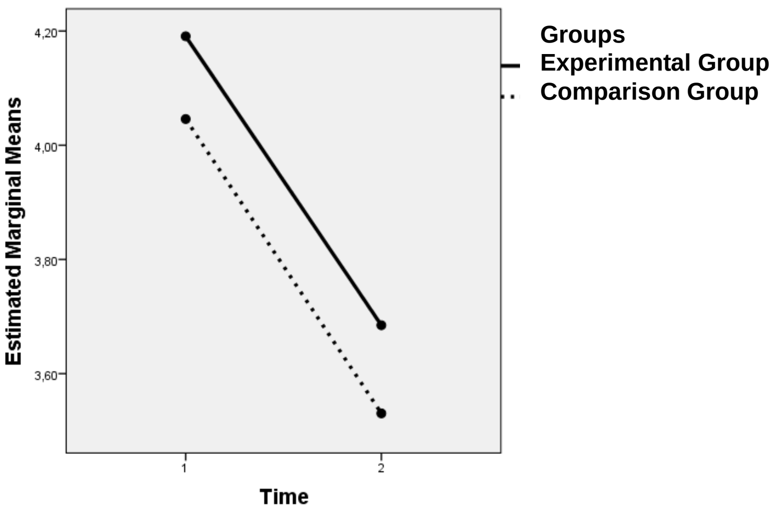

Figure 4.28 Estimated Marginal Means of Students’ Belief on Justification of Knowledge

In summary, the follow up analysis for interaction revealed that the groups did not differ with respect to their scientific epistemological beliefs except their belief about source of knowledge. Additionally, the development of their beliefs varied across four dimensions. Even though students became more sophisticated in their belief about the source of knowledge and the certainty of knowledge, they appeared to hold less sophisticated beliefs about the development of knowledge and the justification of knowledge over the course of the study. Students instructed with both methods endorsed stronger beliefs in observation and reason as a source of knowledge, rather than teachers and other experts and they had more beliefs related to the knowledge is not certain and it is possible to find more than one answer in science. On the contrary, they become to have less sophisticated belief about the science as an evolving subject and about the significance of experiments and data collection to justify the knowledge. The patterns of changes over time resemble for both groups indicating that two implementations have similar influence on students' scientific epistemological beliefs. On the other hand, it should be mentioned that, experimental group students' mean scores indicated stronger beliefs than the comparison group students with respect to all of the dimensions although it only contributed a significant difference for source dimension. After reporting the results regarding scientific epistemological beliefs, the last variable of the study, science process skills, will be examined under the following title.

4.2.2.4 Statistical Analysis Regarding Science Process Skills

SPST used to assess students' science process skills was applied two times, at the beginning the study and at the end of the study, to answer the last main research question reported in Chapter 1.

Q.6. *What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' science process skills?*

This research question was examined through a mixed between-within subjects ANOVA which investigates (1) the relative effect of 7E-LCI and COSI on students' science process skills (2) the change on their science process skills test scores over the implementation process, and (3) the interaction between time and treatment variables.

In detail, the addressed sub-questions in this analysis were as listed next.

Q.6.1. *Is there a significant interaction between treatment and time with respect to students' science process skills?*

Q.6.2.1. *Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' science process skills before the treatment?*

Q.6.2.2. *Is there a significant mean difference between groups exposed to 7E learning cycle instruction and curriculum oriented science instruction with respect to students' science process skills after the treatment?*

Q.6.3.1. *Is there a significant change in science process skills of experimental group students who exposed to 7E learning cycle instruction.*

Q.6.3.2. *Is there a significant change in science process skills of comparison group students who exposed to curriculum oriented science instruction.*

In the analysis, the independent variables were treatment and time while the dependent variables were five subtests of SPST. The results indicated there was not a statistically significant time effect on the collective variables as presented in Table 4.73, Wilk's λ= 0.99, $F(1, 146)$= 1.02, $p > 0.05$. Additionally, the interaction effect was investigated as directed in sub-question Q.6.1 and there was not a significant interaction between time and treatment Wilk's λ= 0.99, $F(1, 146)$= 1.88, $p > 0.05$.

Table 4.73 Mixed-MANOVA Results on SPST Subtests by Treatment and Time

Effect	Wilks' λ	F	Sig. (*p*)	Partial η2
Time	0.99	1.02	0.314	0.07
Time X Treatment	0.99	1.88	0.767	0.01

*Analysis was performed with the significance level of α = 0.05

On the other hand, the main effect of treatment was significant which means that there was a significant mean difference between groups in terms of science process skills $F(1, 146)= 3.98$, $p= 0.048$ (See Table 4.74). The partial η^2 value 0.03 indicating that 3% of multivariate variance of dependent variables was explained by treatment effect. Therefore, the explained variance by the treatment was quite small.

Table 4.74 Tests of Between-Subjects Effects Results for SPST

Source	Type III SS	df	F	Sig. (*p*)*	Partial η^2	Obs. Power
Treatment	64.71	1	3.98	0.048	0.03	0.51

*Analysis was performed with the significance level of α = 0.05

Consistent with the previous analyses the syntax was extended in order to reveal the between groups and within group differences separately for each group and each implementation. Additionally, Bonferroni Adjustment was requested on SPSS to decrease Type 1 error on multiple comparisons. Prior to the pairwise comparisons, the mean of each group students at any time points were summarized in Table 4.75.

Table 4.75 Means of Groups With Respect to Time for Subtests of SPST

Dependent Variable	Treatment	Time	Mean	Std. Error
Science Process Skills	7E-LCI	Pre-test	9.63	0.39
		Post-test	10.04	0.44
	COSI	Pre-test	8.79	0.36
		Post-test	9.01	0.41

The between groups comparisons at each time periods for science process skills addressed by sub-questions Q.6.2.1 and Q.6.2.2 were presented at Table 4.76. As shown in the table, there was not significant mean differences between experimental and comparison groups with respect to science process skills neither at the beginning of the study nor at the end of the study (p> .05).

Table 4.76 Pairwise Comparisons of Groups by Time for Subtests of SPST

Dependent Variable	Time	Treatment I vs J	Mean Difference (I-J)	Std. Error	Sig. (*p*) [1]
Science Process	Pre-test	7E-LCI vs COSI	0.84	0.53	0.11
Skills	Post-test	7E-LCI vs COSI	1.03	0.60	0.09

*Analysis was performed with the significance level of α = 0.05
1 Adjustment for multiple comparisons: Bonferronni

The changes in experimental and comparison group students' science process skill scores over time that addressed in sub-questions Q.6.3.1 and Q.6.3.2 were represented at Table 4.77. It was found that, there were not significant changes in both groups from beginning of the study towards the end of the study ($p > .05$). A clear picture of the slight changes in within group and the differences between groups can be seen in Figure 4.29.

Table 4.77 Pairwise Comparisons of Time by Groups for Subtests of SPST

Dependent Variable	Treatment	Time I vs J	Mean Difference (I-J)	Std. Error	Sig. (*p*) [1]
Science Process	7E-LCI	Pre-test vs Post-test	-0.41	0.46	0.38
Skills	COSI	Pre-test vs Post-test	-0.22	0.43	0.60

*Analysis was performed with the significance level of α = 0.05
1 Adjustment for multiple comparisons: Bonferronni

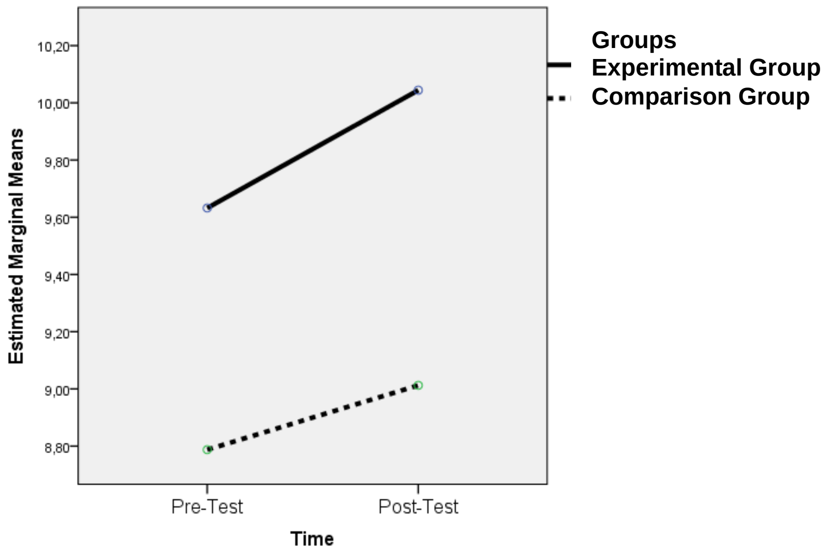

Figure 4.29 Estimated Marginal Means of Students' Science Process Skills.

To sum up, the follow up comparisons revealed that the groups did not differ with respect to science process skills. According to mean scores, experimental group students reported higher scores both at the pre-test and post-test implementations of SPST. The within group changes over time indicated the development of science process skills were similar for both groups. However, the changes in scores did not contribute a significant mean difference in none of the groups. Considering the patterns presented in Figure 4.29, the different nature of 7E-LCI and COSI appeared to fail to make a difference in influencing students' science process skills. However, it must be reemphasized that these conclusions may not reflect the accurate picture concerning the effectiveness of 7E-LCI over COSI because the reliability coefficients regarding the pre-test and post-test implementations of SPST were found to be low.

4.3 Conclusions:

The results of the current study revealed a statistically significant interaction effects over the scores of both Skeletal System Conceptual Inventory (SSCI) and Respiratory System Conceptual Inventory (RSCI) but not Circulatory System conceptual Inventory (CSCI). Besides, 7E Learning Cycle instruction improved students' conceptual understanding on the human body system concepts. When the mean scores of experimental and comparison groups compared, the results indicated the effectiveness of 7E Learning Cycle Instruction over COSI on the learning human body systems concepts. 7E Learning Cycle instruction was also appeared to be more effective than COSI with respect to the retention of the learned concepts.

The analysis of motivational variables, however, indicated a general tendency of decrease in students' motivation towards science learning over time. The difference between before and right after the instruction scores for experimental group was not significant while the difference in comparison group was statistically significant. Additionally, after the instruction, the mean scores differ in the favour of experimental group at all of the motivation variables indicating 7E Learning Cycle instruction had a significant effect on students' intrinsic goal orientation, extrinsic goal orientation, task value, self-efficacy and test anxiety variables.

Regarding the learning strategy use, 7E Learning Cycle instruction has an effect on students' elaboration, critical thinking, metacognitive self-regulation, time and study environment, and effort regulation strategies when after instructions mean scores of experimental and comparison groups compared. On the other hand, 7E Learning Cycle instruction has no effect on students' rehearsal, organization, peer learning, and help seeking strategies. Although the mean scores of these variables were higher for experimental group, it did not contribute a significant difference compared to comparison group. What is more, 7E Learning Cycle instruction improved students' elaboration and peer learning strategies use and these improvements contributed significant differences. Besides, it improved students' rehearsal, organization, critical thinking, and self-regulation strategies use but these improvements did not contribute a significant difference.

7E Learning Cycle instruction has found to affect students' beliefs about source of knowledge when the mean scores of groups compared after the instruction. On the other hand, it has no effect on students' beliefs about certainty, development and justification. Additionally, experimental group students' mean scores indicated stronger beliefs than the comparison group students with respect to all of the dimensions although it contributed a significant difference for only source dimension. Moreover, change on the mean scores over time indicated that 7E Learning Cycle instruction improved students' certainty beliefs.

On the other hand, 7E Learning Cycle instruction has not a striking effect on students' science process skills. The both instructions presented to experimental and comparison groups contributed almost the same development on the scores and these changes were not contributed a significant mean difference. Therefore, the current study failed to show the effectiveness of 7E Learning Cycle instruction over the curriculum based science instruction on students' science process skills.

CHAPTER V

DISCUSSION

In this chapter, the results of the present study were discussed in the light of related literature. Before the discussion of the results, brief information about the process of study was presented. Afterwards, the findings related with each variable of the study were discussed under separate headings. A summary of results for each variable was also covered during the discussion under the related headings. The closure of the chapter covers the implications and some recommendations for future research.

5.1 Summary of the Study

The main purpose of the current study was to compare the relative influence of 7E learning cycle instruction and curriculum oriented science instruction on 6^{th} grade middle school students' understanding of human body system concepts, self-regulation, scientific epistemological beliefs and science process skills. In this dissertation, a quasi-experimental design was utilized. Students' self-regulation, scientific epistemological beliefs, and science process skills were assessed twice as pre-test and post-test while their conceptual understanding assessed three times as pre-test, post-test, and follow-up test.

At the outset of the study, students in both experimental and comparison group were administered MSLQ, EBQ and SPST to assess whether two groups differ in terms of collective dependent variables. The treatment covers three topics of human body concepts; Skeletal System, Circulatory System, and Respiratory System. At the beginning of each topic both group students were tested with the conceptual inventory (i.e. SSCI, CSCI and RSCI) that covers the items related with the implemented subject (Time1). The conducted analyses of mixed between within MANOVAs and mixed between within ANOVAs revealed that there were no preexisting differences among the experimental and comparison groups in terms of dependent variables.

During the course of instruction, experimental group students received the 7E learning cycle instruction which involves hands-on and minds-on activities to recall prior knowledge, increase curiosity, engage students to learn, provide them an environment to explore the concepts and explain their understanding, apply their knowledge in new situations, evaluate and connect the content with the following concepts. The instruction followed seven phases designed based on the constructivist views in learning. In the first phase (elicit), the students engaged with a learning task such as probing questions, discrepant events and KWL chart that activates students existing knowledge related with the content. In the second phase (engage) students' focus on the lesson was raised by the active engagement of students in tasks that create interest in the topic, captivate students' attention and promote curiosity. The simple hands-on/midns-on activities given in this phase hold students mentally and physically active by encoring them to connect and organize prior knowledge to initiate new learning. In the third phase (exploration), students dealt with hands-on activities that provided observation of concrete examples, collaborative works, inquiry questions in the mind related with the events, connections between the various information, in addition to the generation, test and modification of hypotheses with the assist of prior knowledge. The teacher acted as a facilitator or coach to encourage students to do inquiry, to connect the classroom instruction with their prior knowledge, and to direct their own learning. In the next phase (explanation) students were asked to explain the recently explored phenomena. The teacher encouraged them to share their thoughts, their observations, experiences, discoveries, and claims in their own words with other students. Then the teacher provided the connection of students' explanations to scientific clarification and highlighted the important concepts. In the following phase (elaboration), additional activities or contexts were presented to deepen and consolidate students' understanding. During this phase, students had the opportunity to relate new information with previous ones and use their recently learned knowledge and skills in additional but similar situations to reach reasonable conclusions. In the next phase (evaluation) the teacher applied various assessment techniques (e.g. poster evaluation, round house diagrams, and conceptual inventories) to assess the students and to have students aware their own progress. In the final phase (extension) students were prepared for next subject in order to connect the acquired information to the incoming subject.

On the contrary, the comparison group was taught based on teacher explanations, questioning, discussion, and knowledge and activities suggested in the textbook. The information and activities suggested in the textbooks were also student-centered aiming to stimulate students' interest and curiosity. The textbook presented daily life examples in each subject and questions to reinforce ideas previous the instruction. However, the activities in the comparison group were conducted in the purpose to justify the explained content by the teacher instead of facilitate exploration of content by students' themselves.

The instructions in experimental and comparison groups followed the concepts in the same sequence as Skeletal System, Circulatory System, and Respiratory System concepts. At the end of each topic, students in both groups re-administered related conceptual inventory to determine the immediate changes and differences among the groups in terms of understanding of skeletal, circulatory and respiratory system concepts (Time2). Following to one-month period of each conceptual inventory implementation, students were again tested using same instruments to determine the influence of two instructions on the retention of concepts (Time3). Additionally, upon the completion instruction regarding the last topic (respiratory system), both groups were post-tested with MSLQ, EBQ and SPST in order to investigate the contribution of instructions on students' self-regulation, scientific epistemological beliefs, and science process skills.

While the results of mixed between-within subjects ANOVAs showed that both groups created substantially different profiles in terms of conceptual understanding of all three topics, the results of mixed between-within subjects MANOVAs revealed different profiles among the groups in terms of self-regulation but not striking differences in terms of scientific epistemological beliefs. Finally, the result of mixed between-within subjects ANOVA regarding the science process skills revealed similar and nonsignificant contributions of instructions. The findings will be discussed in the light of related literature in the next section, which is Discussion of the Results.

5.2 Discussion of the Results

This section provides the summary and discussion of findings aroused in the current study. The findings were discussed separately for each dependent variable by firstly giving the addressed research question, a brief review of result, and the related discussion attributing with the literature. Firstly, the results related with conceptual understanding of human body system concepts will be discussed.

5.2.1 Understanding of Human Body Systems Concepts

Under this heading, the findings addressing the main research question Q.2. which is “What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students’ understanding of human body systems concept (Skeletal System, Circulatory System, and Respiratory System)?” was discussed.

Students’ conceptual understandings in Skeletal System, Circulatory System, and Respiratory System concepts were investigated separately. At the beginning of the instruction on each topic, students were administered the related conceptual inventory to investigate whether there is a significant mean difference between experimental and comparison groups with respect to related conceptual understanding. In the analyses of all three concepts, no statistically significant mean difference across groups was found before the instruction (Time1). Considering the Skeletal System concept, the mean scores of students in experimental group (M= 2.94) and comparison group (M= 2.54) revealed that both group students have similar conceptual understanding. Similarly, students in experimental (M= 1.85) and comparison groups (M= 1.54) reported comparable scores with respect to understanding of Circulatory System. The mean scores of students' conceptual understanding on Respiratory System was also indicated a similarity between experimental group (M= 2.00) and comparison group (M= 1.17). The investigation of descriptive mean scores in line with the sub-research question Q.1.1. which was "What is the relevant prior knowledge of 6th grade students in skeletal system, circulatory system, and respiratory system concepts?" reveals low scores concerning each topic. Considering the minimum and maximum scores that can be obtained from the conceptual inventories (min= 0, max= 10), students had pretty low scores in all subjects which indicates that they have knowledge deficiencies and scientifically incorrect conceptions concerning human body system concepts. In the literature, it was also found that students hold naïve ideas and difficulties in understanding of skeletal system (Caravita & Falchetti, 2005), circulatory system (Arnaudin & Mintzes, 1985; Sungur, Tekkaya & Geban, 2001), and respiratory system (Alparslan, Tekkaya, & Geban, 2003).

After the 7E learning cycle instruction and curriculum oriented science instruction (Time2) on each topic, students were administered the related conceptual inventory to investigate the relative effects of instruction on conceptual understanding. The results revealed that both group students improved their understandings in all three subjects from the beginning of the instruction towards the end of the instruction. The only unsignificant result in within group comparisons was emerged in comparison group with respect to skeletal system concept. What is more, in all topics, scores of students in experimental groups were higher than the comparison group. However, significant mean differences were found among the groups in terms of their scores in skeletal system concept and respiratory system concept, but not in circulatory system concept. The differences between the groups can be explained by the nature of the treatment. Thus, learning cycle provided better knowledge construction in students. In line with the development theory of Piaget, knowledge construction in learning cycle instruction can be explained as following in the light of related literature (Abraham & Renner, 1986; Marek, Eubanks & Gallaher, 1990; Balci, Cakiroglu & Tekkaya, 2005). The first phase of the cycle activates students existing knowledge and prepare students to construct connected knowledge structures. For example, in the current study, students’ substantial knowledge were recalled by probing questions and KWL charts, and students were encouraged to use them into interpretation of new experiences in following phases. Students assimilate the new concept in the exploration phase in addition to reevaluate their existing conceptions to be able to interpret the new phenomena. In the present study, exploration phases mostly covered hands-on investigations towards the organs in order to provide the understanding of structure and function. Students were able to assimilate the compatible knowledge with their existing knowledge such as four chambered structure of the heart during their observation, however they realized their knowledge is insufficient to explain how the blood moves through these chambers. At this point, the cognitive conflict rose in students existing mental structures and new situation causes disequilibrium which the individual avoid to stay. To be able to reach equilibrium, they accommodate the concept in an environment that they are allowed to explain and discuss their ideas in the explanation phase based on the data obtained from the exploratory activities. This phase is the essential to allow students to accommodate through the discussion and interpretation of data. The teacher let the students to share their ideas and helped them to acquire the scientific terminology in the topic. In the elaboration phase, both assimilation and accommodation occur since the students organize or relate the newly developed concept to prior concepts or daily life applications. The students in the experimental group of this study prepared models and posters as well as completed the KWL chart in this phase which supported them to apply new gathered knowledge, realize their own learning, and resupply the shortage in their conception. Evaluation phase also makes students to realize the change in their knowledge and assess their own conceptions to make necessary arrangements. The treatment of this study had students to fill out a roundhouse diagram in this phase to provide assessment of their learning not only by teacher but also by students' themselves. Finally extension phase prepare student to connect the acquired knowledge to following new phenomena. Considering these characteristics of learning cycle, the higher acquisition and also the retention of concept is anticipated. Indeed, development of understanding over time and the superiority of learning cycle instruction over curriculum oriented science instruction were reported by many studies in the literature. For example, Cakiroglu (2006) and Balci et al. (2006) reported significantly better performances after 5E learning cycle instruction on students' conceptual understanding in photosynthesis and respiration subject compared to traditional instruction. Moreover, Kaynar, Tekkaya and Cakiroglu (2009) found that students who instructed with 5E learning cycle instruction substantially outperformed over comparison group in terms of cell concept achievement.

In the present study, however, the unsignificant result found in the topic of circulatory system is not consistent with the related literature (Sadi & Cakiroglu, 2010; Cardak, Dikmenli, & Saritas, 2008). In their study, Sadi and Cakiroglu (2010) reported significant mean differences among the groups receiving 5E learning cycle instruction and traditional instruction in the favor of learning cycle with respect to their conceptual understanding of circulatory system in high school level. Cardak et al. (2008) found same results in their study conducted with middle school students. In the present study, students in both groups improved their understanding of circulatory system concepts similarly after the instructions.

On the other hand, the superiority of 7E learning cycle instruction on the conceptual understanding of circulatory system concepts emerged when the follow-up test results compared among the groups. Students were re-administered related conceptual inventories one month-later the completion of each topic (Time3) and the results revealed significant mean differences among experimental and comparison groups in terms of their circulatory system and respiratory system concepts. Students who received 7E learning cycle instruction outperformed in all three topics compared to the students who received curriculum based science instruction. The comparison of mean scores between Time1 and Time3 in both groups revealed a significant improvement in all topics except the comparison group in respiratory system. These results implied that 7E learning cycle instruction is more effective in retention of the learned concepts compared to curriculum oriented science instruction. Considering the features of learning cycle instruction revealing this result is sensible. The instruction activates students' prior knowledge and misconceptions, provides and resolves conflicts between the existing knowledge structures and new information, and then facilitates the scientific explanations. In such learning environments students actively construct their own knowledge structures while assimilating the compatible knowledge, dealing with cognitive conflicts, and modifying the existing structures to build more knowledge on them. As stated by Conway, Cohen and Stanhope (1991), the knowledge structures that developed during the acquisition mediate the retention of learned concepts. The higher retention of the concept as found in the present study may be the indication of that the 7E learning cycle supports students' knowledge construction and deeper learning. Compatible findings with the current results were also reported in the literature (Yilmaz, Tekkaya & Sungur 2011; Odom & Kelly, 2001; Aydemir, 2012). For example, while studying the effects of 5E learning cycle and traditional instruction on knowledge acquisition in solubility equilibrium Aydemir (2012) found that 5E learning cycle model appeared to cause a statistically significantly better acquisition and also retention of knowledge. Similarly, Yilmaz et al. (2011) reported the retention of genetic concepts in 8th grade students were higher in students instructed with prediction/discussion-based learning cycle compared to traditional instruction.

Moreover, although the students' scores in follow-up tests in each topic as decreased slightly compared to their after instruction scores expected, this result was appeared to be reverse in circulatory system topic. Experimental group students reported an increase from Time2 towards Time3 in their understanding of circulatory system. What is more, experimental group students showed a significant improvement in circulatory system concept from Time1 to Time3 more than that the comparison group did. This finding has important contribution to relevant literature. As a considerable amount of researchers point out, the students have difficulties to relate the organs in a system and to connect the body systems with each other (Arnaudin & Mintzes, 1985; Reiss & Tunnicliffe 2001; Cuthbert, 2000; Ozsevgenc, 2007). They mostly fail to form mental models reflecting the interrelationships among body systems and the associated organs. Moreover, López-Manjón and Postigo (2005) reported students are unable to explain relationship between the heart and the lungs correctly. The participants of this study also had misconceptions concerning the function of heart and the function of lungs prior to the instructions However, the scores of the tests after the instruction may be interpreted as students in experimental group were more successful to eliminate these misconceptions. Therefore, the findings of the present study indicated that 7E learning cycle instruction is effective to provide a whole understanding towards the body systems. Students' circulatory system conceptual understanding continued to improve because they were supported to develop respiratory system concepts over their circulatory system concepts by recalling their conceptions that gained in previous subject in 7E learning cycle instruction. Students were encouraged to reflect their ideas about the function of circulatory system during the respiratory system instruction and the activities presented in exploration and explanation phases were designed to facilitate the recognition of the links between these two topics.

In general perspective, the findings regarding the data from all three conceptual inventories supported the claim that 7E learning cycle is more effective than curriculum oriented science instruction to improve students' conceptual understanding related with human body systems. Moreover, superiority of 7E learning cycle over curriculum oriented science instruction in maintaining the acquired knowledge over time was observed. Comparison of mean scores indicated clear patterns of higher conceptual understanding for 7E learning cycle students than curriculum oriented science instruction students after the instructions as well as the promotion in their knowledge from the beginning to the end of the study. The retention of learned human body systems concepts in 7E learning cycle classes was also higher at all three analyses of conceptual inventories. The general findings emerged from this study are parallel with the results of other studies in terms of defending the idea that learning cycle model forms better attainment and higher retention of concepts (Musheno & Lawson, 1999; Ates, 2005; Ceylan & Geban 2009; Aydemir, 2012). Considering the features of the learning cycle, these findings are appeared to be as expected outcomes. In learning cycle instruction, students started each topic by recalling their existing ideas regarding the subject matter and reflecting the concepts that they wonder to learn more. Students followed by the activities that warm up students about the concept, connect the subject with daily life, and raise the interest of students. Students engaged in observations and investigations with minimal guidance of the teacher to acquire concrete experiences and dissatisfied with their existing conceptions to interpret these experiences. These investigations were mostly including the hands-on activities and dissections such as exploration of chicken bones or dissection of heart and lungs. These kind of activities are reported in the related literature as enhancing the knowledge and facilitating concrete understanding in abstract and complex concepts (Moore, 2001; Lee, 2001; 2004; Jones et al., 2004, Ates, 2005). During their exploration with such activities, students negotiated the scientific conceptions with their peers and teacher through collaborative work in small groups and whole class discussions. The social interaction in the classroom environment is important in learning cycle since the knowledge gained through negotiation of the meanings and ideas. In the literature, the better acquisition of scientific concepts in human body systems were reported when students supported with the classroom environments that promote student-student and student-teacher interactions, that encourage students to generate questions and seeking solutions, and that require teachers act as to encourage and challenge students to construct their own knowledge (Aydın & Balım, 2009; Alparslan et al., 2003; Sungur et al., 2001 Hymelo, Holdon & Kolonder, 2000; Alkhawaldeh, 2007). Teacher, in the present study, mostly directed probing questions to lead students to figure out the scientific conception own their own instead of giving answers. Students received the scientific terms from the teacher and encouraged to use them during their explanations but they constructed their own understanding through their experiences in activities and tasks.

On the other hand, students who received the curriculum oriented science instruction acquired the knowledge driven from teacher explanations and textbook readings. The implemented curriculum was developed in 2006 embedding a perspective to help student gain “learn how to learn” skills. For that purpose, the instructions and activities suggested in the textbooks are student-centered instead of teacher-centered and aim to stimulate students’ interest and curiosity. The information provided in textbook starts the topic with the related daily life examples and directs questions that may reinforce students’ interest towards the concept. During the instruction, the teacher mostly selected a volunteer student to read the information in the textbook aloud and supported the reading with additional explanations to deepen students’ understanding. Teacher explained the information in lecture format but sometimes let the students to conduct small activities suggested in the textbook, to observe the demonstrations presented by themselves or volunteer students, and to watch the animations about the concept. However, the aim of the mentioned tasks was justification of previously explained information instead of knowledge construction. That is, students were informed about the expected results of experiments or outcomes of the activities before conducting them. They have been already instructed about the subject matter prior to the activities which that prevents the discovery of related ideas from the tasks. The questions asked by teacher were mostly direct-questions that require simple answers about the concept. Consistent with the present study, several national and international studies in the literature empirically showed that application of these kinds of traditional teaching approaches in classrooms resulted in lower understanding compared to learning cycle (Musheno & Lawson, 1999; Akar, 2005; Cakiroglu, 2006; Balci et al., 2006).

Regarding the results of the current study, 7E learning cycle was effective compared to curriculum oriented science instruction when we considered the students’ understanding and retention of human body system concepts. However the mean scores reported in conceptual inventories immediately after the instruction as well as the one-month later revealed that students' in both experimental and comparison groups still hold some misconceptions. Considering the maximum score that possible to get in the conceptual inventories (max= 10) none of the group means in all three subjects were able to reach even to the middle score after the instruction as well as one-month later. Although the students instructed with 7E learning cycle reported higher scores, which indicates lower misconceptions, and reported better development in scores, which indicates eliminating the misconceptions, than the students instructed with curriculum oriented instruction, a striking influence of 7E learning cycle on the misconceptions as expected by the researcher was not observed. Various misconceptions remained in the students' minds even after instruction. This finding implied the robustness of students' misconceptions to change. As also argued by the other researchers, the transform of scientific understanding in the course of instruction is possible to only some extend since the existing conceptions are powerful and resist modifying or refining completely (Driver & Easly, 1978; Chi; 1992; Sungur et al., 2001; López-Manjón & Angón, 2009). Similar results in terms of the remained misconceptions after the learning cycle instruction was also found in the studies conducted by Kaynar, Tekkaya and Cakiroglu (2009) and Aydemir (2012). In the current study, however, students in comparison group reported lower scores accounting for more misconceptions compared to students in experimental group. This finding is also compatible with the previous research that support the claim that compulsory education which directs the traditional methods in teaching is not promising to eliminate the existing misconceptions or to provide meaningful learning (Arnaudin & Mintzes, 1985, 1986; Sungur et al., 2001; Pinarbasi, Canpolat, Bayrakceken & Geban, 2006; Aydemir, 2012).

5.2.2 Self-Regulation

The current study also compared the contribution of 7E learning cycle instruction and curriculum oriented science instruction on students' self-regulation in terms of motivation and learning strategy use. The addressed main research questions in this part were Q.3. and Q.4. which were "What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy for Learning and Performance, and Test Anxiety)?" and "What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' perceived learning strategy use (Rehearsal, Elaboration, Organization, Critical Thinking, and Metacognitive Self-Regulation)?

Students' motivation and learning strategy use were measured by the administration of MSLQ before and after the completion of 7E learning cycle instruction and curriculum based instruction. At the outset of the study, no statistically significant mean difference across groups was found before the instruction (Pre-test) in terms of their scores on motivational variables and learning strategies variables. The descriptive investigations of pre-test scores were conducted as in line with the sub questions Q.1.2 and Q1.3 which were "What are the 6th grade students' perceived motivation (Intrinsic Goal Orientation, Extrinsic Goal Orientation, Task Value, Comparison of Learning Beliefs, Self-Efficacy for Learning and Performance, and Test Anxiety)?" and "What are the 6th grade students' perceived use of learning strategies (Rehearsal, Elaboration, Organization, Critical Thinking, and Metacognitive Self-Regulation)?" The findings indicated that mean scores for the experimental and comparison groups were above the scales' midpoints indicating quite high levels of motivation and learning strategy use in science learning. Previous studies that surveyed elementary Turkish students also demonstrated high motivation and learning strategy use in science course (Ozkan, 2008; Kahraman & Sungur, 2011; Yerdelen, 2014).

After the completion of instructions, significant differences were found between experimental and comparison groups with respect to students' perceptions of intrinsic goal orientation, extrinsic goal orientation, task value, and self-efficacy in favor of students instructed with 7E learning cycle instruction. Between groups analyses showed that students instructed through learning cycle perceived themselves to be more intrinsically and extrinsically goal oriented. That is, compared to the students in curriculum oriented instruction classes, students in the 7E learning cycle classrooms more attempted to engage the learning process with the aim of not only to acquire the information, understand the material, or satisfy the need for curiosity but also to take external rewards such as receiving a good grade or compliment. Additionally, they perceived science learning as interesting, important and useful more than comparison group students. They also reported higher self-efficacy in their science learning compared with comparison group students. In other words, they appeared to perceive the science as more interesting, important, and useful and they seemed to hold more positive beliefs in terms of existing ability to accomplish a task in science than the comparison group students. More specifically in this study, the activities in 7E learning cycle was designed to challenge students in an optimum difficulty level and workload, to provide the link between classroom science with daily life, to raise the sense of independence and control in the classrooms, to enable students to realize their own learning and progress, to give opportunity collaboration as well as individual work. For example, engagement phase of each learning cycle presented an interesting and daily life activity such as finding the heath beat by using a stethoscope. In the following phases students made individual observations of organs and shaped an understanding through the discussions in groups and in whole class. The evaluation of the students focused on their progress rather than the comparison with peers in the class and teacher gave feedbacks that foster students self-monitoring skills and awareness towards their learning. All these features of learning cycle instruction helped students realize importance and usefulness of science instruction improving their task value beliefs. Additionally, implementation of challenging but attainable tasks, evaluation strategies based on individual progress, presence of small group works, and autonomy support encourage students to adopt intrinsic goals. In the present study, the students in experimental group were requested to state what they want to learn about the topic at the beginning of learning cycle approach. Students listed the concepts that they wonder to learn more and the teacher concerned these requests to ensure they have learnt what they curious about during the instruction. Moreover, in the engagement and exploration phases students had the opportunity to explore the concept without given a conceptual knowledge from the teacher. This kind of situations help students to adopt intrinsic goals such as learning to satisfy the curiosity the need for challenge or the desire to master the content. Parallel with the current study, the studies conducted by Aydemir (2012) and Ceylan (2008) also supported the positive effect of 5E learning cycle model on students' intrinsic goal orientation, extrinsic goal orientation, self-efficacy, and task value. Indeed, the instruction implemented in experimental group reflected the characteristics of learning environment supportive for the improvement in task value and adaptive goals as explained by Epstein (as cited in Pintrich & Shunk, 2002).

On the other hand, experimental group students in this study appeared to perceive extrinsic goal orientation higher than the comparison group students. This finding can be attributed to the existence of a competitive climate in classrooms and exam oriented education system in Turkey. Turkish elementary students enter various standardized nationwide tests during the transition at high school. These multiple choice tests evaluate students' knowledge in each grade and compare their scores to enroll them high schools in different quality. In order to get an acceptance at a qualitative high school, which may lead them better universities after graduation, students strive to get higher scores from the tests. The test orients students to learn the contents to achieve better than the others. Although there was not an orientation in the 7E learning cycle instruction classes towards the extrinsic goals, students appeared to hold their goal orientations originating from this kind of an education system. Considering the duration of the treatment, six week, though not too short, might not be enough to influence students' extrinsic goal orientation positively.

In addition, the significant mean difference between groups with respect to perceived self-efficacy for learning might be due to the fact that 7E learning cycle model supports a student-centered environment that encourage active participation of students, engagement in challenging activities, and experiences of successful outcomes. As also supported by several researchers, the most influential source of self-efficacy is the perceived results of student's own performance or their mastery experience (Pintrich & Shunk, 2002; Pintrich & Linnenbrink, 2003; Ward & Lee, 2006; Usher & Pajares 2009). At the elaboration and evaluation phases of each learning cycle instruction students had the opportunity to apply the newly acquired knowledge to create a product such as a model or poster and to present in class which results the awareness in own learning progress and the experience of accomplishment. This result empirically supports the claim that students perceive more confidence in themselves to attain within a specific task when they supported with a challenging environment that enables them to accomplish the task successfully (Linnenbrink & Pintrich, 2003). Contrary to the significant findings in terms of between group comparisons, the current study failed to find significant mean differences among groups with respect to students' perceived control of learning beliefs and test anxiety. On the other hand, the comparison of change on these variables over time also supports the superiority of learning cycle instruction over curriculum oriented science instruction.

Considering the change in students' motivation variables over time, the current study revealed an important finding: There was a tendency to decrease on the scores from pre-test to post-test measures for both groups, except for test-anxiety which indicates an increase which were statistically significant for students instructed with curriculum oriented science instruction. 7E learning cycle instruction, on the other hand, did not contribute a significant mean difference over time. These results implied that students' motivation towards science learning tends to decrease across time and the curriculum oriented science instruction has a detractive effect on this situation while the 7E learning cycle has a balancing effect. The decrease on students' motivational perceptions over time was supported in both national and international studies (Gungoren, 2009; Yavuz-Gocer, Sungur & Tekkaya, 2011; Guvercin, Tekkaya & Sungur, 2010; Eccles, Wigfield, Harold & Blumenfeld, 1993; Lepper, Corpus & Iyengar, 2005; Metallidou & Vlachou, 2007). Distinctively from the current study, these studies asserted the changes in students' motivation variables over years by conducting the comparisons based on grade level. Considering the context of Turkey, for example, Gungoren (2009), Yavuz-Gocer et al. (2011) and Guvercin et al. (2010) administered MSLQ to students from 6th to 8th grades and explained a negative relationship between elementary students' motivation and grade level indicating a decrease in perceived motivation as the grade level increases. The possible reasons of this situation were discussed as the science classrooms in which traditional teaching methods and the teacher-centered learning environments were employed and reduced the perceived student autonomy. Another possible reason was discussed as competitive and exam oriented educational system in Turkey. As recommended by other researchers, it is possible to counterbalance the negative changes in students' perceived motivational variables through generating a learner-centered environment in classrooms that appropriate to students' developmental needs (Urdan & Midgley 2003; Meece, Herman & McCombs, 2003). Considering the findings of the current study, 7E learning cycle instruction can be suggested as a possible teaching strategy to prevent the incline in the elementary students' motivation in science.

Furthermore, regarding the results of the study that 7E learning cycle instruction was effective over curriculum oriented instruction when we considered the students' learning strategy use. The findings revealed statistically significant mean differences between groups after the instructions (post-test) with respect to learning strategies of elaboration, critical thinking, self-regulation, time and study environment, and effort regulation in the favor of 7E learning cycle instruction. These findings were in congruence with the previously reported findings. For example, higher use of elaboration strategies with learning cycle instruction was found in the comparison studies conducted by Ceylan (2008), Yılmaz (2007) and Aydemir (2012). In these studies, the nonsignificant results in other learning strategies were attributed to limited time period of the treatment implementation. However, the time period of the current study was longer than the mentioned studies which may give a clearer picture about the effectiveness of learning cycle on students' learning strategy use. The phases of learning cycle consist of activities that enhance elaboration strategies. The beginning phases concern students' existing knowledge, while the following ones engage students to integrate and connect new knowledge with the previous ones. As argued by Ceylan (2008), in the elaboration phase of learning cycle, students' learning was supported by the application in new situations in which they transfer and relate the recent knowledge in different context. These principles also correspond to critical thinking strategy which refers learners' ability to apply acquired information in a new situation to solve a problem or to make a decision (Pintrich et al., 1991). The strategy also includes reflecting critical evaluations to ideas. In this respect, the study of Mecit (2006) presents important results which support the claim that 7E learning cycle instruction encourages critical thinking skills more than the curriculum driven instruction. In her study, she investigated the comparative effect of science instructions on middle school students' critical thinking skills and found significant mean differences arousing from instructions. She discussed that the social interaction in the 7E learning cycle environment facilitates students to learn how to think better, to reason and criticize into subject matter, to be open to alternative views, and to justify their own opinions.

There are no existing studies that support the effectiveness of learning cycle on students' metacognitive self-regulation, effort regulation, and time and study environment. However, other constructivist teaching methods such as problem-based learning was claimed to foster students' mentioned strategies more than the traditional teaching methods. For instance, after finding significant contribution of problem-based learning on metacognitive self-regulation Sungur and Tekkaya (2006) discussed that the small group works while dealing with ill-structured problems helps students to reflect on their own thinking, revise their ideas and realize the gaps in their thoughts which is a metacognitive process. In another study, the findings reported by Demirel and Arslan Turan, (2010) also supported the claim that problem-based learning fosters students' metacognitive awareness through let them strive to solve the problems. Moreover, in their study Tosun and Taskesengil (2012) explained that students' self-regulatory skills can be enhanced by problem-based learning in which the students had the opportunities to associate their existing knowledge with recently acquired information to hypothesize multiple solutions to problem situations.

Similar with the problem-based learning instruction, the tasks directed during the whole process of learning cycle encourage students to permanently reevaluate their experiences and knowledge (Balci et al., 2006). As emphasized by Perry, VandeKamp, Mercer, and Nordby (2002), students engage in self-regulatory strategies including goal setting, planning, monitoring, regulating and evaluating while striving a complex task that provides opportunities to make and perform decisions, to observe the progress, and finally evaluate the results. In this process, the negotiation between teacher and student as well as the interaction, sharing, and collaboration between the peers contribute an insight towards the one's own learning. Considering the 7E learning cycle, the social interaction is an important feature that provides the meaningful learning. The small group works and whole class discussions enable students to criticize themselves, discuss the status of their conceptions and realize the deficiencies in their own knowledge. The teacher, on the other hand, guide students by asking probing questions and provides enough time to students for their exploration about the concept. The feedbacks, clarifications and corrections provided by teachers also support students' self-regulatory skills and their beliefs in the effort exertion results in positive outcomes. For example, through the comments received in the elaboration and evaluation phases as well as their own self-evaluations students realize the improvement in their knowledge and experience the consequences of their employed effort towards the task. Moreover, the tasks given in especially elaboration phase endorse students to adjust their own study time by scheduling and planning as well as to arrange the study environment well organized and free from distractors and enable to work with peers. For instance, students prepared posters in which they decided the design to apply and the information to cover on it, planned the schedule to accomplish the task until the due date, and arranged places to work together at both inside and outside of the school.

Considering the developmental effect of learning cycle on students' learning strategy use the present study revealed statistically significant change for the variables of elaboration, effort regulation, and peer learning with respect to experimental group scores while there were statistically significant change on the scales of organization, self-regulation, time and study environment, effort regulation, and peer learning compared to comparison group scores. In the experimental group, students perceived themselves as using elaboration and peer learning strategies more after they are instructed with 7E learning cycle instruction than before. As mentioned before, the activities that students engage during the seven phases of learning cycle requires students to build internal connections between the new information as well as the existing ones. Moreover, they support the use of strategies such as paraphrasing or summarizing. For example, most of the investigations conducted in exploration and explanation phases requested the students to explain their ideas with their own word not only in written form on the worksheets but also aloud during the discussions. Students encouraged to relate the materials in the activities to their prior knowledge in order to interpret the new situation. Additionally, 7E learning cycle instruction appeared to have a relatively more significant effect on increasing students' peer learning compared to the curriculum directed science instruction since the students were conducted more small group works and assignments.

The negative influence of curriculum oriented science instruction over students' strategies regarding metacognitive self-regulation and time and study environment was appeared in the findings of the current study. Comparison group students' scores were decreased over time and this change was contributed a significant mean difference. The present findings of the study supports the claim of Lan (1998) that defend the traditional instruction is inefficient in developing and practicing of many learning strategies since students have no possibility to involve in self-regulation. The only significant and positive contribution of curriculum base instruction was revealed on organization strategy use, which can be attributed to students' textbook readings during the instruction. In other words, students in comparison group were appeared to become more tended to use strategies such as clustering, outlining, and selecting the main idea from text since they mostly asked to read aloud the texts given in the textbooks in class. After readings, the teacher highlighted the important parts given in the text and added more explanations for deeper understanding. Although the mean scores of the experimental group students also increased over time, it failed to reveal a significant difference. Additionally, as an unexpected finding, effort regulation of students was decreased over time for both groups. However, the decrease on the comparison group classes is more striking. Therefore, it can be concluded that students have a tendency to lower to control their effort and attention when there are distractions or difficulties however 7E learning cycle instruction might have a positive effect to balance this decline.

On the other hand, this study could not confirm the relative influence of instructions over students' rehearsal and help-seeking strategies. Although the mean scores of experimental group were higher than the comparison group in the after scores of both strategies, a statistical difference did not arouse from nature of different instructions.

Overall, considering the findings of the study 7E learning cycle was effective compared to curriculum oriented science instruction concerning student self-regulation. The science instruction designed based on the principles of 7E learning cycle model is promising to overcome the decrease on students' motivation in science learning. Moreover, it has significant effect on students learning strategy use. The findings aroused in the present study supported the significant role of classroom environment and instruction in students' self-regulation as also pointed out by Pintrich, (2005) and Meyer and Turner (2002). Moreover, the findings were in line with the recommendations of Paris and Paris (2001) concerning the features of learning environment to promote self-regulation. As stated by the researchers, self-regulation is possible to be enhanced in a classroom that allow students to be autonomous, to seek challenges, to reflect on their own progress, and to take responsibility and pride in their accomplishments. Similarly, according to Corte, Verschaffel and Masui, (2004), the necessary factors in a classroom to foster self-regulation include social interaction, active participation and construction of knowledge, and enabling the transfer of knowledge in authentic situations. The findings of the present study supported these recommendations since 7E learning cycle instruction provided such environment in science class and appeared to have a contribution on students' self-regulation.

Moreover, the relative influence of the self-regulatory strategies on academic performance was clear as extensively cited by various researchers in the literature (Pintrich, 1999; Pintrich & De Groot, 1990; Eshel & Kohavi, 2003; Hwang & Vrongistinos, 2002; Yumusak, Sungur & Cakiroglu, 2007). Considering the importance of these strategies on understanding, it was not surprising to obtain the positive influence of 7E learning cycle instruction on students' conceptual understanding as discussed in the previous part since it also developed students' learning strategy use.

5.2.3 Scientific Epistemological Beliefs

In this section, the discussion was directed towards the findings of the main research question of Q.5. which was "What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' perceived epistemological beliefs (Source, Certainty, Development, and Justification)?"

Students' scientific epistemological beliefs were measured by the administration of EBQ before and after the completion of 7E learning cycle instruction and curriculum based instruction. At the outset of the study, there were no preexisting differences across experimental and comparison groups in terms of their scores in all epistemological beliefs dimensions. The descriptive investigations of pre-test scores were investigated in line with the sub-research question of Q.1.4 which was "What are the 6^{th} grade students' perceived epistemological beliefs (Source, Certainty, Development, and Justification)?" The results indicated that mean scores for the experimental and comparison groups were above the midpoint of the scales accounting for naïve beliefs towards source and certainty knowledge while sophisticated beliefs towards development and justification of knowledge. That is, students appeared to naïvely believe that the knowledge relies on the external authorities, there is an absolute truth and there is only one right answer. This finding was consistent with Sadic, Cam and Topcu's (2012) conclusion that elementary Turkish students tend to believe simple and certain knowledge as well as the mastery of authority. On the other hand, students in the present study hold sophisticated beliefs towards the changing nature of science and the role of experiments to evaluate knowledge. These results were compatible with the findings of the study conducted by Boz, Aydemir and Aydemir (2011). In their study, 6th grade students were reported as holding sophisticated beliefs in justification and development of knowledge similar with the present study. However, inconsistent with this study, students were appeared to have sophisticated beliefs in combined dimension of source and certainty of knowledge in the study of Boz and her colleagues.

After the completion of instructions, the analysis of between group differences based on post-test scores illustrated a significant mean difference only in terms of source of knowledge beliefs in the favor of experimental group. More specifically, according to the results, students instructed with 7E learning cycle instruction appeared to rely on authority as the source of the knowledge, such as teachers or textbooks less than students who received curriculum oriented science instruction. This result was as expected because students in the experimental group were active constructers of knowledge rather than being passive receivers from teacher or textbooks. They also were encouraged to associate the knowledge with other information as well as with their own prior experiences. The instruction was student-centered and the teacher supported the students to control their own knowledge construction and perceive the autonomy in the class. On the contrary, students receiving curriculum oriented science instruction was taught based on teacher explanations, questioning, discussion, and knowledge and activities suggested in the textbook. The activities conducted in the class mostly aimed to justify the previously learned information instead of knowledge construction. Therefore, the facilitator role of teacher in the 7E learning cycle class and active participation of students in learning process were possible reasons for higher sophisticated beliefs in the source of knowledge and less reliance on authorities in experimental group than comparison group. Actually, in the related literature, Saunders, Cavallo and Abraham (1999) reported higher sophisticated beliefs in students exposed more inquiry in chemistry laboratory compared to students exposed less inquiry. They suggested that teachers in less inquiry instructions may orient students to endorse the idea that knowledge transmitted to them rather than gained through direct experiences. Similarly, Smith, Maclin, Houghton and Hennessey (2000) found out that students instructed with constructivist classroom approaches hold more sophisticated epistemological beliefs compared to students in traditional classroom. However, the current study failed to reveal the significant differences in the effectiveness of instructions on the students' beliefs in certainty, development, and justification of knowledge. The possible reasons of finding will be discussed after the discussion of within group findings.

Regarding the influence of instructions on the development of epistemological beliefs, descriptive statistics indicated decrease on the scores of both groups over all four of the dimensions when we consider only the mean scores. In other words, students' in experimental and comparison group become more sophisticated in the beliefs of source and certainty of knowledge while become more naïve in the beliefs of development and justification of knowledge. Similarly, the findings reported in the study of Boz et al., (2011) considering the Turkey context demonstrated consistencies with the findings of this study. The authors applied the same questionnaire utilized in the present study to the sample of 427 students from 4^{th}, 6^{th} and 8^{th} grades which instructed with curriculum oriented instruction. They reported a negative change on students' epistemological beliefs over years indicating a movement towards less sophisticated beliefs in development and justification of knowledge as they continue through their elementary education. Regarding the combined dimension of source/certainty they reported an increase over time but it was still naïve considering the reported mean scores. In another study from Turkey context, Sadic et al. (2012) investigated the scientific epistemological beliefs of 160 students from 4^{th}, 6^{th} and 8^{th} grades via their self-responses to the questionnaire developed by Schommer-Aikins and her colleagues (2000). The findings of the study implied a movement towards more sophisticated ideas in terms of certainty of knowledge and reliance of authority over years.

The results of inferential statistics concerning the development of epistemological beliefs, on the other hand, revealed that the statistically significant changes over time was found in the certainty dimension with respect to only experimental group students' scores while the changes in development and justification dimensions were found to be significant for both group students. Reflecting on certainty dimension, 7E learning cycle instruction appeared to influence students significantly to develop more sophisticated ideas such as the existence of multiple truth and complex nature of knowledge. On the other hand, the curriculum oriented science instruction did not result in a significant effect although it also developed students' beliefs towards more sophisticated ideas. The findings regarding the improvement in beliefs of certainty are consistent with the previous studies. For instance, Conley and her colleagues (2004) found out that inquiry-based instruction lead to significant gains in middle schools students' beliefs for source and certainty of knowledge indicating more sophisticated beliefs. They attributed this finding to the instruction that provide less reliance on authorities (eg. teacher, textbook) and emphasis on the doubts about the certainty of knowledge. Similarly, Tolhurst (2007) explained after the completion of course that designed based on active learning through web-supported independent activities as well as small group workshops, undergraduate students reported a trend to reduced beliefs on seeking only one right answer. Another study reporting more sophisticated results over certainty belief after a constructivist instruction was carried out by Ogan-Bekiroglu and Sengul-Turgut (2012) investigating the high school students' epistemological belief development. The authors concluded that students' epistemological beliefs can change and improve in higher levels through constructivist learning experiences.

On the other hand, the findings revealed a similar and negative change in development and justification of knowledge in the students of both groups over time. In other words, two instructions did not indicate an advantage over each other in terms of influencing students' ideas towards the science as a concrete or evolving subject in addition to the importance of experiments to justify knowledge. Both group students reported a parallel decrease over time indicating a movement towards less sophisticated understanding towards related dimensions.

As a conclusion, the development of epistemological beliefs through 7E learning cycle instruction was not found to be as effective as it was hypothesized at the outset of the study. Prior to the implementation, it was expected that students instructed with 7E learning cycle will develop sophisticated epistemological beliefs more than the students instructed with curriculum oriented science because they engaged with historical stories that emphasize the development and evolvement of scientific knowledge over time, the necessity of experiments on justifying the scientific knowledge, the existence of multiple truths, and the possibility of directing different ideas and conclusions on same subject by different scientists. They also engaged some activities that emphasize the subjective nature of knowledge. As acknowledged by Abd-El-Khalick and Lederman (2000), beliefs towards scientific knowledge can be developed in two ways; one is implicit ways such as using group learning that they can discuss and share ideas towards inquiry activities with their peers while the other is explicit ways like application of elements from the history and philosophy of science. Utilizing both of the strategies that suggested by Abd-El-Khalick and Lederman, the present study, however, only contributed significant but not striking influences of 7E learning cycle on students' source and certainty of knowledge beliefs. Consequently, the result of the current study might provide evidence to Sandoval's (2005) contention, which directs a different suggestion than the others, that students' scientific epistemological beliefs are developed in consequence of their own epistemic practices in generation and judgment of knowledge claims. Accordingly, students need to deal with epistemological practices similar to scientists when they learn science to be able to develop sophisticated beliefs. In 7E learning cycle instruction, explaining the epistemological practices of scientists through the short historical stories was not sufficient to develop the sophisticated understandings over complex and evolving nature of scientific knowledge and how individuals approach and evaluate the knowledge claims. On the other hand, the process of 7E learning cycle instruction was significantly effective to develop the sophisticated ideas in terms of source and certainty of knowledge since the students experienced this situation during the whole process of learning cycle instead of explicitly receiving this epistemic information. Furthermore, Conley et al. (2004) reported that the effect of inquiry based instruction in science on development of beliefs regarding justification and development of knowledge in middle school students were not significant when their achievement and socio economic status were entered as covariate in the analysis. Moreover, the authors discussed the implementation process of treatment and predicated the nonsignificant results along development and justification to the limited opportunities that given students to argue about their ideas using evidence and to reflect on their investigations. Developing claims, generating evidences to support these claims or refute other claims, and using evidences again to support or refute the directed claims in debates raises epistemological beliefs during the argumentation (Sandoval & Millwood, 2008). Because the nature of the content utilized in the current study, it was unlikely possible to generate debates in the topics that enable students develop claims and argue about their own claims. Consequently, the present study could not find enough evidence to support that the 7E learning cycle instruction did enhance middle school students' scientific epistemological beliefs.

5.2.4 Science Process Skills

The discussion of findings addressing the main research question of Q.6. which was "What is the relative effect of 7E learning cycle instruction and curriculum oriented science instruction on 6th grade students' science process skills?" was given in this section.

Students' science process skills were measured by the administration of SPST as pre-test at the beginning and as post-test at the end of the study. At the beginning, there were no preexisting differences across experimental and comparison groups in terms of their performance in SPST. The descriptive investigations of pre-test scores, which was addressed in sub-question of Q.1.5 as “What are the 6th grade students’ science process skills?” indicated that means for the experimental (M= 9.63) and comparison groups (M= 8.79) were below the middle score considering the maximum score of 26. Similar with this result, Cansiz (2014), Aydinli (2007), and Ozgelen (2012) reported moderate level and low level of integrated science process skills in the 6 grade Turkish middle school students. This situation may be attributed to the grade level of the students. Actually, during the 4^{th} and 5^{th} grade science and technology lessons, students were engaged with the instruction mostly emphasizing the basic science process skills rather than the integrated skills as suggested in the curriculum (Cakiroglu & Aydin, 2009). Student engagement with activities in the following grades based on the integrated skills has potential enhance their mastery in science process skills. This situation was evidenced by the studies conducted by Aydinli (2007) and Can (2008) reporting students better performances concerning these skills. However, the profile in the later years might not be considered as sufficient to meet the objective of the curriculum. This situation challenges the educators to seek and develop activities and teaching methods in order to practice science process skills more.

At the outset of the present study, it was hypothesized that the 7E learning cycle instruction may enhance students’ mastery of science process skills more than the curriculum oriented science instruction. However, the results of the study revealed that students in both groups receiving the two instructions did not significantly differ in terms of science process skills neither in the post-test scores nor in the gain scores. The change in the mean scores over time followed the same pattern for both group students involving a slight increase after the instructions. Although the comparison of gain scores indicated a better effect of 7E learning cycle instruction over the curriculum oriented instruction, this effect did not enough to contribute to a significant change. This result could be attributed to three reasons; first is the nature of the topic implemented in the study, second is the instrument used to measure students’ science process skills, and third is the duration of the intervention.

The nature of topic can be discussed in this manner as following. The finding of the current study is in congruence with the results reported in the study of Kula (2009) who studied in the same topic with this study. She investigated the effectiveness of inquiry based instruction and curriculum driven instruction in skeletal, circulatory and respiratory systems concepts on 6th grade students of science process skills. The findings of the study revealed that students learnt the topic through inquiry approach did not substantially outperform over the other group students. Utilizing the same topic to the same grade level with the inquiry approaches, the aroused results of current study and Kula's study might be attributed to the nature of the content. Human body systems concept is a biological content that may limit to conduct manipulative experiments during the learning process. Students were able to do natural experiments such as observing and investigating the materials or comparing and classifying things according to their features. However, they could partly engage in manipulative experiments that they define the variables and manipulate the independent variable to investigate and record the relative effects on the dependent variable. The previously reviewed studies in the literature chapter evidenced the fact that the science process skills is possible to be enhanced when the students practice the skills during interacting with the materials, designing experiments, gathering, analyzing and interpreting data, formulating solutions to research problems, and reach solutions. This idea is also supported with the studies reporting promotion in science process skills through the instrumentality of learning cycle approach (Anagun & Yasar, 2009; Kanli & Yagbasan, 2008; Sornsakda, Suksringarm & Singseewo, 2009). These studies were presenting many experimental situations to students during the phases of learning cycle that students repeatedly practice all skills in the laboratories. On the other hand, the researcher of the current study was able to design only three activities in the current content that the students can practice integrated science process skills. Students may need more activities to realize the steps of a scientific process, the importance of variable definition and how these variables manipulates the results of an experiment, representing the findings of the experiment, and defending the conclusions through the evidences collected during the experimental process. Yet, it was unlikely possible to generate these kind of experiences for students in the conducted topic. In conclusion, the concept employed in the study may not be so applicable to embed various science process skill developing activities to result in a significant contribution.

Furthermore, the nonsignificant difference found between the groups with respect to science process skills of the students may be attributed to the instrument (SPST) that was administered to measure students' science process skills. The conclusions towards the analysis of data may not be accurate since the reliability coefficients regarding the pre-test and post-test implementations of SPST were found to be low in the current study. Moreover, the reliability coefficients of separated subtests in the SPST were very low which also interfered with conducting separate analyses for each skill. This is a limitation of the study which may also suppress to observe the effectiveness of learning cycle on each science process skills. The studies in the literature point out that the activities may enhance some skills of science process while not affecting the others (Padilla, 1990; Turpin, 2000; Anagun & Yasar, 2009; Allen, 1967 as cited in Baybee et al., 2006). Therefore, if the current study would be able to investigate the influence of instructions on separated skills, it seems to be more possible to observe relative effects of the activities in the learning cycle.

Another possible reason of the nonsignificant results might be the six week duration of the intervention. The long lasting studies appeared to show better evidences towards the positive influence of instruction on the student science process skill development. For instance, Turpin (2000) conducted a long term study to investigate effect of inquiry on science process skills and reported significant and higher scores in students instructed with inquiry based curriculum in whole school year compared to the students with traditional science curriculum. Similarly, Anagun and Yasar (2009) found significant contribution of 5E learning cycle instruction on students' science process skills following to the 50 hour intervention. Moreover, as suggested by Padilla (1990) students need multiple opportunities to practice the experimenting skills in various content areas and contexts in order to mastery these skills. Therefore, in the present study, it was clear that students required to engage more activities enhancing science process skills to improve their skills.

Consequently, the present study could not find enough evidence to support that the 7E learning cycle instruction improves middle school students' science process skills. On the other hand, the results did not revealed a negative effect of 7E learning cycle instruction instead the scores of the students' slightly increased parallel with the comparison group students' scores. To reveal a more accurate picture regarding the contribution of 7E learning cycle approach on science process skills it was recommended to embed more experimental situations to the phases and to utilize multiple assessment techniques to determine students' science process skills.

5.3 Implications

This study compared the effectiveness of 7E learning cycle instruction and curriculum oriented science instruction on 6^{th} grade students' understanding of human body system concepts, self-regulation, scientific epistemological beliefs, and science process skills. It was found that 7E learning cycle instruction has effectiveness over curriculum oriented science instruction on students' understanding of skeletal, circulatory and respiratory system concepts and their self-regulation in science. However, 7E learning cycle instruction contributed no striking difference on the improvement of epistemological beliefs and science process skills. Accordingly the current study has a number of implications aroused from these findings to teachers, curriculum developers, MoNE, and educators.

The implementation of learning cycle approach in lessons might be advisable to science teachers since it develops better understanding and retention of concepts. In science classes, students hold various ideas related the science topics which arouse based on their previous experiences and instructions. The human body system concepts are a part of students' every daily life since they always experience this content through their own body. However, the abstract and micro-structured nature of content may result in development of unscientific ideas towards the subject matter.

Moreover, considering the spiral nature of science curriculum of Turkish elementary science education, student understanding of instructed concepts was highly influenced from acquired conceptions in previous grades. The teachers need to consider and determine students' possible misconceptions prior to the content instruction in order to foster meaningful learning as well as to avoid the building of more misconceptions. Additionally, the teachers need to be aware of the difficulties that students experience while comprehending the interrelations among the human body systems. The instructions towards this subject matter must be designed to encourage the connection among distinctive systems and to develop a general understanding towards human body. 7E learning cycle approach, distinctively from the other forms of learning cycle model, highlights the necessity of prior knowledge activation besides connecting them with the new knowledge with the first phase of the model. In addition, it connects the recently acquired knowledge with the future subjects or context with the final phase. Moreover, in learning cycle, students investigate the related materials to explore the subject matter before the scientific explanations given to them. During the course of instruction, the teachers act as facilitator to encourage students to explore the content by themselves. They direct probing questions, provide appropriate materials, monitor the progress of students learning, and encourage student inquiry. Considering these features, 7E learning cycle instruction is plausible to recommend using by science teachers in their classrooms.

For proper application of learning cycle instruction, science teachers need to be well prepared for their lessons. This can be accomplished through MoNE's periodical and long-term professional training of pre-service and in-service science teachers regarding the pedagogical content knowledge, constructivist learning approaches, and learning cycle model. The teachers should be trained about the principles and fundamentals of 7E learning cycle instruction to be able to design their own lessons to encourage students to construct their own knowledge. In this manner, workshops, summer schools, or training courses need to be designed to provide the knowledge and skills regarding effective teaching methods. It is also suggested to design a learning environment in the course of trainings that the teachers can comprehend by active participation in the learning process, experience the students' roles in the class, and practice the methods rather than receiving the theoretical information. Teachers need to be encouraged to participate in these trainings and the educators in the universities should contribute to the development and implementation of these trainings. Actually, the practice is important not only for in-service but also pre-service science teachers. The courses given at the universities in the aim of teaching the methods in science education should provide opportunity to practice of pre-service teachers in learning cycle approach.

Furthermore, the study has another implication to MoNE concerning the implementation of the science curriculum. The 7E learning cycle approach is actually consistent with the reform movement implemented in Turkey since 2006. Nonetheless, the findings of the study implied the curriculum oriented science instruction has some inadequacies in practice to develop conceptual understanding, self-regulation, scientific epistemological beliefs, and science process skills. Thus, the curriculum developers are recommended to consider the findings of the current study related with the practical outcomes of curriculum in order to decide and carry out necessary revisions.

Moreover, the incorporation between educational researchers and science teachers is highly recommended to increase the implementation of 7E learning cycle. To facilitate teachers' use of learning cycle approach in their teaching, comprehensively prepared lesson plans based on learning cycle approaches including hands-on and minds-on activities can be developed by teachers and researchers. Furthermore, the science teachers need to be informed about the positive consequences of constructivist instructions in students' understanding of concepts as well as the development of self-regulation in order to encourage them to use related strategies.

Furthermore, the findings of the study implied that to promote students' epistemological beliefs and science process skills through 7E learning cycle instruction, some concerns need to be accounted in the design of activities. In order to develop sophisticated epistemological beliefs, the tasks given students should involve debates that generate argumentation among the students. These activities need to foster the students to claim their opinions, to support their opinions with the evidences collected from credible sources, to analyze others' points of view, to make interpretive judgments, and to refute others claims by supporting evidences or modify their own claims. For example, an argumentation about the organ donation can be embedded to learning cycle instruction to improve sophisticated understanding of scientific knowledge and knowing. Furthermore, students should engage with more experimental situations to adopt a scientific process. They need to be allowed to design and perform experiments in which they can practice in applying various science process skills. It can be suggested to develop activities that students able to experience the process of a real scientist in which they can realize how to construct the scientific knowledge through employing the necessary scientific skills such as observing, inferring, identifying variables, designing investigations and communicating with the peers. The exploration and explanation phases are suitable to embed this kind of activities which may benefit students to promote scientific epistemological beliefs and science process skills.

Finally, the findings of the study have some implications for the education researchers. This study revealed that investigating the skeletal, circulatory, and respiratory systems concepts distinctively in a repeated measure design is more informative to indicate the effectiveness of instructions on relative conceptual understanding. Instead of instrumenting a general human body systems concept test, this study utilized three distinct conceptual inventory in the topics of skeletal, circulatory, and respiratory systems. Moreover, the inventories were implemented three times; prior to the related concept instruction, after the completion of instruction, and one-month later the completion of instruction. The influence of two instructions on students' understandings showed different patterns towards each concept over tree time instrumentation period. Moreover, the effectiveness of learning cycle approach on retention of concepts as well as on the comprehension of links among the systems was enabled to explore by this design. For example, experimental and comparison group students' understanding of circulatory system concepts were appeared to be similar right after the instruction. The retention of the concepts as appeared on the follow-up test, on the other hand, was significantly better in the experimental group students which also showed a continuum to increase over time. This result indicated the support of respiratory system activities in 7E learning cycle instruction over students' circulatory system conceptions. Therefore, it was recommended to investigate each human body systems topic separately and to utilize follow-up measurements in the investigations of conceptual understanding. Moreover, the exploration of positive influence of 7E learning cycle instruction over experimental group students' motivational constructs would not be possible in the absence of a comparison group. Namely, there was a decrease on the motivation scores of experimental group students over time which may discredit the use of learning cycle approach. However, the striking decrease on the scores of comparison groups insights the balancing effect of 7E learning cycle on student motivation. The absence of comparison groups in the experimental studies limits the reliability of conclusions. Hence, the educational researchers investigating the effectiveness of learning cycle approach on students various learning outcomes are highly recommended to assign a comparison group that instructed with regular teaching methods.

The overall conclusion emerged from the study is that instruction based on 7E learning cycle model can lead better acquisition of scientific concepts in addition to higher perception of motivation and learning strategy use. This approach is recommended to use in science education considering its long term effects on students' life in and out of the schools.

5.4 Limitations and Recommendations

There are a number of limitations of the study and various recommendations emerged on the basis of these limitations to strength the validity of future research as following.

First of all, the current study was limited to 185 sixth-grade students attending a public elementary school in Ankara. The participants of the study were selected by convenient sampling method which is a nonrandom selection. Therefore, the generalizability of findings is pretty limited considering the size of population. The comparison studies investigating the effectiveness of 7E learning cycle instruction over curriculum oriented science instruction can be conducted in different school types and different grades levels. The replication of this study in different school context and with randomly selected participants in a larger sample size can be beneficial to increase the generalizability of conclusions.

Second, the current findings are limited to Human Body Systems unit in sixth grade science course. That is, the study was conducted in only the topics of skeletal, circulatory, and respiratory concepts, which may not be sufficient to generalize the findings to all science concepts. Similar studies exploring the effectiveness of 7E learning cycle on the science concepts other than skeletal, circulatory and respiratory systems may provide evidence about the generalizability of the findings over different science topics.

Third, this study compared the effectiveness of 7E learning cycle instruction with only curriculum oriented instruction. The comparison of different constructivist teaching methods with 7E learning cycle as well as the comparison of different learning cycle approaches with each other can be studied in terms of science learning and other outcomes. This may not only draw more complete picture about the influence of 7E learning cycle but also may provide the development of more lesson plans based on learning cycle approach. Moreover, future studies implementing constructivist teaching methods other than the 7E learning cycle instruction can be carried out to investigate relative influences on conceptual understanding, self-regulation, epistemological beliefs, and science process skills.

Fourth, in the current study the only administered data collection technique was self-report instruments. Although students were assumed to respond the questionnaires seriously, honestly and cautiously under standard conditions in class, collecting data with only self-report instruments may limit to reveal the real situation. Future studies might overcome this limitation with utilizing different data collection techniques such as open-ended questions, interviews, or direct observations. Using alternative instruments to collect data in the course of a study may increase the reliability of conclusions. Future studies also call for different research methodologies including qualitative or mixed methods research.

Fifth, the activities in the 7E learning cycle instruction failed to cause a striking effect on scientific epistemological beliefs and science process skills of students. Further studies can be conducted to develop effective activities in line with the suggestions given in implication part of this study. More research that investigates the strategies to enhance the views and skills of students towards science is necessary to shed light on ideal science practices.

Sixth, the 7E learning cycle intervention period of the present study took about six weeks. This period was enough to develop scientific conception in students although, it may not be enough to influence affective domains and beliefs of students. It is recommended to woven the 7E learning cycle throughout one semester or one school year to may provide more information about the effect of instruction.

Seventh, two volunteer science teachers and six intact classes were participated to this study. Actually during the conclusion drawing, it was assumed that the teachers who implied the study were not biased in the course of treatment and instrumentation process; all experimental group classes received the same intervention, all control group classes received the same instruction, and all classes received same instrumentation process. In fact, to ensure these situations, all classes were observed by the researcher and treatment fidelity and verification strategies were applied. However, of course there were some nuances in instructions between the classes due to two different teachers and various student characteristics. In future studies, the influence of this limitation may be dissipated by using HLM which enables to study student and teacher characteristics simultaneously. Thus, the effect of variables like teacher experience can be controlled.

Eighth, there was a limitation with respect to the analysis of the study. The independence of observations assumptions of mixed-ANOVA and mixed-MANOVA might be violated since experimental groups students worked in groups occasionally. When the students work with their peers, they develop mutual understanding and affect from each other's expressions. In future studies, the effect of this limitation might be eliminated by an HLM analysis considering the group structure of the data. It is also recommended to collect the data from a larger sample to obtain more robust results from the HLM analysis.

Last, in this study, the reliability coefficient for Science Process Skills Test was appeared to be lower than the reported values in previous studies. Accordingly, the findings should be interpreted with caution in terms of science process skills. This may be arising from the wording of the test items which have some unfamiliar terms and complication for middle school students. It was recommended to revise the items with alternative wording to increase the intelligibility and reliability of the test.

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APPENDICES

APPENDIX A

DESTEK VE HAREKET SİSTEMİ KAVRAM TESTİ

Bu testte 10 adet çoktan seçmeli soru bulunmaktadır. Her soruda size göre **<u>en doğru</u>** olan cevabı işaretleyiniz.

1. Dört öğrenci sınıfta kemiklerin canlı mı yoksa cansız mı olduklarını tartışmakta ve neden öyle düşündüklerini açıklamaktadır. Aşağıda dördünün de fikirleri verilmiştir. Siz hangi öğrencinin fikrine ve açıklamasına katılıyorsunuz?

a) I. Öğrenci: Kemikler canlıdır. Çünkü hareket edebiliyor.
b) II. Öğrenci: Kemikler canlıdır. Çünkü canlı hücrelerden oluşmuşlardır.
c) III. Öğrenci: Kemikler cansızdır. Çünkü biz hareket ettirmezsek kendi başına hareket edemezler.
d) IV. Öğrenci: Kemikler cansızdır. Ama içinde bulunan damarlar canlıdır.
e) Bu soru hakkında hiçbir fikrim yok.

1a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

2. Bir öğrenciye kemik çeşitleri sorulmuş ve bir cümle ile açıklaması istenmiştir. Öğrencinin ifadeleri şu şekildedir:

I. Yassı kemik: oynamayan kemiktir.
II. Uzun kemik: oynar kemiktir.
III. Kısa kemik: yarı oynar kemiktir.

Bu açıklamalara göre öğrenci ile ilgili olarak aşağıdakilerden hangisi söylenebilir?

a) Kemik çeşitlerini bilmiyor.
b) Kemik çeşitlerini ve işlevlerini çok iyi biliyor.
c) Kemiklerin görevlerini bilmiyor.
d) Kemik çeşitleri ile eklem çeşitlerini birbirine karıştırıyor.
e) Bu soru hakkında hiçbir fikrim yok.

2a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

3. Destek ve Hareket sisteminin diğer vücut sistemleri ile ilişkisini anlatan aşağıdaki ifadelerden hangisi <u>**yanlıştır**</u>?

a) Solunum sistemi ile ilişkilidir çünkü akciğer gibi önemli organları korur.
b) Sinir sistemi ile ilişkilidir çünkü omurganın içinde bulunan omuriliği korur.
c) Sindirim sistemi ile ilişkilidir çünkü iç organlarımıza askı görevi görür.
d) Dolaşım sistemi ile ilişkilidir çünkü damarlar vücudumuza kemiklerin içinden yayılır.
e) Bu soru hakkında hiçbir fikrim yok.

3a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

4. Vücudumuzda kemiklerimizin olmadığı bir durumda olabilecek ifadeler aşağıda verilmiştir. Sizce bu ifadelerden hangisi **yanlıştır**?

a) Tüm derimiz, kaslarımız ve organlarımız yere yığılırdı.
b) İç organlarımız en ufak bir darbede bile zarar görürdü.
c) Dokunup temas ettiğimiz hiçbir şeyi hissedemezdik.
d) Alyuvar üretimi azalırdı.
e) Bu soru hakkında hiçbir fikrim yok.

4a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

5. Kaslarımız ile ilgili aşağıda verilen bilgilerden hangisi doğrudur?

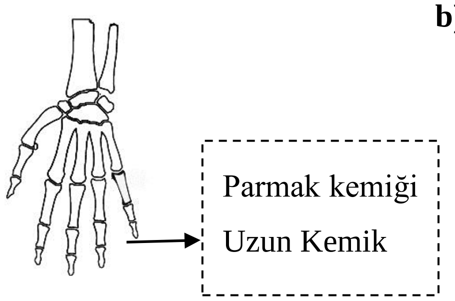
a) Vücudumuzda soluk alıp vermemize yardımcı olan kaslar vardır.
b) Bazı kaslarımız akyuvar ve alyuvar hücreleri üretmekle görevlidir.
c) Oksijence fakir kan kaslarımızda temizlenir.
d) Kemikleri ve kıkırdakları korumak kaslarımızın görevlerindendir.
e) Bu soru hakkında hiçbir fikrim yok.

5a. Bu soruya verdiğiniz yanıttan emin misiniz?

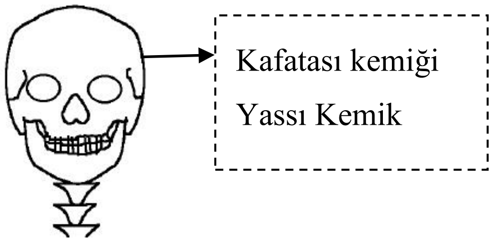
a. Evet **b.** Hayır

6. Öğretmen öğrencilerden kemik çeşitlerini bir örnek ile göstermelerini istemiştir. Aşağıdaki öğrencilerden hangisi bahsettiği çeşide **yanlış** bir örnek göstermiştir?

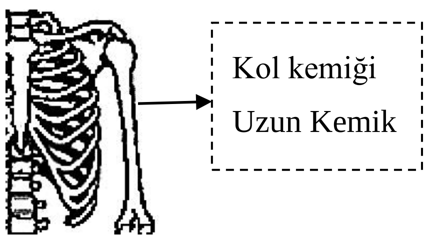
a)



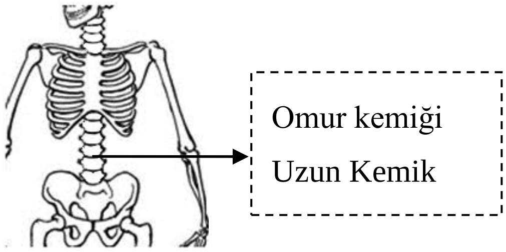
b)



c)



d)



e) Bu soru hakkında hiçbir fikrim yok.

6a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

7. Bir bebek ile yetişkin bir insanın kemiklerini düşündüğünüzde aşağıdakilerden hangisi doğrudur?

a) Bebek ile yetişkin insan iskeleti arasında hiçbir fark yoktur.

b) Yetişkinlerin daha fazla kemiği vardır çünkü büyüdükçe yeni hücreler ve yeni kemikler üretilir.

c) Bebeklerin iskeleti yetişkinlerin iskeletinden daha fazla kıkırdak içerir.

d) Yetişkinlerin kemikleri daha incedir çünkü uzadıkça incelmiştir.

e) Bu soru hakkında hiçbir fikrim yok.

7a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

8. Parmaklarımızı boynumuzdan daha çok hareket ettirebiliyoruz çünkü…

a) Boynumuzda hayati damarlar vardır ama parmaklarımızda yoktur.
b) Parmaklarımızda boynumuzdan daha çok eklem vardır.
c) Parmaklarımızdaki kemikler boynumuzdaki kemiklerden daha incedir.
d) Parmaklarımızdaki eklemler oynar, boynumuzdakiler yarı oynardır.
e) Bu soru hakkında hiçbir fikrim yok.

8a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

9. Kol ve bacaklarımızın hareketini kontrol edebiliyoruz ama iç organlarımızın hareketini kontrol edemiyoruz çünkü…

a) Kol ve bacaklarımızı sinir sistemi yönetir, iç organlarımızın sinir sistemi ile bir ilişkisi yoktur.
b) Kol ve bacaklarımızda istemli kaslar, iç organlarımızda istemsiz kaslar yer alır.
c) Kol ve bacaklarımız beyin tarafından, iç organlarımız ise kalp tarafından yönetilir.
d) Kol ve bacaklarda kemik ve kas vardır, iç organlarımızda ise yoktur.
e) Bu soru hakkında hiçbir fikrim yok.

9a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

10. Aşağıdakilerden hangisinin destek ve hareket sisteminin sağlığına doğrudan bir etkisi **yoktur**?

a) Bol bol su içmek
b) Düzenli egzersiz yapmak
c) Süt ve süt ürünleri tüketmek
d) Güneş ışığı altında dolaşmak
e) Bu soru hakkında hiçbir fikrim yok.

10a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

Doğru Cevaplar:	**1**)B **2**)D **3**)D **4**)C **5**)A **6**)D **7**)C **8**)D **9**)B **10**)A

APPENDIX B

DOLAŞIM SİSTEMİ KAVRAM TESTİ

Bu testte 10 adet çoktan seçmeli soru bulunmaktadır. Her soruda size göre **<u>en doğru</u>** olan cevabı işaretleyiniz.

1. Dört öğrenci kalp atışı sayesinde gerçekleşen olayları konuşmaktadır. Her öğrencinin açıklaması aşağıda verilmiştir. Siz hangi öğrencinin fikrine katılıyorsunuz?

a) Öğrenci 1: Kalp her atışında yeni kan hücreleri üretir.
b) Öğrenci 2: Kalp her atışında kirli kanı temizler, temiz kanı vücut organlarına gönderir.
c) Öğrenci 3: Kalp her atışında oksijence fakir kanı akciğere gönderir.
d) Öğrenci 4: Kalp her atışında kandaki karbondioksiti süzer ve atılması için akciğere gönderir.
e) Bu soru hakkında hiçbir fikrim yok.

1a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

2. Aşağıda bir öğrencinin kanın görevi ve içeriği ile ilgili yaptığı açıklamalar bulunmaktadır. Sizce öğrencinin hangi ifadesi doğrudur?

a) Kandaki alyuvarlar kanın pıhtılaşmasını sağlar.
b) Oksijen kanda gaz kabarcığı şeklinde serbest olarak taşınır.
c) İçinde glikoz gibi maddeler olan kana kirli kan denir.
d) Kanda bulunan akyuvarlar vücudu hastalıklardan korur.
e) Bu soru hakkında hiçbir fikrim yok.

2a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

3. Bir öğrenci vücuttaki damar çeşitlerini ve görevlerini aşağıdaki gibi yazmıştır.

- **I. Atardamar**: Bütün atardamarlar oksijence zengin kanı taşır.
- **II. Toplardamar**: Bütün toplardamarlar oksijence fakir kanı taşır.
- **III. Kılcal damar**: Bütün kılcal damarlar madde alışverişini sağlar.

Bu öğrenci için aşağıdakilerden hangisi söylenebilir?

a) Damar çeşitlerinde Şahdamar'ı yazmayı unutmuştur.
b) Akciğer atar ve toplardamarının diğer atar ve toplardamarlardan farkını unutmuştur.
c) Damarların çeşitlerini doğru bilmektedir ancak görevlerini birbirine karıştırmıştır.
d) Damar çeşitlerini ve görevlerini doğru ve eksiksiz biliyor.
e) Bu soru hakkında hiçbir fikrim yok.

3a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

4. Kanın damarlarda dolaşabiliyor olma nedenini nasıl açıklarsınız?

a) Nefes alınca vücuda giren hava kanı damarlar içinde itiyor.
b) Kalp kasılıp gevşeyerek kanın hareketini sağlıyor.
c) Soluduğumuz oksijenin kana karışması kanın akışkan olmasını sağlıyor.
d) Beyin sinirler yoluyla kan hücrelerine hareket etme emrini gönderiyor.
e) Bu soru hakkında hiçbir fikrim yok.

4a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

5. Dolaşım sisteminde kanın vücutta dolaşması ile ilgili aşağıdaki ifadelerden hangisi doğrudur?

a) Kan kalpten damarlar yoluyla ayrılır, vücut hücrelerine gider ve hücrelerin çevresine dolar.
b) Kan kalpten damarlar yoluyla ayrılır, hücrelere gider ve geldiği aynı damarla kalbe geri döner.
c) Kan kalpten damarlar yoluyla ayrılır, hücrelere gider ve başka damarlarla kalbe geri döner.
d) Kan kalpten damarlar yoluyla ayrılır, hücrelere gider, başka damarlarla akciğere gider ve temizlendikten sonra kalbe döner.
e) Bu soru hakkında hiçbir fikrim yok.

5a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

6. Bir öğrenci dolaşım sistemi rahatsızlıklarını araştırırken kalp rahatsızlıklarının tüm vücudu olumsuz yönde etkileyebileceğini öğrenmiştir. Buna göre kalbi sağlıklı çalışmayan insanlarda aşağıdakilerden hangisi **gerçekleşmez**?

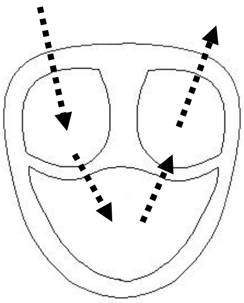
a) Kişinin vücudundaki kan hücrelerinin miktarı azalabilir.
b) Kalbin vücuda kan pompalaması yavaşlayabilir.
c) Hücrelerdeki atık maddeler uzaklaştırılamayabilir.
d) Hücrelerdeki oksijen miktarı azalabilir.
e) Bu soru hakkında hiçbir fikrim yok.

6a. Bu soruya verdiğiniz yanıttan emin misiniz?

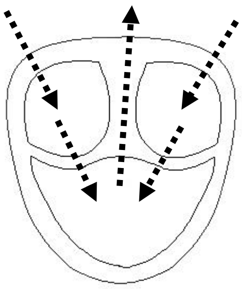
a. Evet **b.** Hayır

7. Öğretmen öğrencilerden insan kalbinin odacıklarını ve kanın kalp içindeki hareketini oklarla gösteren bir şema çizmelerini istemiştir. Aşağıda verilen öğrenci çizimlerinden hangisi doğrudur?

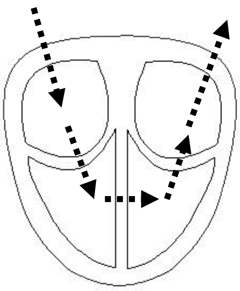
a)



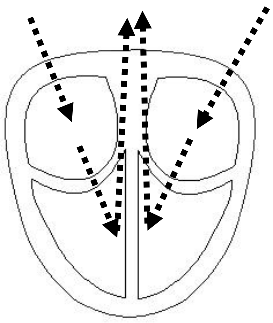
b)



c)



d)

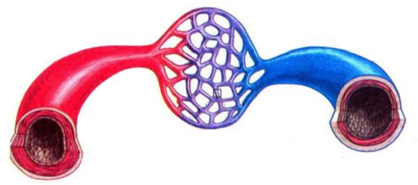


e) Bu soru hakkında hiçbir fikrim yok.

7a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

8. Defne insan vücudundaki damarlarla ilgili bilgileri araştırırken ders kitabında yandaki resme rastlamıştır.



Bu resimde ve genelde diğer dolaşım sistemi resimlerinde mavi ve kırmızı renk kullanılmasın sebebi sizce nedir?

a) Çünkü vücudumuzda bulunan oksijence zengin kan kırmızı, oksijence fakir kan mavidir.

b) Çünkü vücudumuzda besinleri taşıyan kan kırmızı, atık maddeleri taşıyan kan mavidir.

c) Çünkü vücudumuzda bulunan atardamarlar kırmızı, toplardamarlar ise mavidir.

d) Çünkü, atardamar ve toplardamarlarda bulunan kandaki oksijen miktarının farklı olduğu vurgulanmak istenmektedir.

e) Bu soru hakkında hiçbir fikrim yok.

8a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

9. Ali iskeletini ve kaslarını kullanarak yapacağı bir egzersizin kalp atışına etkisini merak etmiştir. Bunun için koşmadan önce ve 15 dakika koştuktan sonra kalp atışını ölçerek deney yapmıştır. Yaptığı deneyde nasıl bir sonuç beklersiniz?

a) Kalp atışı değişmez çünkü destek hareket sistemi ile dolaşım sisteminin bir ilişkisi yoktur.
b) Kalp atışı artar çünkü vücutta kanın taşıdığı maddelere ihtiyaç artar.
c) Kalp atışı artar çünkü aldığımız nefes sayısı artmıştır.
d) Kalp atışı azalır çünkü iskelet kasları yorulur, kalp kasları yavaşlayarak bunu dengeler.
e) Bu soru hakkında hiçbir fikrim yok.

9a. Bu soruya verdiğiniz yanıttan emin misiniz?
a. Evet **b.** Hayır

10. Dolaşım sisteminin diğer vücut sistemleri ile ilişkisini anlatan aşağıdaki ifadelerden **yanlış** olan hangisidir?

a) Sindirim sistemi ile ilişkilidir çünkü dolaşım sistemi bazı besinleri parçalayarak sindirime yardımcı olur.
b) Solunum sistemi ile ilişkilidir çünkü oksijen ve karbondioksit gerekli organlara dolaşım sistemi sayesinde ulaşır.
c) Boşaltım sistemi ile ilişkilidir çünkü atık maddeler dolaşım sistemi sayesinde organlardan uzaklaştırılır.
d) Lenf sistemi ile ilişkilidir çünkü hücreler arasına süzülen maddeleri lenf damarları toplayıp dolaşım sistemine verir.
e) Bu soru hakkında hiçbir fikrim yok.

10a. Bu soruya verdiğiniz yanıttan emin misiniz?
a. Evet **b.** Hayır

Doğru Cevaplar: **1**)C **2**)D **3**)B **4**)B **5**)C **6**)A **7**)D **8**)D **9**)B **10**)A

APPENDIX C

SOLUNUM SİSTEMİ KAVRAM TESTİ

Bu testte 10 adet çoktan seçmeli soru bulunmaktadır. Her soruda size göre **en doğru** olan cevabı işaretleyiniz.

1. Akciğerin görevi aşağıdaki şıklardan hangisinde doğru olarak verilmiştir?

a) Akciğerler, solunumu gerçekleştirmek ile görevlidir.

b) Akciğerler, oksijeni alıp karbondioksite çevirmek ve vücuttan atmak ile görevlidir.

c) Akciğerler, oksijeni kana verip kandaki karbondioksiti atmakla görevlidir.

d) Akciğerler, nefes ile alınan oksijence zengin havayı depolamak ile görevlidir.

e) Bu soru hakkında hiçbir fikrim yok.

1a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

2. Sizce verdiğimiz nefesteki karbondioksitin kaynağı aşağıdaki şıklardan hangisinde doğru açıklanmıştır?

a) Nefes ile alınan havadaki oksijen akciğerler tarafından süzülür, akciğerlerde kalan hava karbondioksit olarak atılır.

b) Oksijenin hücrelerde enerji üretilmek için kullanılmasıyla karbondioksit oluşur ve verilen nefesle vücuttan atılır.

c) Solunum esnasında karaciğerde karbondioksit biriktirilir ve verilen nefesle atılır.

d) Kalbin sağ karıncığında biriken oksijence fakir kandaki karbondioksit akciğerlere gönderilir ve nefesle atılır.

e) Bu soru hakkında hiçbir fikrim yok.

2a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

3. Nefes alma esnasında havanın akciğerlere dolması nasıl sağlanır?

a) Burnumuzdan hava almamız sayesinde akciğerlere hava dolar.

b) Akciğerlerde bulunan kaslar akciğerleri genişleterek içlerine hava dolmasını sağlar.

c) Göğüs kasları ve diyafram kasılarak akciğerlere hava dolmasını sağlar.

d) Akciğerlere hava kalbin kanı pompalaması sırasında oluşan basınç sayesinde dolar.

e) Bu soru hakkında hiçbir fikrim yok.

3a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

4. Aşağıda dört öğrencinin **solunum** için yaptığı tanımlar verilmektedir. Sizce doğru olan tanım aşağıdakilerden hangisidir?

a) Solunum nefes alıp vermek demektir.

b) Solunum oksijen alıp karbondioksit vermek demektir.

c) Solunum nefesin alınıp nefesteki oksijenin süzülmesi ve kalan havanın nefes verilerek atılması demektir.

d) Solunum alınan oksijenin hücrelerde enerji üretiminde kullanılması demektir.

e) Bu soru hakkında hiçbir fikrim yok.

4a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

5. Burnumuzun solunum sistemindeki görevi aşağıdakilerden hangisidir?

- **a)** Havadaki oksijeni ayırarak akciğerlere sadece oksijen gitmesini sağlamak.
- **b)** Nefes alırken alınan havadaki toz ve yabancı maddeleri süzmek.
- **c)** Havadaki karbondioksiti ayırmak ve akciğerlere ulaşmasını engellemek.
- **d)** Çevremizdeki nesnelerin kokusunu almak.
- **e)** Bu soru hakkında hiçbir fikrim yok.

5a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

6. Nefes alıp vermek vücudumuz için neden hayati önem taşımaktadır?

- **a)** Çünkü nefes alıp vermek sayesinde hücrelere oksijen sağlanırken hücrelerde biriken karbondioksit atılır.
- **b)** Çünkü nefes alıp vermek kanın damarlarda dolaşmasını sağlar.
- **c)** Çünkü aldığımız nefesteki oksijen kana karışmazsa kan pıhtılaşır ve bu yüzden kan dolaşımı engellenir.
- **d)** Çünkü nefes alıp vermezsek atmosferdeki karbondioksitli havayı temizleyemeyiz.
- **e)** Bu soru hakkında hiçbir fikrim yok.

6a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

7. Dört öğrenci alınan ve verilen nefeste bulunan oksijen ve karbondioksit gazları ile ilgili fikirlerini tartışmaktadır. Sizce aşağıda verilen öğrenci fikirlerinden hangisi doğrudur?

a) Alınan nefesteki karbondioksit miktarı ile verilen nefesteki karbondioksit miktarı aynıdır.
b) Alınan nefesteki oksijen miktarı verilen nefesteki oksijen miktarından fazladır.
c) Alınan nefeste sadece oksijen, verilen nefeste ise sadece karbondioksit bulunur.
d) Alınan nefeste oksijen ve karbondioksit bulunur ama verilen nefeste sadece karbondioksit bulunur.
e) Bu soru hakkında hiçbir fikrim yok.

7a. Bu soruya verdiğiniz yanıttan emin misiniz?
a. Evet **b.** Hayır

8. Bir öğrenciye solunum sisteminin organları sorulmuştur. Öğrencinin cevabı şu şekildedir:

IV. Burun
V. Yutak
VI. Gırtlak
VII. Soluk borusu
VIII. Akciğerler

Bu cevaba göre öğrenci ile ilgili olarak aşağıdakilerden hangisi söylenebilir?

a) Karbondioksiti vücuttan atmakla görevli böbrekleri eklemeyi unutmuştur.
b) Kirli ve temiz havayı ayırarak akciğerlere yardımcı olan karaciğeri eklemeyi unutmuştur.

c) Oksijen ve karbondioksit taşınmasında görevli kalbi eklemeyi unutmuştur.

d) Solunum sistemi organlarını doğru ve eksiksiz bilmektedir.

e) Bu soru hakkında hiçbir fikrim yok.

8a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

9. Mert iskeletini ve kaslarını kullanarak yapacağı bir egzersizin nefes alışverişine ve kalp atışına etkisini merak etmiştir. Bunun için koşmadan önce ve 15 dakika koştuktan sonra hem nefes alışverişini hem kalp atışını ölçerek deney yapmıştır. Yaptığı deneyde nefes alışveriş hızının da kalp atış hızının da arttığını fark etmiştir. Egzersiz sonrası hem **nefes alışveriş hızının** hem de **kalp atış hızının** artmasının sebebi nedir?

a) Koşma sırasında nefes alışveriş hızının atması damar basıncını yükseltmiştir, bu da kalp atışını hızlandırmıştır.

b) Koşma sırasında kalp atışının hızlanması, nefes alışverişinin hızlanmasına neden olmuştur.

c) Koşma sırasında hücrelerin oksijen ve besin ihtiyacı ile biriken karbondioksit ve atık maddelerin miktarı artar, bu yüzden kalp atışı ve nefes alışverişi artmıştır.

d) Koşma sırasında, nefes alışverişinin artması kana karışan oksijen miktarını artırmıştır, bu kanı daha da sıvılaştırmıştır ve kanın akışkanlığı arttığı için kalp atışı da artmıştır.

e) Bu soru hakkında hiçbir fikrim yok.

9a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

10. Solunum sisteminin diğer sistemler ile ilişkisini anlatan aşağıdaki ifadelerden **yanlış** olan ifade hangisidir?

a) Boşaltım sistemi ile ilişkilidir çünkü havanın alınması solunum sisteminin, verilmesi ise boşaltım sisteminin görevidir.

b) Dolaşım sistemi ile ilişkilidir çünkü oksijen ve karbondioksit kan yolu ile taşınır.

c) Destek ve hareket sistemi ile ilişkilidir çünkü vücutta nefes alıp vermeye yardımcı kaslar vardır.

d) Sinir sistemi ile ilişkilidir çünkü oksijen beynin çalışması için gereklidir.

e) Bu soru hakkında hiçbir fikrim yok.

10a. Bu soruya verdiğiniz yanıttan emin misiniz?

a. Evet **b.** Hayır

Doğru Cevaplar: **1**)C **2**)B **3**)C **4**)D **5**)B **6**)A **7**)B **8**)D **9**)C **10**)A

APPENDIX D

ÖĞRENMEDE GÜDÜSEL STRATEJİLER ANKETİ

Bu anket iki kısımdan oluşmaktadır. İlk kısımda fen bilgisi dersine karşı tutumunuzu, motivasyonunuzu, ikinci kısımda ise fen bilgisi dersinde kullandığınız öğrenme stratejileri ve çalışma becerilerini belirlemeye yönelik ifadeler yer almaktadır. Cevap verirken aşağıda verilen ölçeği gözönüne alınız. **Eğer ifadenin sizi tam olarak yansıttığını düşünüyorsanız, 7' yi yuvarlak içine alınız. Eğer ifadenin sizi hiç yansıtmadığını düşünüyorsanız, 1' yi yuvarlak içine alınız. Bu iki durum dışında ise 1 ve 7 arasında sizi en iyi tanımladığını düşündüğünüz numarayı yuvarlak içine alınız.** Unutmayın Doğru ya da Yanlış cevap yoktur yapmanız gereken sizi en iyi tanımlayacak numarayı yuvarlak içine almanızdır.

1 --- 2 --- 3 --- 4 --- 5 --- 6 -- 7

beni hiç yansıtmıyor — beni tam olarak yansıtıyor

A. Motivasyon (Güdülenme)

	Beni hiç yansıtmıyor					**Beni tam olarak yansıtıyor**	
1. Fen bilgisi dersinde yeni bilgiler öğrenebilmek için, büyük bir çaba gerektiren sınıf çalışmalarını tercih ederim.	1	2	3	4	5	6	7
2. Eğer uygun şekilde çalışırsam, fen bilgisi dersindeki konuları öğrenebilirim.	1	2	3	4	5	6	7
3. Fen bilgisi sınavları sırasında, diğer arkadaşlarıma göre soruları ne kadar iyi yanıtlayıp yanıtlayamadığımı düşünürüm	1	2	3	4	5	6	7
4. Fen bilgisi dersinde öğrendiklerimi başka derslerde de kullanabileceğimi düşünüyorum.	1	2	3	4	5	6	7
5. Fen bilgisi dersinden çok iyi bir not alacağımı düşünüyorum.	1	2	3	4	5	6	7

6. Fen bilgisi dersi ile ilgili okumalarda yer alan en zor konuyu bile anlayabileceğimden eminim.	1	2	3	4	5	6	7
7. Benim için şu an fen bilgisi dersi ile ilgili en tatmin edici şey iyi bir not getirmektir	1	2	3	4	5	6	7
8. Fen bilgisi sınavları sırasında bir soru üzerinde uğraşırken, aklım sınavın diğer kısımlarında yer alan cevaplayamadığım sorularda olur	1	2	3	4	5	6	7
9. Fen bilgisi dersindeki konuları **öğrenemezsem** bu benim hatamdır.	1	2	3	4	5	6	7
10.Fen bilgisi dersindeki konuları öğrenmek benim için önemlidir	1	2	3	4	5	6	7
11. Genel not ortalamamı yükseltmek şu an benim için en önemli şeydir, bu nedenle fen bilgisi dersindeki temel amacım iyi bir not getirmektir.	1	2	3	4	5	6	7
12. Fen bilgisi dersinde öğretilen temel kavramları öğrenebileceğimden eminim.	1	2	3	4	5	6	7
13. Eğer başarabilirsem, fen bilgisi dersinde sınıftaki pek çok öğrenciden daha iyi bir not getirmek isterim	1	2	3	4	5	6	7
14. Fen bilgisi sınavları sırasında bu dersten başarısız olmanın sonuçlarını aklımdan geçiririm	1	2	3	4	5	6	7
15. Fen bilgisi dersinde, öğretmenin anlattığı en karmaşık konuyu anlayabileceğimden eminim.	1	2	3	4	5	6	7
16. Fen bilgisi derslerinde öğrenmesi zor olsa bile, bende merak uyandıran sınıf çalışmalarını tercih ederim.	1	2	3	4	5	6	7
17. Fen bilgisi dersinin kapsamında yer alan konular çok ilgimi çekiyor.	1	2	3	4	5	6	7
18. Yeterince sıkı çalışırsam fen bilgisi dersinde başarılı olurum.	1	2	3	4	5	6	7
19. Fen bilgisi sınavlarında kendimi mutsuz ve huzursuz hissederim.	1	2	3	4	5	6	7
20. Fen bilgisi dersinde verilen sınav ve ödevleri en iyi şekilde yapabileceğimden eminim.	1	2	3	4	5	6	7
21. Fen bilgisi dersinde çok başarılı olacağımı umuyorum	1	2	3	4	5	6	7
22. Fen bilgisi dersinde beni en çok tatmin eden şey, konuları mümkün olduğunca iyi öğrenmeye çalışmaktır.	1	2	3	4	5	6	7
23. Fen bilgisi dersinde öğrendiklerimin benim için faydalı olduğunu düşünüyorum.	1	2	3	4	5	6	7
24. Fen bilgisi dersinde, iyi bir not getireceğimden emin **olmasam** bile öğrenmeme olanak sağlayacak ödevleri seçerim.	1	2	3	4	5	6	7
25. Fen bilgisi dersinde bir konuyu **anlayamazsam** bu yeterince sıkı çalışmadığım içindir.	1	2	3	4	5	6	7
26. Fen bilgisi dersindeki konulardan hoşlanıyorum.	1	2	3	4	5	6	7

27. Fen bilgisi dersindeki konuları anlamak benim için önemlidir.	1	2	3	4	5	6	7
28. Fen bilgisi sınavlarında kalbimin hızla attığını hissederim.	1	2	3	4	5	6	7
29. Fen bilgisi dersinde öğretilen becerileri iyice öğrenebileceğimden eminim.	1	2	3	4	5	6	7
30. Fen bilgisi dersinde başarılı olmak istiyorum çünkü yeteneğimi aileme, arkadaşlarıma göstermek benim için önemlidir.	1	2	3	4	5	6	7
31. Dersin zorluğu, öğretmen ve benim becerilerim gözönüne alındığında, fen bilgisi dersinde başarılı olacağımı düşünüyorum	1	2	3	4	5	6	7

B. Öğrenme Stratejileri

	Beni hiç yansıtmıyor					Beni tam olarak yansıtıyor	
32. Fen bilgisi dersi ile ilgili birşeyler okurken, düşüncelerimi organize etmek için konuların ana başlıklarını çıkarırım.	1	2	3	4	5	6	7
33. Fen bilgisi dersi sırasında başka şeyler düşündüğüm için önemli kısımları sıklıkla kaçırırım.	1	2	3	4	5	6	7
34. Fen bilgisi dersine çalışırken çoğu kez arkadaşlarıma konuları açıklamaya çalışırım	1	2	3	4	5	6	7
35. Genelde, ödevlerime rahat konsantre olabileceğim bir yerde çalışırım.	1	2	3	4	5	6	7
36. Fen bilgisi dersi ile ilgili birşeyler okurken, okuduklarıma odaklanabilmek için sorular oluştururum.	1	2	3	4	5	6	7
37. Fen bilgisi dersine çalışırken kendimi çoğu zaman o kadar isteksiz ya da o kadar sıkılmış hissederim ki, planladıklarımı **tamamlamadan** çalışmaktan vazgeçerim.	1	2	3	4	5	6	7
38. Fen bilgisi dersiyle ilgili duyduklarımı ya da okuduklarımı ne kadar gerçekçi olduklarına karar vermek için sıklıkla sorgularım.	1	2	3	4	5	6	7
39. Fen bilgisi dersine çalışırken, önemli bilgileri içimden defalarca tekrar ederim	1	2	3	4	5	6	7
40. Fen bilgisi dersinde bir konuyu anlamakta zorluk çeksem bile hiç kimseden yardım almaksızın kendi kendime çalışırım.	1	2	3	4	5	6	7
41. Fen bilgisi dersi ile ilgili birşeyler okurken bir konuda kafam karışırsa, başa döner ve anlamak için çaba gösteririm.	1	2	3	4	5	6	7
42. Fen bilgisi dersine çalışırken, daha önce okuduklarımı ve aldığım notları gözden geçirir ve en önemli noktaları belirlemeye çalışırım.	1	2	3	4	5	6	7
43. Fen bilgisi dersine çalışmak için ayırdığım zamanı iyi değerlendirebiliyorum.	1	2	3	4	5	6	7
44.Eğer fen bilgisi dersi ile ilgili okumam gereken konuları anlamakta zorlanıyorsam, okuma stratejimi değiştiririm.	1	2	3	4	5	6	7
45. Fen bilgisi dersinde verilen ödevleri tamamlamak için sınıftaki diğer öğrencilerle çalışırım.	1	2	3	4	5	6	7

46. Fen bilgisi dersine çalışırken, dersle ilgili okumaları ve ders sırasında aldığım notları defalarca okurum	1	2	3	4	5	6	7
47. Ders sırasında veya ders için okuduğum bir kaynakta bir teori, yorum ya da sonuç ifade edilmiş ise, bunları destekleyen bir bulgunun var olup olmadığını sorgulamaya çalışırım.	1	2	3	4	5	6	7
48. Fen bilgisi dersinde yaptıklarımızdan **hoşlanmasam bile** başarılı olabilmek için sıkı çalışırım.	1	2	3	4	5	6	7
49. Dersle ilgili konuları organize etmek için basit grafik, şema ya da tablolar hazırlarım.	1	2	3	4	5	6	7
50. Fen bilgisi dersine çalışırken konuları sınıftaki arkadaşlarımla tartışmak için sıklıkla zaman ayırırım	1	2	3	4	5	6	7
51. Fen bilgisi dersinde işlenen konuları bir başlangıç noktası olarak görür ve ilgili konular üzerinde kendi fikirlerimi oluşturmaya çalışırım.	1	2	3	4	5	6	7
52. Çalışma planına bağlı kalmak benim için zordur.	1	2	3	4	5	6	7
53. Fen bilgisi dersine çalışırken, dersten, okuduklarımdan, sınıf içi tartışmalardan ve diğer kaynaklardan edindiğim bilgileri biraraya getiririm.	1	2	3	4	5	6	7
54. Yeni bir konuyu detaylı bir şekilde çalışmaya başlamadan önce çoğu kez konunun nasıl organize edildiğini anlamak için ilk olarak konuyu hızlıca gözden geçiririm.	1	2	3	4	5	6	7
55. Fen bilgisi dersinde işlenen konuları anladığımdan emin olabilmek için kendi kendime sorular sorarım.	1	2	3	4	5	6	7
56. Çalışma tarzımı, dersin gereklilikleri ve öğretmenin öğretme stiline uygun olacak tarzda değiştirmeye çalışırım.	1	2	3	4	5	6	7
57. Genelde derse gelmeden önce konuyla ilgili birşeyler okurum fakat okuduklarımı çoğunlukla **anlamam**	1	2	3	4	5	6	7
58. İyi anlamadığım bir konuyu öğretmenimden açıklamasını isterim.	1	2	3	4	5	6	7
59. Fen bilgisi dersindeki önemli kavramları hatırlamak için anahtar kelimeleri ezberlerim.	1	2	3	4	5	6	7
60. Eğer bir konu zorsa ya çalışmaktan vazgeçerim ya da yalnızca kolay kısımlarını çalışırım	1	2	3	4	5	6	7
61. Fen bilgisi dersine çalışırken, konuları sadece okuyup geçmek yerine ne öğrenmem gerektiği konusunda düşünmeye çalışırım.	1	2	3	4	5	6	7
62. Mümkün olduğunca fen bilgisi dersinde öğrendiklerimle diğer derslerde öğrendiklerim arasında bağlantı kurmaya çalışırım.	1	2	3	4	5	6	7
63. Fen bilgisi dersine çalışırken notlarımı gözden geçirir ve önemli kavramların bir listesini çıkarırım.	1	2	3	4	5	6	7
64. Fen bilgisi dersi için birşeyler okurken, o anda okuduklarımla daha önceki bilgilerim arasında bağlantı kurmaya çalışırım.	1	2	3	4	5	6	7
65. Ders çalışmak için devamlı kullandığım bir yer (oda vs.) vardır	1	2	3	4	5	6	7
66. Fen bilgisi dersinde öğrendiklerimle ilgili ortaya çıkan fikirlerimi sürekli olarak gözden geçiremeye çalışırım.	1	2	3	4	5	6	7

67. Fen bilgisi dersine çalışırken, dersle ilgili okuduklarımı ve derste aldığım notları inceleyerek önemli noktaların özetini çıkarırım.	1	2	3	4	5	6	7
68. Fen bilgisi dersinde bir konuyu anlayamazsam sınıftaki başka bir öğrenciden yardım isterim.	1	2	3	4	5	6	7
69. Fen bilgisi dersiyle ilgili konuları, ders sırasında öğrendiklerim ve okuduklarım arasında bağlantılar kurarak anlamaya çalışırım.	1	2	3	4	5	6	7
70. Fen bilgisi derslerinde verilen ödevleri ve derse ilgili okumaları zamanında yaparım.	1	2	3	4	5	6	7
71. Fen bilgisi dersindeki konularla ilgili bir iddia ya da varılan bir sonucu her okuduğumda veya duyduğumda olası alternatifler üzerinde düşünürüm	1	2	3	4	5	6	7
72. Fen bilgisi dersinde önemli kavramların listesini çıkarır ve bu listeyi ezberlerim.	1	2	3	4	5	6	7
73. Fen bilgisi derslerini düzenli olarak takip ederim	1	2	3	4	5	6	7
74. Konu çok sıkıcı olsa da, ilgimi **çekmese** de konuyu bitirene kadar çalışmaya devam ederim.	1	2	3	4	5	6	7
75. Gerektiğinde yardım isteyebileceğim arkadaşlarımı belirlemeye çalışırım.	1	2	3	4	5	6	7
76. Fen bilgisi dersine çalışırken iyi anlamadığım kavramları belirlemeye çalışırım.	1	2	3	4	5	6	7
77. Başka faaliyetlerle uğraştığım için çoğu zaman fen bilgisi dersine yeterince zaman ayıramıyorum	1	2	3	4	5	6	7
78. Fen bilgisi dersine çalışırken, çalışmalarımı yönlendirebilmek için kendime hedefler belirlerim.	1	2	3	4	5	6	7
79. Ders sırasında not alırken kafam karışırsa, notlarımı dersten sonra düzenlerim.	1	2	3	4	5	6	7
80. Fen bilgisi sınavından önce notlarımı ya da okuduklarımı gözden geçirmek için fazla zaman **bulamam**.	1	2	3	4	5	6	7
81. Fen bilgisi dersinde, okuduklarımdan edindiğim fikirleri sınıf içi tartışma gibi çeşitli faaliyetlerde kullanmaya çalışırım.	1	2	3	4	5	6	7

APPENDIX E

EPİSTEMOLOJİK İNANÇLAR ANKETİ

	Kesinlikle Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
Tüm insanlar, bilim insanlarının söylediklerine inanmak zorundadır.	1❑	2❑	3❑	4❑	5❑
Bilimde, bütün soruların tek bir doğru yanıtı vardır.	1❑	2❑	3❑	4❑	5❑
Bilimsel deneylerdeki fikirler, olayların nasıl meydana geldiğini merak edip düşünerek ortaya çıkar.	1❑	2❑	3❑	4❑	5❑
Günümüzde bazı bilimsel düşünceler, bilim insanlarının daha önce düşündüklerinden farklıdır.	1❑	2❑	3❑	4❑	5❑
Bir deneye başlamadan önce, deneyle ilgili bir fikrinizin olmasında yarar vardır.	1❑	2❑	3❑	4❑	5❑
Bilimsel kitaplarda yazanlara inanmak zorundasınız.	1❑	2❑	3❑	4❑	5❑
Bilimsel çalışma yapmanın en önemli kısmı, doğru yanıta ulaşmaktır.	1❑	2❑	3❑	4❑	5❑
Bilimsel kitaplardaki bilgiler bazen değişir.	1❑	2❑	3❑	4❑	5❑
Bilimsel çalışmalarda düşüncelerin test edilebilmesi için birden fazla yol olabilir.	1❑	2❑	3❑	4❑	5❑
Fen Bilgisi dersinde, öğretmenin söylediği herşey doğrudur.	1❑	2❑	3❑	4❑	5❑
Bilimdeki düşünceler, konu ile ilgili kendi kendinize sorduğunuz sorulardan ve deneysel çalışmalarınızdan ortaya çıkabilir.	1❑	2❑	3❑	4❑	5❑
Bilim insanları bilim hakkında hemen hemen her şeyi bilir, yani bilinecek daha fazla bir şey kalmamıştır.	1❑	2❑	3❑	4❑	5❑
Bilim insanlarının bile yanıtlayamayacağı bazı sorular vardır.	1❑	2❑	3❑	4❑	5❑
Olayların nasıl meydana geldiği hakkında yeni fikirler bulmak için deneyler yapmak, bilimsel çalışmanın önemli bir parçasıdır.	1❑	2❑	3❑	4❑	5❑
Bilimsel kitaplardan okuduklarınızın doğru olduğundan emin olabilirsiniz.	1❑	2❑	3❑	4❑	5❑
Bilimsel bilgi her zaman doğrudur.	1❑	2❑	3❑	4❑	5❑
Bilimsel düşünceler bazen değişir.	1❑	2❑	3❑	4❑	5❑
Sonuçlardan emin olmak için, deneylerin birden fazla tekrarlanmasında fayda vardır.	1❑	2❑	3❑	4❑	5❑
Sadece bilim insanları , bilimde neyin doğru olduğunu kesin olarak bilirler.	1❑	2❑	3❑	4❑	5❑

Bilim insanının bir deneyden aldığı sonuç, o deneyin tek yanıtıdır.	1❑	2❑	3❑	4❑	5❑
Yeni buluşlar, bilim insanlarının doğru olarak düşündüklerini değiştirir.	1❑	2❑	3❑	4❑	5❑
Bilimdeki, parlak fikirler sadece bilim insanlarından değil, herhangi birinden de gelebilir.	1❑	2❑	3❑	4❑	5❑
Bilim insanları bilimde neyin doğru olduğu konusunda her zaman hemfikirdirler.	1❑	2❑	3❑	4❑	5❑
İyi çıkarımlar, birçok farklı deneyin sonucundan elde edilen kanıtlara dayanır.	1❑	2❑	3❑	4❑	5❑
Bilim insanları, bilimde neyin doğru olduğu ile ilgili düşüncelerini bazen değiştirirler.	1❑	2❑	3❑	4❑	5❑
Bir şeyin doğru olup olmadığını anlamak için deney yapmak iyi bir yoldur.	1❑	2❑	3❑	4❑	5❑

APPENDIX F

BİLİMSEL SÜREÇ BECERİLERİ TESTİ

1) Arabaların verimliliğini inceleyen bir araştırma yapılmaktadır. Sınanan hipotez, benzine katılan katkı maddesinin arabaların verimliliğini arttırdığı yolundadır. Aynı tip beş arabaya aynı miktarda benzin farklı miktarlarda katkı maddesi konur. Arabalar benzinleri bitinceye kadar aynı yol üzerinde giderler. Daha sonra her arabanın aldığı mesafe kaydedilir. Bu çalışmada arabaların verimliliği sizce nasıl ölçülür?

- **a.** Arabaların benzinleri bitinceye kadar geçen süre ile.
- **b.** Her arabanın gittiği mesafe ile.
- **c.** Kullanılan benzin miktarı ile.
- **d.** Kullanılan kattı maddesinin miktarı ile.

2) Bir araba üreticisi daha ekonomik arabalar yapmak istemektedir. Araştırmacılar arabanın litre başına alabileceği mesafeyi etkileyebilecek değişkenleri araştırmaktadırlar. Sizce aşağıdaki değişkenlerden hangisi arabanın litre başına alabileceği mesafeyi etkileyebilir?

- **a.** Arabanın ağırlığı.
- **b.** Motorun hacmi.
- **c.** Arabanın rengi
- **d.** a ve b.

3) Bir polis şefi, arabaların hızının azaltılması ile uğraşmaktadır. Arabaların hızını etkileyebilecek bazı faktörler olduğunu düşünmektedir. Sürücülerin ne kadar hızlı araba kullandıklarını sizce aşağıdaki hipotezlerin hangisiyle sınayabilir?

- **a.** Daha genç sürücülerin daha hızlı araba kullanma olasılığı yüksektir.
- **b.** Kaza yapan arabalar ne kadar büyükse, içindeki insanların yaralanma olasılığı o kadar azdır.
- **c.** Yollarda ne kadar çok polis ekibi olursa, kaza sayısı o kadar az olur.
- **d.** Arabalar eskidikçe kaza yapma olasılıkları artar.

4) Bir fen sınıfında, tekerlek yüzeyi genişliğinin tekerleğin daha kolay yuvarlanması üzerine etkisi araştırılmaktadır. Bir oyuncak arabaya geniş yüzeyli tekerlekler takılır, önce bir rampadan (eğik düzlem) aşağı bırakılır ve daha sonra düz bir zemin üzerinde gitmesi sağlanır. Deney, aynı arabaya daha dar yüzeyi tekerlekler takılarak tekrarlanır. Hangi tip tekerleğin daha kolay yuvarlandığı sizce nasıl ölçülür?

- **a.** Her deneyde arabanın gittiği toplam mesafe ölçülür.
- **b.** Rampanın (eğik düzlem) eğim açısı ölçülür.
- **c.** Her iki deneyde kullanılan tekerlek tiplerinin yüzey genişlikleri ölçülür.
- **d.** Her iki deneyin sonunda arabanın ağırlıkları ölçülür.

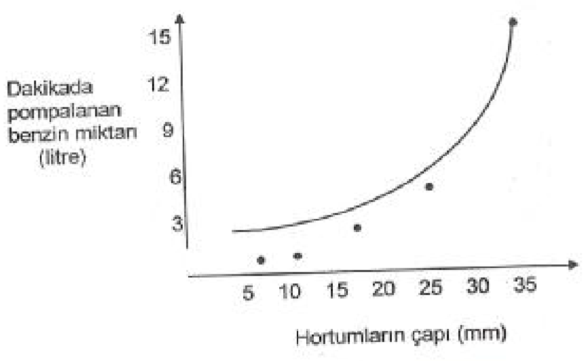
5) Ahmet basketbol topunun içindeki hava arttıkça, topun daha yükseğe sıçrayacağını düşünmektedir.

Bu hipotezi araştırmak için, birkaç basketbol topu alır ve içlerine farklı miktarda hava pompalar. Sizce

Ahmet hipotezini nasıl sınamalıdır?

- **a.** Topları aynı yükseklikten fakat değişik hızlarla yere vurur.
- **b.** İçlerinde farklı miktarlarda hava olan topları, aynı yükseklikten yere bırakır.
- **c.** İçlerinde aynı miktarlardaki hava olan topları, zeminle farklı açılardan yere vurur.
- **d.** İçlerinde aynı miktarlarda hava olan topları, farklı yüksekliklerden yere bırakır.

6) Bir tankerden benzin almak için farklı genişlikte 5 hortum kullanılmaktadır. Her hortum için aynı pompa kullanılır. Yapılan çalışma sonunda elde edilen bulgular aşağıdaki grafikle gösterilmiştir.

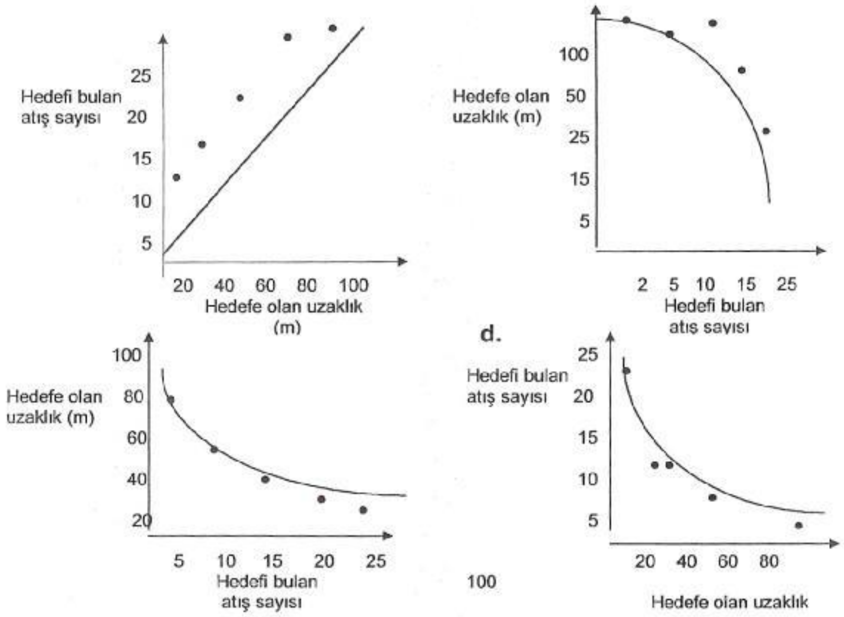


Size göre aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?

a. Hortumun çapı genişledikçe dakikada pompalanan benzin miktarı da artar.
b. Dakikada pompalanan benzin miktarı arttıkça, daha fazla zaman gerekir.
c. Hortumun çapı küçüldükçe dakikada pompalanan benzin miktarı da artar.
d. Pompalanan benzin miktarı azaldıkça, hortumun çapı genişler.

7) Bir hedefe çeşitli mesafelerden 25 er atış yapılır. Her mesafeden yapılan 25 atıştan hedefe isabet edenler aşağıdaki tabloda gösterilmiştir.

Mesafe (m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2



Ayşe, güneşin karaları ve denizleri aynı derecede ısıtıp ısıtmadığını merak etmektedir. Bir araştırma yapmaya karar verir ve aynı büyüklükte iki kova alır. Bunlardan birini toprakla, diğerini de su ile doldurur ve aynı miktarda güneş ısısı alacak şekilde bir yere koyar. 8.00-18.00 saatleri arasında, her saat başı sıcaklıklarını ölçer.

8) Sizce araştırmada aşağıdaki hipotezlerden hangisi sınanmıştır?
a. Toprak ve su ne kadar çok güneş ışığı alırlarsa, o kadar ısınırlar.
b. Toprak ve su güneş altında ne kadar fazla kalırlarsa, o kadar çok ısınırlar.
c. Güneş farklı maddeleri farklı derecelerde ısıtır.
d. Günün farklı saatlerinde güneşin ısısı da farklı olur.

9) Sizce araştırmada aşağıdaki değişkenlerden hangisi kontrol edilmiştir?

- **a.** Kovadaki suyun cinsi.
- **b.** Toprak ve suyun sıcaklığı.
- **c.** Kovalara koyulan maddenin türü.
- **d.** Her bir kovanın güneş altında kalma süresi.

10) Sizce araştırmada ölçülen değişken hangisidir?

- **a.** Kovadaki suyun cinsi.
- **b.** Toprak ve suyun sıcaklığı.
- **c.** Kovalara koyulan maddenin türü.
- **d.** Her bir kovanın güneş altında kalma süresi.

11) Sizce araştırmada değiştirilen değişken hangisidir?

- **a.** Kovadaki suyun cinsi.
- **b.** Toprak ve suyun sıcaklığı.
- **c.** Kovalara koyulan maddenin türü.
- **d.** Her bir kovanın güneş altında kalma süresi.

Murat, suyun sıcaklığının, su içinde çözünebilecek şeker miktarını etkileyip etkilemediğini araştırmak ister. Birbirinin aynı dört bardağın her birine 50 şer mililitre su koyar. Bardaklardan birisine 0 0C de, diğerine de sırayla 50 0C, 75 0C ve 95 0C sıcaklıkta su koyar. Daha sonra her bir bardağa çözünebileceği kadar şeker koyar ve karıştırır.

12) Bu araştırmada sizce sınanan hipotez hangisi olabilir?

- **a.** Şeker ne kadar çok suda karıştırılırsa o kadar çok çözünür.
- **b.** Ne kadar çok şeker çözünürse, su o kadar tatlı olur.
- **c.** Sıcaklık ne kadar yüksek olursa, çözünen şekerin miktarı o kadar fazla olur.
- **d.** Kullanılan suyun miktarı arttıkça sıcaklığı da artar.

13) Bu araştırmada sizce kontrol edilebilen değişken hangisidir?

- **a.** Her bardakta çözünen şeker miktarı.
- **b.** Her bardağa konulan su miktarı.
- **c.** Bardakların sayısı.
- **d.** Suyun sıcaklığı.

14) Sizce araştırmanın ölçülen değişkeni hangisidir?

- **a.** Her bardakta çözünen şeker miktarı.
- **b.** Her bardağa konulan su miktarı.
- **c.** Bardakların sayısı.
- **d.** Suyun sıcaklığı.

15) Sizce araştırmadaki değiştirilen değişken hangisidir?

- **a.** Her bardakta çözünen şeker miktarı.
- **b.** Her bardağa konulan su miktarı.
- **c.** Bardakların sayısı.
- **d.** Suyun sıcaklığı.

16) Bir bahçıvan domates üretimini arttırmak istemektedir. Değişik birkaç alana domates tohumu eker. Hipotezi, tohumlar ne kadar çok sulanırsa, o kadar çabuk filizleneceğidir. Sizce bu hipotezi nasıl sınar?

- **a.** Farklı miktarlarda sulanan tohumların kaç günde filizleneceğine bakar.
- **b.** Her sulamadan bir gün sonra domates bitkisinin boyunu ölçer.
- **c.** Farklı alanlardaki bitkilere verilen su miktarını ölçer.
- **d.** Her alana ektiği tohum sayısına bakar.

17) Ahmet, buz parçacıklarının erime süresini etkileyen faktörleri merak etmektedir. Buz parçalarının büyüklüğü, odanın sıcaklığı ve buz parçalarının şekli gibi faktörlerin erime süresini etkileyebileceğini düşünür. Daha sonra şu hipotezi sınamaya karar verir. Buz parçalarının şekli erime süresini etkiler. Sizce Ahmet bu hipotezi sınamak için aşağıdaki deney tasarımlarının hangisini uygulamalıdır?

- **a.** Her biri farklı şekil ve ağırlıkta beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.
- **b.** Her biri aynı şekilde fakat farklı ağırlıkta beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.
- **c.** Her biri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.
- **d.** Her biri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar farklı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

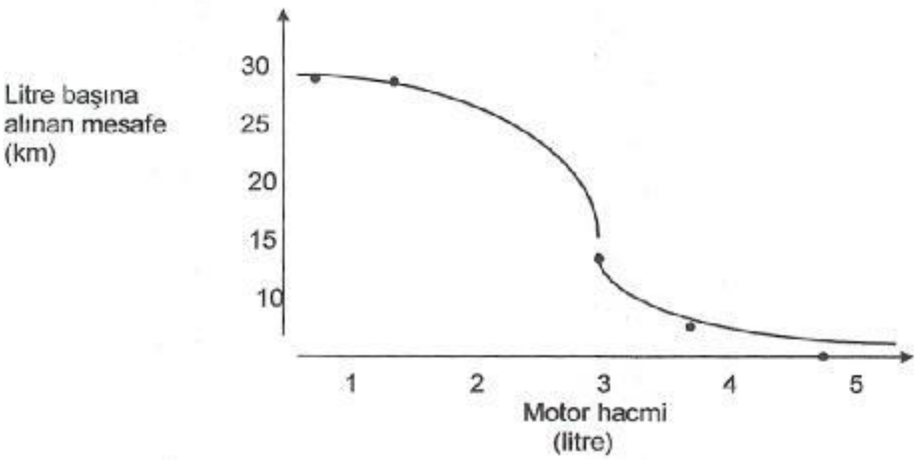
18) Bir biyolog şu hipotezi test etmek ister; Farelere ne kadar çok vitamin verilirse o kadar hızlı büyürler. Biyolog farelerin büyüme hızını sizce nasıl ölçebilir?

a. Farelerin hızını ölçer.
b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.
c. Her gün fareleri tartar.
d. Her gün farelerin yiyeceği vitaminleri tartar.

19) Öğrenciler, şekerin suda çözünme süresini etkileyebilecek değişkenleri düşünmektedirler. Suyun sıcaklığını, şekerin ve suyun miktarlarını değişken olarak saptarlar. Öğrenciler, şekerin suda çözünme süresini sizce aşağıdaki hipotezlerden hangisiyle sınayabilir?

a. Daha fazla şekeri çözmek için daha fazla su gereklidir.
b. Su soğudukça, şekeri çözebilmek için daha fazla karıştırmak gerekir.
c. Su ne kadar sıcaksa, o kadar çok şeker çözünecektir.
d. Su ısındıkça şeker daha uzun sürede çözünür.

20) Bir araştırma grubu, değişik hacimli motorları olan arabaların randımanlarını ölçer. Elde edilen sonuçların grafiği aşağıdaki gibidir:



Sizce aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

a. Motor ne kadar büyükse, bir litre benzinle gidilen mesafe de o kadar uzun olur.
b. Bir litre benzinle gidilen mesafe ne kadar az olursa, arabanın motoru o kadar küçük demektir.
c. Motor küçüldükçe, arabanın bir litre benzinle gidilen mesafe artar.
d. Bir litre benzinle gidilen mesafe ne kadar uzun olursa, arabanın motoru o kadar büyük demektir.

Toprağa karıştırılan yaprakların domates üretimine etkisi araştırılmaktadır. Araştırmada dört büyük saksıya aynı miktarda ve tipte toprak konulmuştur. Fakat birinci saksıdaki toprağa 15 kg., ikinciye 10 kg., üçüncüye ise 5 kg. Çürümüş yaprak karıştırılmıştır. Dördüncü saksıdaki toprağa ise hiç çürümüş yaprak karıştırılmamıştır. Daha sonra bu saksılara domates ekilmiştir. Bütün saksılar güneşe konmuş ve aynı miktarda sulanmıştır. Her saksıdan elde edilen domates tartılmış ve kaydedilmiştir.

21) Bu araştırmada sizce sınanan hipotez hangisidir?

- **a.** Bitkiler güneşten ne kadar çok ışık alırlarsa, o kadar fazla domates verirler.
- **b.** Saksılar ne kadar büyük olursa, karıştırılan yaprak miktarı o kadar fazla olur.
- **c.** Saksılar ne kadar çok sulanırsa, içlerindeki yapraklar o kadar çabuk çürür.
- **d.** Toprağa ne kadar çok çürük yaprak karıştırılırsa, o kadar fazla domates elde edilir.

22) Sizce bu araştırmada kontrol edilen değişken hangisidir?

- **a.** Her saksıdan elde edilen domates miktarı.
- **b.** Saksılara karıştırılan yaprak miktarı.
- **c.** Saksılardaki toprak miktarı.
- **d.** Çürümüş yaprak karıştırılan saksı sayısı.

23) Sizce araştırmada ölçülen değişken hangisidir?

- **a.** Her saksıdan elde edilen domates miktarı.
- **b.** Saksılara karıştırılan yaprak miktarı.
- **c.** Saksılardaki toprak miktarı.
- **d.** Çürümüş yaprak karıştırılan saksı sayısı.

24) Sizce araştırmada değiştirilen değişken hangisidir?

- **a.** Her saksıdan elde edilen domates miktarı.
- **b.** Saksılara karıştırılan yaprak miktarı.
- **c.** Saksılardaki toprak miktarı.
- **d.** Çürümüş yaprak karıştırılan saksı sayısı.

25) Sibel, akvaryumdaki balıkların bazen çok hareketli bazen ise durgun olduklarını gözler. Balıkların hareketliliğini etkileyen faktörleri merak eder. Sizce balıkların hareketliliğini etkileyen faktörleri hangi hipotezle sınayabilir?

- **a.** Balıklara ne kadar çok yem verilirse, o kadar çok yeme ihtiyaçları vardır.
- **b.** Balıklar ne kadar hareketli olursa o kadar çok yeme ihtiyaçları vardır.
- **c.** Su da ne kadar çok oksijen varsa, balıklar o kadar iri olur.
- **d.** Akvaryum ne kadar çok ışık alırsa, balıklar o kadar hareketli olur.

26) Murat Bey'in evinde birçok elektrikli alet vardır. Fazla gelen elektrik faturaları dikkatini çeker.

Kullanılan elektrik miktarını etkileyen faktörleri araştırmaya karar verir. Sizce aşağıdaki değişkenlerden hangisi kullanılan elektrik enerjisi miktarını etkileyebilir?

- **a.** TV nin açık kaldığı süre.
- **b.** Elektrik sayacının yeri.
- **c.** Çamaşır makinesinin kullanma sıklığı.
- **d.** a. ve c.

APPENDIX G

LIST OF CONCEPTS FOR CONCEPTUAL INVENTORIES

The List of Concepts for Skeletal System Conceptual Inventory

DESTEK VE HAREKET SİSTEMİ
- Destek ve Hareket sisteminin görevi
- Destek ve Hareket sisteminin diğer sistemlerle ilişkisi
- Destek ve Hareket sisteminin sağlığı

KEMİKLER
- Kemikler canlıdır
- Kemik çeşitleri
- Kemiklerin yapısı
- İnsan vücudundaki kemikler
- Bir bebek ve yetişkin iskeleti arasındaki farklar.
  - Kemikler büyür ve uzar.
  - Bebekelerde yetişkinlere oranla daha çok kıkırdak vardır.

EKLEMLER
- Eklemler ve vücudumuzdaki eklem çeşitleri

KASLAR
- Kaslar ve vücudumuzdaki kas çeşitleri
- Kasların görevleri

The List of Concepts for Circulatory System Conceptual Inventory

DOLAŞIM SİSTEMİ
- Dolaşım sisteminin görevi
- Dolaşım sisteminin diğer vücut sistemleriyle ilişkisi
- Kan dolaşımının gerçekleşmesi
  - Dolaşımda kanın izlediği yol
  - Dolaşımda kanın damarlardaki hareketi
- Egzersizin kalp atışına etkisi

KALP
- Kalbin görevi
- Kalbin yapısı ve kanın kalpte izlediği yol

KAN
- Kanın yapısı
- Kanın görevi

DAMARLAR
- Damar çeşitleri ve görevleri

The List of Concepts for Respiratory System Conceptual Inventory

SOLUNUM SİSTEMİ
- Solunum nedir?
- Nasıl soluk alip veriyorum?
- Solunumda Oksijen ve Karbondioksit gazı
  - Nefes ile alınan ve verilen gazlar
- Solunum sisteminin görevi
- Egzersizin nefes alışveriş hızına etkisi
- Solunum sisteminin diğer vücut sistemleri ile ilişkisi.

SOLUNUM SİSTEMİ ORGANLARI
- Solunum sisteminin organları ve görevleri
  - Akciğerlerin görevi

APPENDIX H

OPEN-ENDED QUESTIONS AND STUDENT ANSWERS

6th Graders' Deficient Responses to Open-ended Questions related with Skeletal System

DESTEK VE HAREKET SİSTEMİ

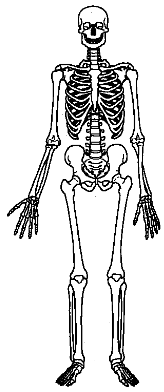
1. İskelet sistemimiz olmasaydı ne olurdu? İskelet sisteminin görevlerini düşünerek cevaplayınız.

Etten bir yığıntı gibi olurduk.

Hiçbir şeye dokunup algılayamazdık.

Nefes alamayız.

2. Kemik çeşitlerini yazınız ve aşağıdaki resimde birer örnek gösteriniz.



Eklemler

Oynar kemikler (parmak)

Yarı oynar kemikler (kafa tası)

Oynamayan kemikler (çene)

Hareketli (bilek), az hareket eden (omurga), hareketsiz kemik (kafa tası)

Yassı (kafa tası), küçük (omurga), büyük kemik (uyluk).

Düz kemik (kafa tası örneği)

Omurga

Göğüs kafesi

Kollar ve bacaklar

3. İskelet sistemindeki kemiklerin hareketi nasıl sağlanır?

Hareketli eklemler sayesinde.

Eklemler yoluyla.

Eklemler sayesinde. Eklem sıvı bir maddedir kemikler arasında bulunur.

Beynimizin yardımıyla, o bizi yönlendirir. Yürü derse yürürüz, kollarınla birşey yap derse yaparız.

Beyin ile.

4. Parmaklarımızı boynumuzdan daha çok hareket ettirebilmemizin veya kollarımızı belimizden daha çok döndürebilmemizin sebebi nedir?

Parmaklarımız ve kollarımızda daha çok kemik ya da eklem olabilir.

Kemiklerin çeşitlerine bağlıdır. Yani yatsı kemik boynumuz, kısa kemik parmaklarımız ve uzun kemik kollarımız.

Çünkü bazıları yarı oynar kemikler, bazıları da oynar kemiklerdir.

Parmakalarımızda veya kolumuzda daha çok, boynumuzda veya belimizde daha az eklem olmasından.

Çünkü parmak ve kollar oynar kemikler, boyun ve belimiz ise az oynar kemikler.

Çünkü kollarımız ve parmaklarımız hareketli kemiktir, boyun ve belimiz ise az hareketli kemiktir.

Parmaklarımız ve kollarımızda eklem vardır boynumuz ve belimizde yoktur.

5. Kıkırdak nerelerde bulunur ve görevi nedir?

Kafa tasında

6. Kolumuzu istediğimiz gibi hareket ettirebildiğimiz halde iç organlarımızın hareketlerini kontrol edemeyiz. Bunun sebebi nedir?

Kolumuzu eklemlerle hareket ettiririz ama organlarımızda kemik vb. olmadığından hareket ettiremeyiz.

Kolumuz kemiklerden oluşur. Eklemler aracılığıyla hareket eder. Ancak iç organlarımızda kemikler ve eklemler yoktur.

Organlarımızda kemikler ve iskelet sistemi olmadığı için.

Kemikler. Çünkü organlarımız kemikler koruyor.

İç organlarımızda eklemler bulunmaz.

İç organlarımız damarlarımıza bağlı olduğu için hareket ettiremiyor olabiliriz.

Çünkü kolumuzda kemikler vardır ama iç organlarımızda yoktur.

Çünkü iç organlarımızda kas yoktur. Bu yüzden hareket ettiremeyiz.

İç organların hareketini beyin yapar.

İç organlarımız kalbin, kollarımız ise beyinin emrini dinler.

Beyin onları (kollar) kontrol ediyor.

Çünkü kolumuzu biz kemikler sayesinde oynatırız. Ama iç organlarımızın bazılarını kalp, öbürlerini de beyin kontrol eder.

7. Kemiklerin ve kasların sağlığı için,

A) Yapmamız gerekenlere örnek veriniz?
B) Yapmamamız gerekenlere örnek veriniz.

8. Sizce iskelet sisteminin,

A) Solunum sistemi ile ilişkisi var mıdır? Açıklayınız.

Yoktur. Çünkü solunum boru gibi damarlarla yapılır.

Yoktur. Çünkü solunum sistemi akciğer ve karaciğerde gerçekleşir. İskeletten solunum sistemi almayız.

Yoktur. Çünkü iskelet sistemi sadece kemiklerden oluşur.

Yoktur. Çünkü solunum iskelete bir şey sağlamaz.

Hayır. Çünkü solunum sistemi ile nefes alıyoruz, iskeletle dik duruyoruz.

Vardır. Çünkü iskelet sisteminde solunum için kullanılan organlarımız vardır.

Vardır. Çünkü solunum sistemimiz ağızdan ve burundan alınır. Bunun için kemiklerimiz sayesinde koku alabiliyoruz. Ağzımızı kemiklerimiz olduğunda açıp kapatabiliyoruz.

Vardır. Çünkü soluduğumuz hava organlarımıza iskelet sistemi ile ulaşır.

B) Dolaşım sistemi ile ilişkisi var mıdır? Açıklayınız.

Yoktur. Çünkü dolaşım sistemi damarlarda gerçekleşir iskelette değil.
Yoktur. Çünkü iskelet vücudun dışındadır.

Vardır. Çünkü iskelet sistemi ile damarlar ona göre oluşmuştur.
Vardır. Kemikler ve damarlar sayesinde dolaşım gerçekleşir.
Vardır. Damarlar iskelete bağlıdır.
Vardır. Çünkü dolaşım sisteminde kan dolaşırken kalbimiz pompalıyor o da kemiklerimizin içinden geçiyor.

Vardır. Çünkü kemiklere kan gider.

Vardır. Kanımızın damarlarda dolaşmasında iskelet sisteminin rolü vardır.

Olabilir. Çünkü ***kemiklerin içinde kaslar*** *olduğu için kan dolaşımı olur.*

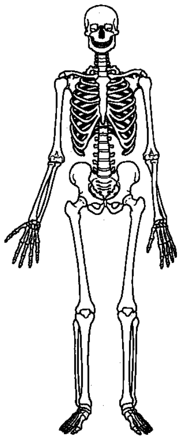
7th Graders' Deficient Responses for Open-ended Questions related with Skeletal System

DESTEK VE HAREKET SİSTEMİ

1. İskelet sistemimiz olmasaydı ne olurdu? İskelet sisteminin görevlerini düşünerek cevaplayınız.

Et yığını gibi olurduk.

2. Kemik çeşitlerini yazınız ve aşağıdaki resimde birer örnek gösteriniz.



Düz kemik (kafa tası örneği)

Yatay kemik (kafa tası örneği)

Oval kemik (kafa tası örneği)

Kısa kemiğe örnek: kafa tası ve parmaklar

Yassı kemiğe örnek: kaburgalar ve parmaklar

Kafa tası

Omur iliği

Kuyruk sokumu

Göğüs kafesi

Kürek kemiği

3. İskelet sistemindeki kemiklerin hareketi nasıl sağlanır?

Eklemler ve hareket sistemi sayesinde sağlanır.

Eklem sayesinde hareket edebilir.

Kaslarla.

Biz hareket ettikçe kemiklerimiz hareket etmeye başlar. Mesela bacağımızdaki kemik, biz hareket edince bacağımızdaki kemikde hareketi sağlar.

Beyin yoluyla sağlanır. Beyin ne derse iskelet onu yapar. Yani iskeletin komudu beyine bağlıdır.

Kemiklerimizin arasında bulunan kıkırdaklarla sağlanır.

4. Parmaklarımızı boynumuzdan daha çok hareket ettirebilmemizin veya kollarımızı belimizden daha çok döndürebilmemizin sebebi nedir?

Çünkü belimizde ve boynumuzda eklemsiz bir kemik bulunmaktadır. Buna omur iliği denir. Parmaklarımızda eklem bulunur ve daha rahat hareket eder.

Eklemlerimiz olmayan yerler fazla hareket edemez.

Eklemler daha gevşektir.

Kollarımız tam oynardır, parmaklarımız da tam oynardır. Ama boynumuz yarıoynar olduğu için parmaklarımız kadar dönmez.

Çünkü parmaklarımız ve kolumuz daha esnektir.

Parmaklarımızda olan kemik daha çok hareketli olduğu için.

Omurga kemiği sayesinde.

Parmakta daha çok kemik vardır.

Çünkü kırılabilir, çıkabilir. Ondan dönmez ve dönemez.

Parmağımızdaki kaslar hareketlidir. Ama boynumuzdaki kaslar parmaklarımızdaki kaslara göre daha az hareketlidir.

Parmaklarımızdaki kaslar fazladır. Boynumuzdaki kaslar az olduğu için boynumuzu az hareket ettiririz.

Çünkü parmaklarımız yassı kemiktir.

5. Kıkırdak nerelerde bulunur ve görevi nedir?

Kafatasında

6. Kolumuzu istediğimiz gibi hareket ettirebildiğimiz halde iç organlarımızın hareketlerini kontrol edemeyiz. Bunun sebebi nedir?

Çünkü onlar isteğimiz dışı gerçekleşir.

Bunun sebebi, iç organlarımızın her birinin görevi vardır, ondan oynatamayız.

Çünkü kolumuz esnektir.

Kolumuzdaki kaslar hareketli kaslardır. Ama iç organlarımzıdaki kaslar hareketsiz kaslardır.

Kolumuz istemli çalışır fakat iç organlarımızı beynimiz yönetir.

İç organlarımız vücudumuzun içinde bulunur. Ama kollarımız dış organlarımız olduğundan ve hareket edebildiğinden hareket eder.

Kolumuz dışarıdadır. Ama organımız içimizdedir.İç organlarımızı hareket ettirememememizin sebebi, onları göremeyiz ve de dokunamyız.

7. Kemiklerin ve kasların sağlığı için,

C) Yapmamız gerekenlere örnek veriniz.
D) Yapmamamız gerekenlere örnek veriniz.

Çok fazla yemek yemek.

8. Sizce iskelet sisteminin,

C) Solunum sistemi ile ilişkisi var mıdır? Açıklayınız.

Yoktur.

Yoktur çünkü kemik ve solunum ayrı.

Yoktur. Çünkü solunum sistemi kemikten oluşmaz.

Vardır. Sonuçta vücudu dengede tutan iskelet sistemi.

D) Dolaşım sistemi ile ilişkisi var mıdır? Açıklayınız.

Yoktur.
Yoktur. Çünkü dolaşım sistemi damarlardan orgalardan ve kaslardan başka şeylerle ilişkisi yok.
Yoktur. Çünkü sadece dik ve hareket etmemizi sağlar.
Yoktur. Çünkü dolaşım sistemi iç organlarımızdan oluşur.

Vardır. Çünkü iskelet sistemi herşeyi birbirine bağlar.
Alyuvarlar ve akyuvarlarla ilişkisi vardır.
Olabilir. Çünkü damarlar kemiklerin üstünde olabilir.
Vardır. Damarlar iskelet sisteminin üstünden geçer.

6th Graders' Deficient Responses for Open-ended Questions related with Circulatory System

DOLAŞIM SİSTEMİ

1. Dolaşım sisteminin vücudumuz için önemi nedir?

Dolaşım yapmazsak vücudumuzdaki zararlı şeyler bizi hasta eder.

Bize temiz kan üretmesi.

Dolaşım sistemi boşaltım, kan dolaşımı ve dolaşım diye üçe ayrılır. Hepsinin vücudumuzda görevi vardır. Kirli besinleri dışarı atma, besinlerin her yere ulaşması.

Dolaşım sistemi vücudumuzda kan üretir. Bundan önemlidir.

Dolaşım sistemi olmazsa kan üretilmez.

2. Dolaşım sisteminin tüm elemanlarını ve görevlerini yazınız.

Beyin: Bütün dolaşım sistemi onun elindedir.

Beyin

Karaciğer

Sindirim sistemi organları: Ağız, Yutak, Bağırsaklar, Yemek borusu

Boşaltım sistemi organları: Böbrek, İdrar borusu, İdrar kesesi, Üreter, Üretra

Solunum sistemi organları: Akciğer, Gırtlak, Soluk borusu

3. Vücudumuzda kan nerede üretilir?

Kalpte

Damarlarda

4. Kan nelerden oluşur? Yapısında bulunanları yazınız.

Kanın yapısında oksijen ve karbon hitrat bulunmaktadır.

Midemizde parçalanan yiyecekler sayesinde kan oluşur.

Kan yemeklerden, vitaminlerden ve içeceklerden oluşur.

Su ve mineraller, vitaminler yağlar proteinler besinler.

Kanın içinde gerekli ve sağlıklı olan besinler vardır.

Sağlıklı yiyecek ve içecekleden yapısında bulunur.

Yediğimiz meyve, sebze ve yemeklerden oluşur.

5. Kanın vücudun farklı organlarına taşıdığı maddeler nelerdir?

Mikroplar.

Hücrelerdir.

6. Kalp rahatsızlığı olan bir insanda kalbin düzenli çalışmaması vücudu neden güçsüz düşürür?

Besini iyi üretemediği için, vitamin üretemediği için.

Kalp kanı pompalar. Kalp olmazsa kan olmaz bu yüzden sorun oluşur. (3. Soruya kanın kapte üretildiğini belirtmiş)

7. Damar çeşitlerini yazınız ve görevlerini açıklayınız.

Şahdamar
Şahdamar: Beyni besleyen ana damardır.

İnce damar

Can damarı

Kan damarı

Bilek damarı: Görevi: nabzımızı göstermek.

Aort

8. Yukarıdaki soruda bahsettiğiniz damarların hangisinin kesilmesi daha tehlikelidir? Neden?

9. Bademcikler hangi sisteme aittir ve ne işe yararlar?

Boğaza aittir.

Alınırsa hasta olunmaz.

Soluk borusuna aittir hasta olunca şişer.

Öksürmemizi sağlar.

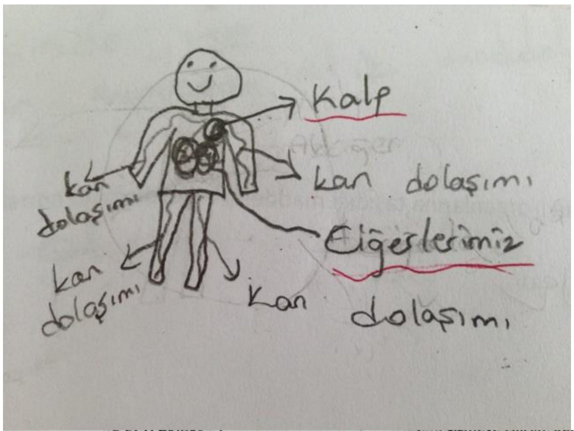
Yutkunmamızı sağlar.

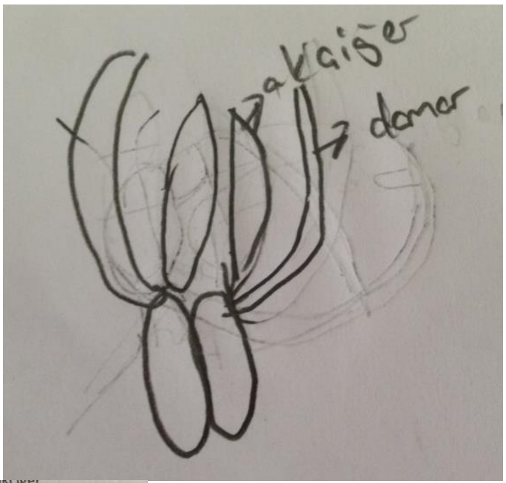
Seslerle bağlantısı vardır.

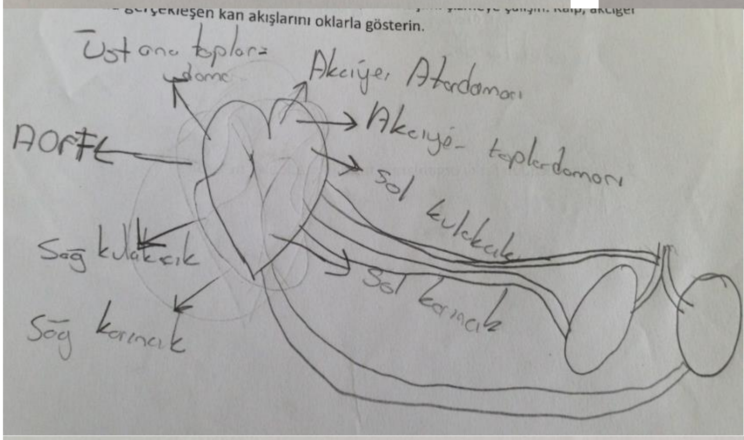
Ses sistemi

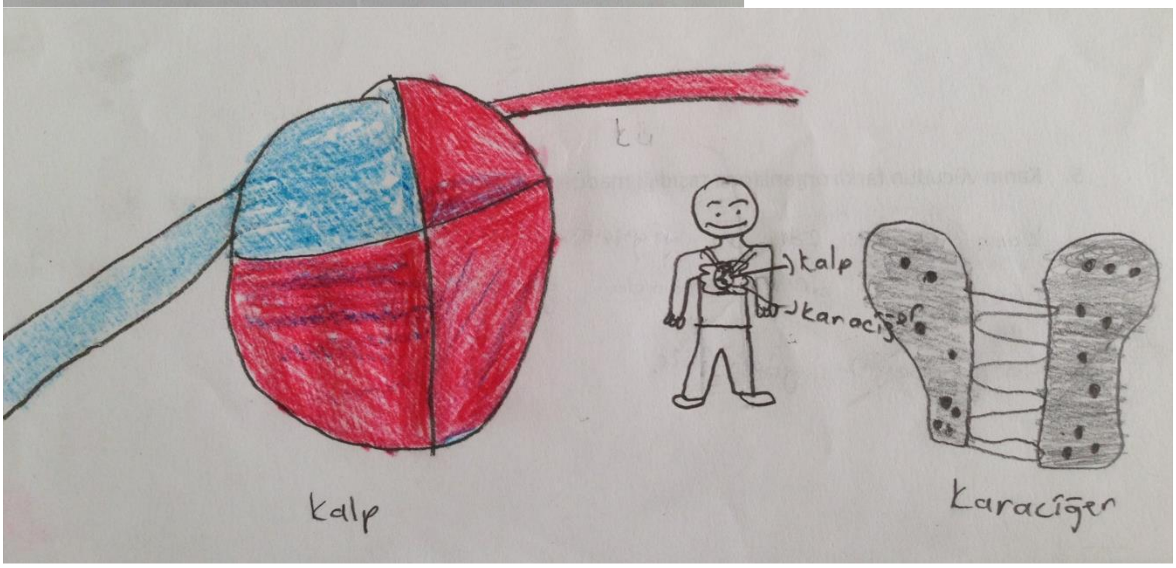
Solunum sistemi

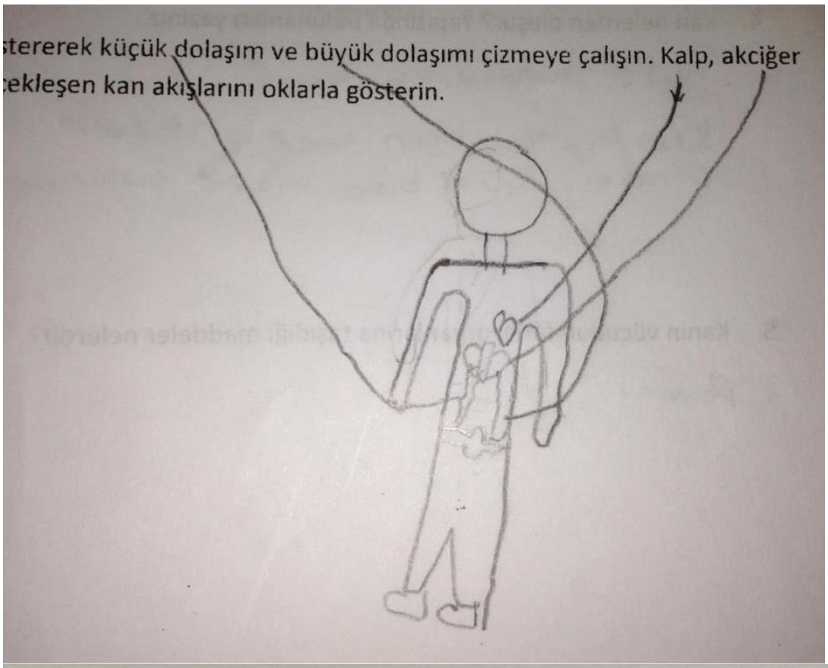
10. Kalbin bölümlerini göstererek küçük dolaşım ve büyük dolaşımı çizmeye çalışın. Kalp, akciğer ve vücut arasında gerçekleşen kan akışlarını oklarla gösterin.

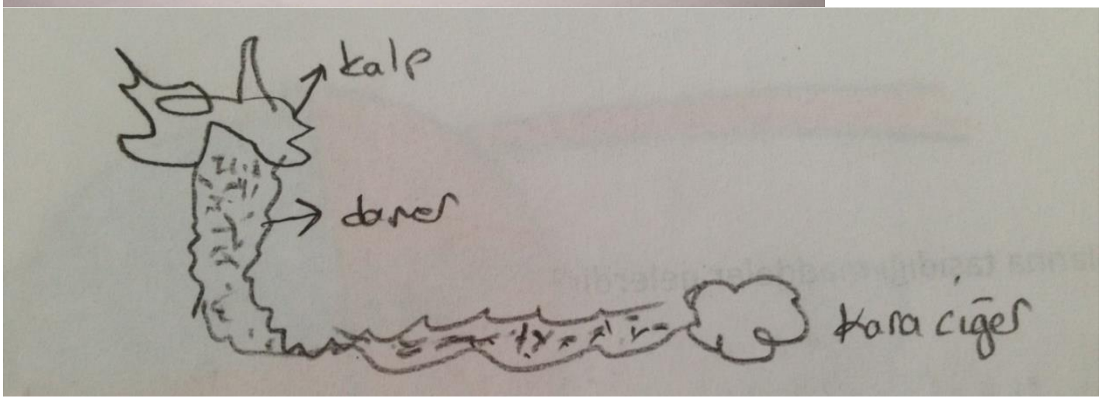

Kalp
kan dolaşımı
kan dolaşımı
Ciğerlerimiz
kan dolaşımı
kan dolaşımı


akciğer
damar

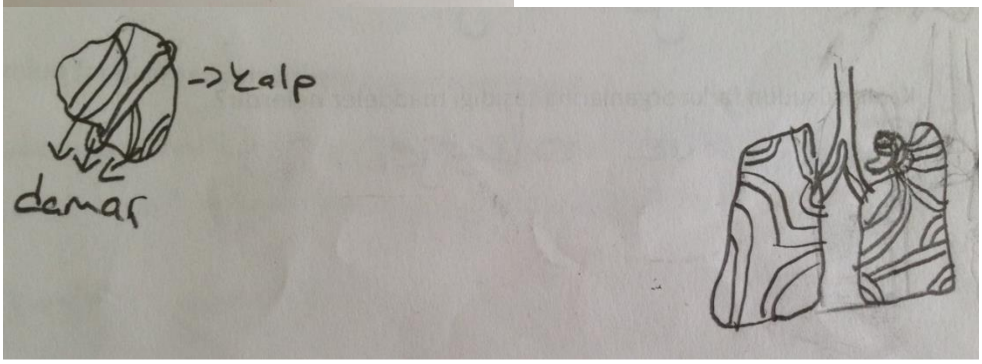

gerçekleşen kan akışlarını oklarla gösterin.
Üst ana toplar damar
Akciyer Atardamarı
Akciyer toplardamarı
AORT
Sol kulakçık
Sağ kulakçık
Sol karıncık
Sağ karıncık


kalp
karaciğer
Kalp
Karaciğer


stererek küçük dolaşım ve büyük dolaşımı çizmeye çalışın. Kalp, akciğer
ekleşen kan akışlarını oklarla gösterin.


kalp
damar
kara ciğer


kan akışı
pompa


kalp
damar

7th Graders' Deficient Responses for Open-ended Questions related with Circulatory System

DOLAŞIM SİSTEMİ

1. Dolaşım sisteminin vücudumuz için önemi nedir?

Yediğimiz besinlerin kötüsünü dışarı atar, iyileri kana karışır.

Yediğimiz besinleri zararlı besinleri bir tarafa, zararsız besinleri bir tarafa iletilmesini sağlar.

Yediğimiz besinleri vücudumuzda gezdirir.

Kanı temizler.

Kirli kanın temizlenmesi için önemlidir.

Kirli kanı temizler.

Yediğimiz besinleri sindirerek organlardan damarlara geçerek vitamin ve protein sağlar.

Nefes almayı, yaşamamızı kolaylaştırır ve bu yönden de bizim için önemi büyüktür.

Kirli kanın temizlenmesi açısından önemlidir.

2. Dolaşım sisteminin tüm elemanlarını ve görevlerini yazınız.

Omurilik,

Akciğer,

Böbrekler: Kanı süzer

Karaciğer

Kan pulcukları

Atar damar

Lenf

Gırtlak

Diafram

İdrar torbası

Lenf sistemi

Kalp: Kanı ***temizler*** *ve geri vücuda gönderir.*

3. Vücudumuzda kan nerede üretilir?

Kalpte

Üreterde. Çünkü orada toplanıyor.

Kalp kanı yeniler.

Vücudumuzdaki alyuvarda üretilir.

Toplar damarlarda.

4. Kan nelerden oluşur? Yapısında bulunanları yazınız.

Yiyeceklerden.

Yediğimiz ve içtiğimiz şeylerden oluşur.

Yediğimiz besnlerin emilmesi tarafından oluşur.

Yiyeceklerden, vitaminler ve proteinlerden oluşur.

5. Kanın vücudun farklı organlarına taşıdığı maddeler nelerdir?

Alyuvar, akyuvar, kan plazması

Mikrop vb.

6. Kalp rahatsızlığı olan bir insanda kalbin düzenli çalışmaması vücudu neden güçsüz düşürür?

Nefes alıp vermesi zorlaşır. (1. Soruda dolaşım sistemi nefes almayı kolaylaştırır cevabı vermişti.)

Kan temizlenemez ve organların çalışımını olumsuz etkiler.

7. Damar çeşitlerini yazınız ve görevlerini açıklayınız.

Kılcal damar: Atar damar ile toplar damarı birbirine bağlar.
Aort damar: En büyük damardır.
Atar damar: Kirli kanı vücuda verir. / Toplar damar: Kirli kanı toplar.
Akciğer atardamarı / Akciğer toplardamarı

8. Yukarıdaki soruda bahsettiğiniz damarların hangisinin kesilmesi daha tehlikelidir? Neden?

Kılcal damar

Kılcal damar, çünkü en önemli damarımızdır.

Kılcal damar. Çünkü atar damar ile toplar damarı birbirine bağlar.

Şah damarı, çünkü en çok kan oradan geçiyor.

9. Bademcikler hangi sisteme aittir ve ne işe yararlar?

Boğaz, yutmayı kolaylaştırır.

Solunum sistemi, mikropları koruyor.

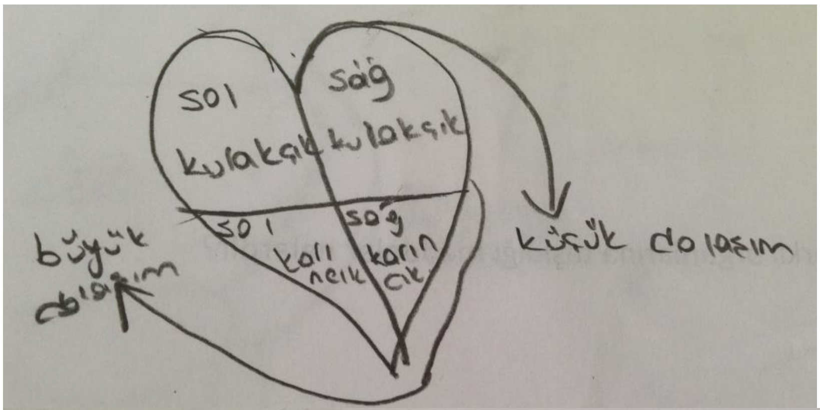
Sindirim sistemine. Sıcak soğuk şeyler yiyince şişip şişmemesi.

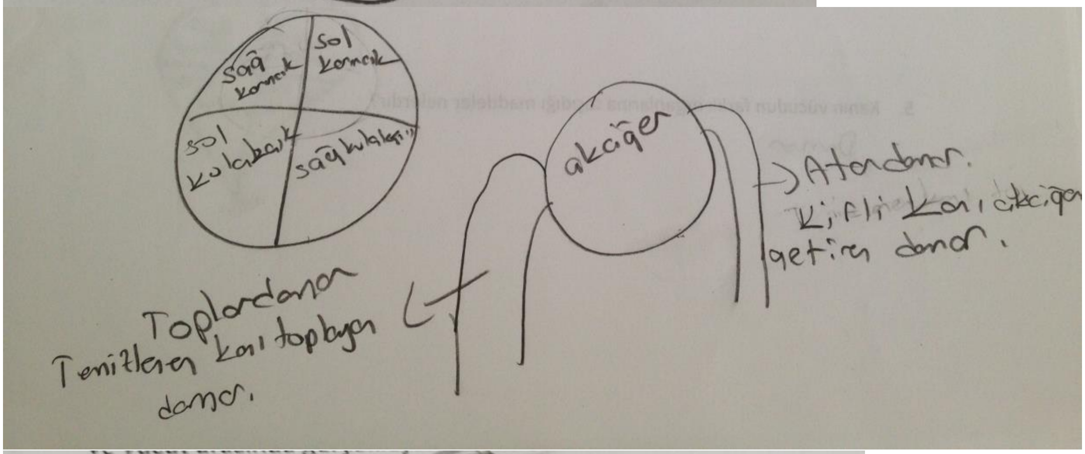
Sindirim sistemi. Ağızdan alınan havanın içindeki mikropları toplar.

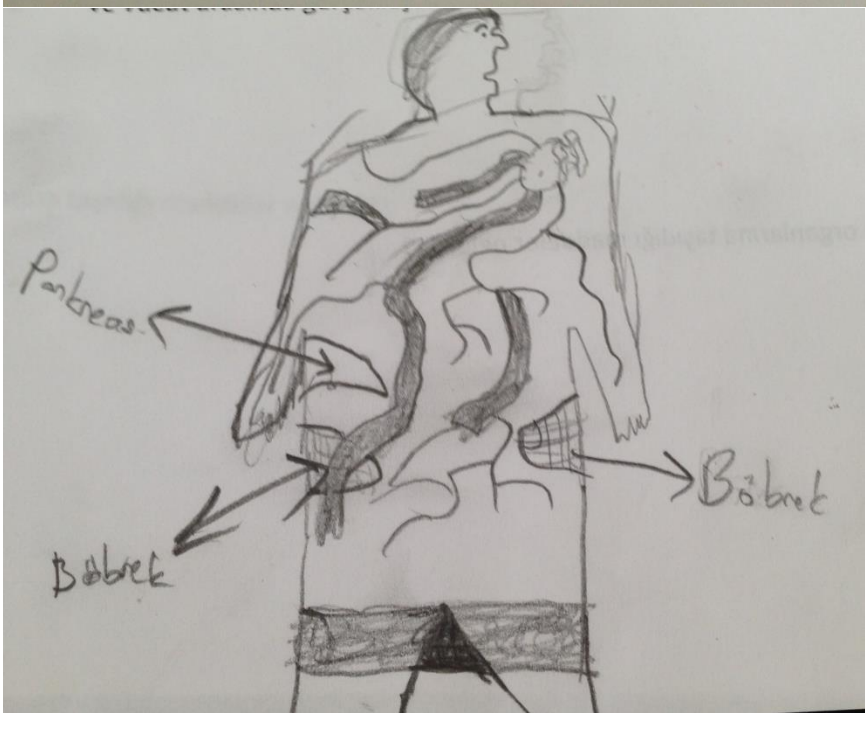
Dilin arka bölümünde bulunur.

Dolaşım sistemine aittir. Soğuğu ve sıcağı ayırt etmemize yarar.

10. Kalbin bölümlerini göstererek küçük dolaşım ve büyük dolaşımı çizmeye çalışın. Kalp, akciğer ve vücut arasında gerçekleşen kan akışlarını oklarla gösterin.


sol
sağ
küçük dolaşım
büyük dolaşım


sol
akciğer


Pankreas
Böbrek
Böbrek

6th Graders' Deficient Responses for Open-ended Questions related with Respiratory System

SOLUNUM SİSTEMİ

1. Solunum sisteminin organlarını yazınız ve yandaki şemada çizerek gösteriniz.

Diyafram

Ağız

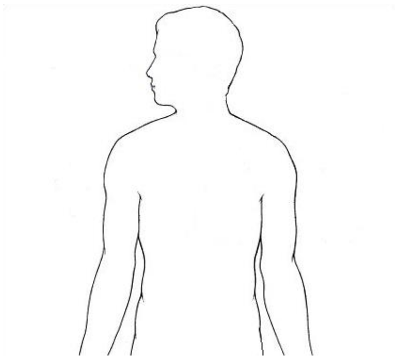
Solunum borusu

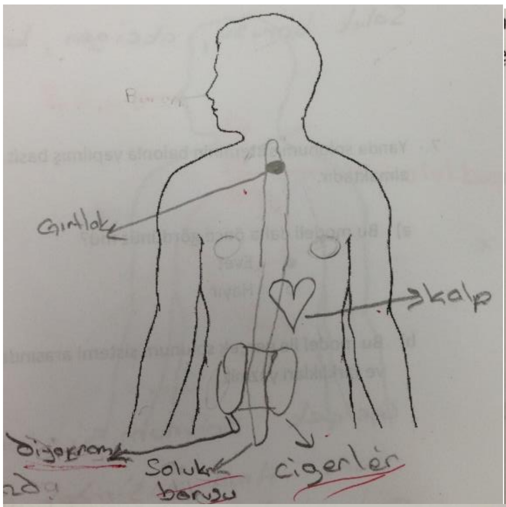
Karaciğer

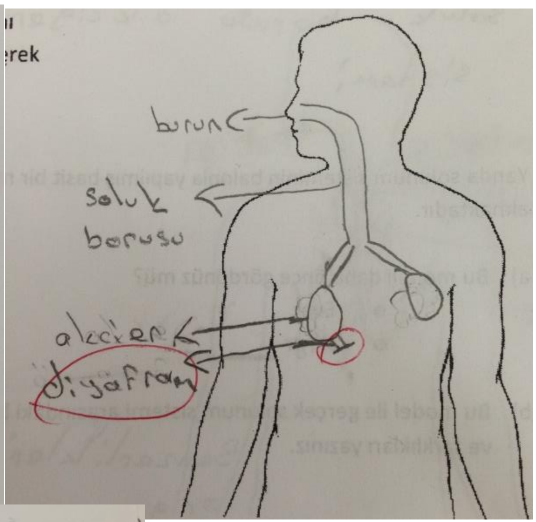
Böbrekler

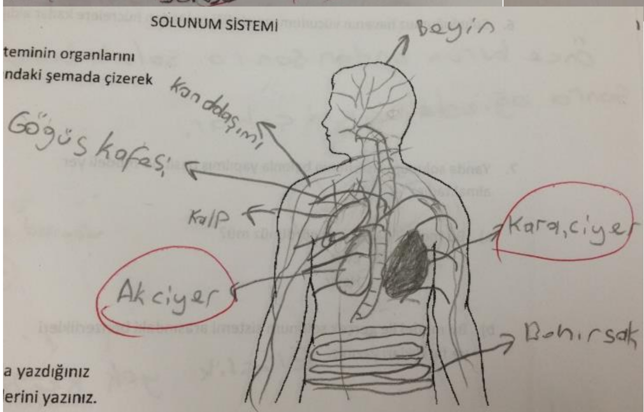
Mide

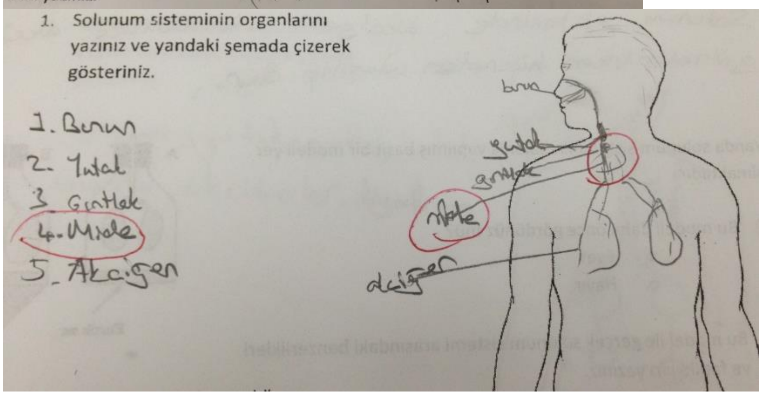
Kalp

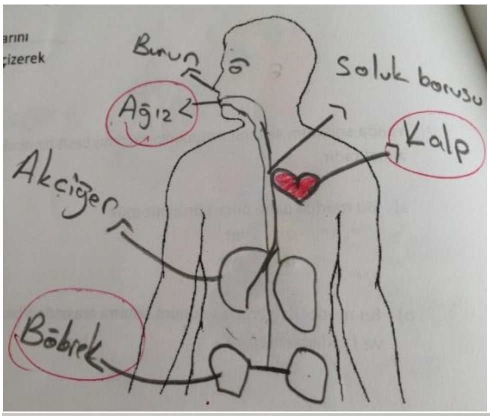


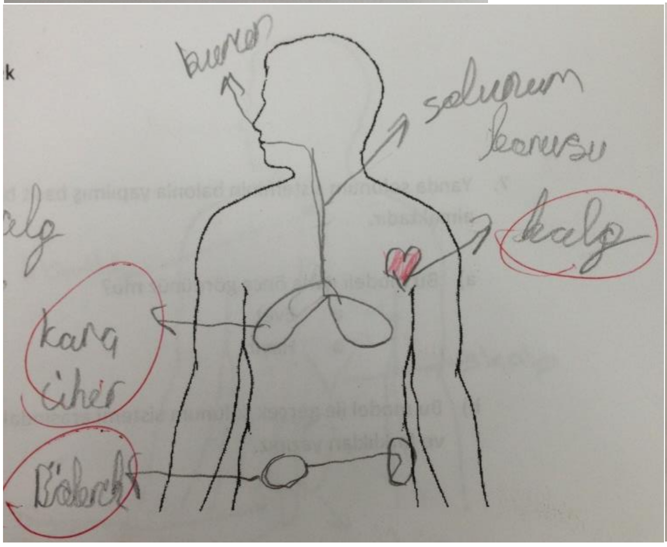

Gırtlak
kalp
Diyafram
Soluk borusu
Ciğerler

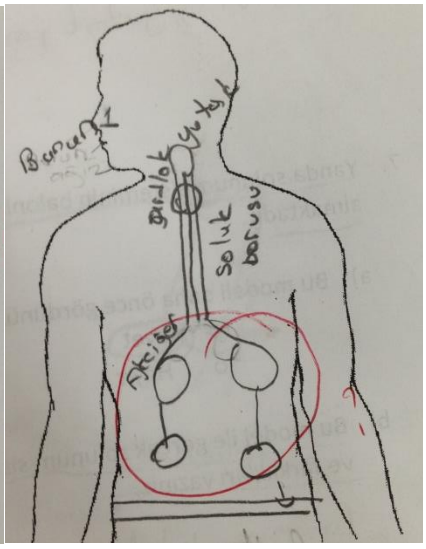

burun
Soluk borusu
Diyafram


SOLUNUM SİSTEMİ
teminin organlarını
ndaki şemada çizerek
a yazdığınız
lerini yazınız.
Beyin
kan dolaşımı
Göğüs kafesi
Kalp
Karaciyer
Akciyer
Bahırsak


1. Solunum sisteminin organlarını yazınız ve yandaki şemada çizerek gösteriniz.
1. Burun
2. Yutak
3. Gırtlak
4. Mide
5. Akciğer







2. Yukarıdaki soruda yazdığınız organların görevlerini yazınız.

*Burun **dışarıdaki O2'yi alır**. Yutak **O2'yi** içeri verir. Gırtlak soluk borusuna giden yoldur. Soluk borusu ise **O2'nin** akciğerlere ulaşmasını sağlar. **Akciğerler soluğu hapis eder** ve yaşarız. **Ağız** ise burundan soluk alamayanların tercihidir.*

*Burun **O2'yi içine alır**. Ağız **O2'yi dışarıya verir**. Yutak **O2'yi** gırtlağa yollar oradan **solunum borusu O2yi** akciğerlere yollar ve **akciğerde solunum işi biter**.*

Ağız. Solunumun başladığı yerdir.
Burun: Havadaki oksijeni içine çeker
Burun: Oksijen alır verir. Ağız: Ağız ise karbondioksit alır ve verir.
Akciğer: Havayı temizler
Akciğer: Yaşamamıza yarar
Akciğer: Havayı alır ve geri bırakır biz de nefes alırız.
Akciğer: Havayı alır ve bırakır.
Akciğer: Dolaşım sistemini sağlar.
Akciğer: Soluğu hapis eder.
Akciğer: havayı temizler. Böbrek: Kirli kanı temizler.
Solunum borusu: Nefesi böbreklere taşır.
Solunum borusu: Nefes almamıza yarıyor.
Soluk borusu: Akciğere solunum yapar.

Karaciğer ve akciğer: nefes alıp verme
Böbrekler: Havayı temizler
Böbrekler: Kirli kanı temizler.
Kalp: nefes alıp vermemize yarar.
Kalp: Kanımızı depolar.

3. Nefes alıp verme sırasında gaz alışverişi nerede ve nasıl olur?

Dışarıdan temiz havayo alıp (oksijen) dışarıya kirli havayı veririz (karbondioksit).
Ağız ve burunda olur.
Burun ve nefes borusu
Burundan oksijen alınarak ağızdan karbondioksit verilir.
Nefes alma burundan akciğere yol alarak vücudun içindeki karbondioksiti ağızdan vermektir.
Akciğerlerde olur. Akciğerler temizler havayı, alıp verir.
Burundan oksijen alınarak, ağızdan karbondioksit verilerek.

4. Nefes alıp verebilmemiz için diyafram ve kaburga kaslarında olması gereken değişiklikleri açıklayınız. Hava akciğerlere nasıl dolar ve nasıl boşalır?

Diyaframın nefes aldığımızda şişmesi gerekir.
Havayı ağzımızdan verir burnumuzdan alırız bu sayede diyafram şişer ve iner.
Diyafram soluk alırken içeri çekilir, soluk verirken kaburga kasları kasılır.
Büyüme ve küçülme olur.
Nefes aldığımızda diyafram şişer, verdiğimizde iner.
Nefes alırken diyafram ve kaburga kasları şişer ve burundan ***aldığımız hava diyafram ve kaburga kaslarına dolar.***
Hava akciğerlerimize burundan hava alarak dolar.
Nefes alırken içimize enerji depolarız ama verince o enerjiyi geri veririz.

5. Uzun süre nefes almazsak ne olur? Sizce vücudumuzun nefes alıp vermeye neden ihtiyacı vardır?

Uzun süre nefes almazsak oksijen dışarı çıkar ve ölmemize nedne olur.

Bayılabiliriz. Vücudumuzun nefes alıp vermeye kan dolaşımını hızlandırması için ihtiyaç olabilir.

İç prganlarımız hava alamaz ve havasızlıktan ölür.

Kalbin ritmi bozulur.

Ölürüz çünkü kalp=solunum.

Ölürüz. Nefes alıp verdiğinde organlarımız çalışır.

Nefes almazsak kalbimizin ***nabzı düşer.***

Oksijen olmazsa kalp atmaz. Kalp atmayınca yaşayamayız.

6. Soluduğumuz havanın vücudumuza girdiği noktadan hücrelere kadar aldığı yolu açıklayınız.

Burun, yutak, gırtlak, soluk borusu, ***akciğer, hücreler***

Burun, yutak, gırtlak, ***nefes borusu****, akciğerler,* ***diyafram***

Soluk borusu, akciğer, ***kalp*** *ve solunum sistemi.*

Burundan alınan hava soluk borusuna taşınır. Oradan akciğere gider ve hava temizlenir ve ağzıdan dışarı çıkar.

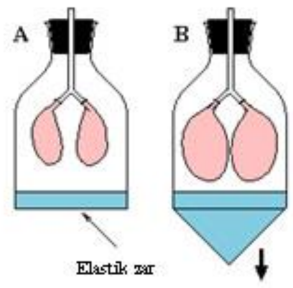
Solunum sisteminde oksijen vücudumuzda dolaştığında hücrelere ulaşır.

7. Yanda solunum sisteminin balonla yapılmış basit bir modeli yer almaktadır.

a) Bu modeli daha önce gördünüz mü?

- o Evet
- o Hayır

b) Bu model ile gerçek solunum sistemi arasındaki benzerlikleri ve farklıkları yazınız.



Diyafram nefes aldığımızda şişmiş, verdiğimizde inmiştir.

Elastik yok (vücutta) kendi şişer (akciğerler kendisi şişer)

8. Solunum sisteminin sağlığını korumak için,

A) Yapılması gerekenler nelerdir?

Su içmek

B) Yapılmaması gerekenler nelerdir?

Büyük lokmalar yememeliyiz.

Asitli şeyler içmemeliyiz.

Abur cubur yememeliyiz.

Fazla hereketli olmamalıyız.

Erken uyumalıyız.

Fazla yağlı şeyler yememeliyiz yoksa tıkanıklığa yol açar.

9. Solunum sistemi ve dolaşım sistemi arasında bir ilişki var mıdır? Açıklayınız.

Solunum nefes almamızı, dolaşım kan dolaşımını sağlar.
Solunum sistemi havayı taşır fakat dolaşım sistemi kanı taşır.
Solunum sistemi oksijeni, dolaşım sistemi kanı ulaşması gereken yere ulaştırır. İkisi de vücut içinde dolaşır ve ikisi de vücudun ihtiyacı olan şeylerdir.
Aldığımızı nefesi alırken kirli kanlar gider.
Evet. Aldığımız nefes kanı temizler.
Evet. Solunum sistemi ve dolaşım sistemi de aynı organlar ile hareket eder.
Ever var. Aldığımızı nefes kanlarda dolaşır.

10. Solunum sisteminin diğer vücut sistemleri ile ilişkilerini açıklayınız.

Vücudun diğer elemanlarına yardım eder.

Solunum sisteminden hava alırız, diğer organlara gider ve sağlığımızı koruruz.

Solunum sisteminde bazı organlar boşaltım sistemin de aynı görevi yapabilirler. (İlk soruda böbrek denmiş ve resimde gösterilmiş.)

7th Graders' Deficient Responses for Open-ended Questions related with Respiratory System

SOLUNUM SİSTEMİ

1. Solunum sisteminin organlarını yazınız ve yandaki şemada çizerek gösteriniz.

Ağız

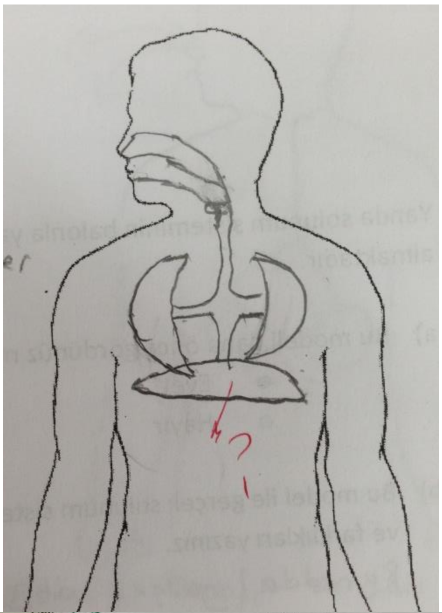
Yutak

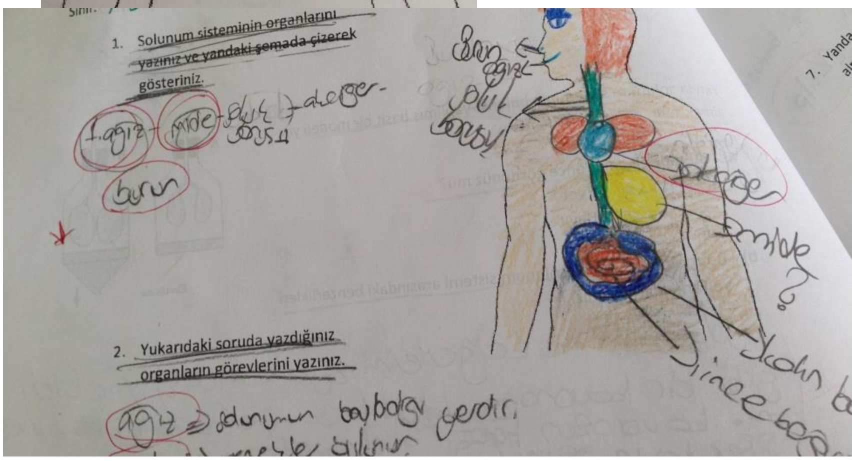
Diyafram

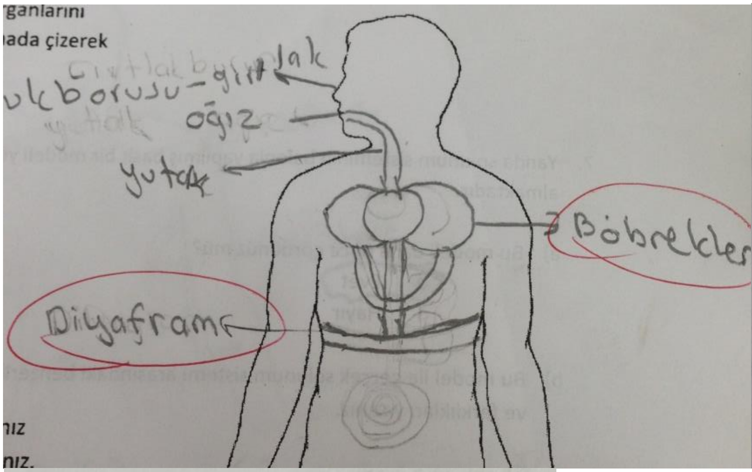
Nefes borusu

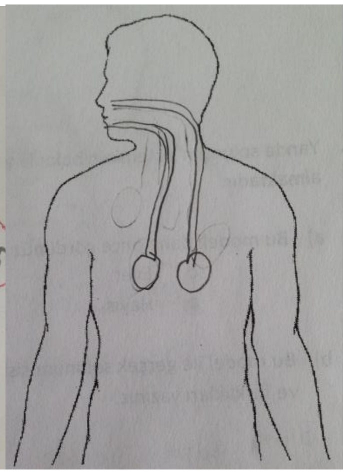
Karaciğer

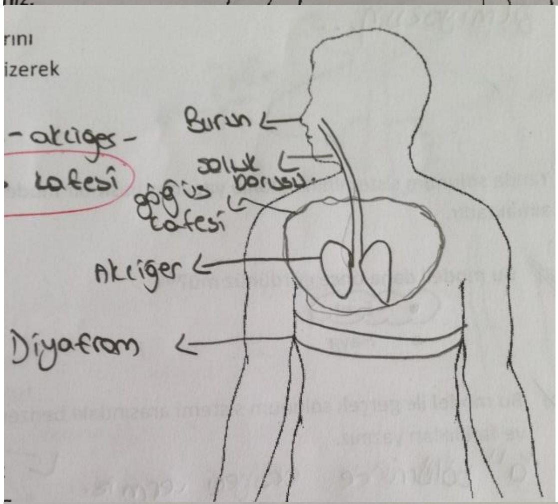
Böbrekler

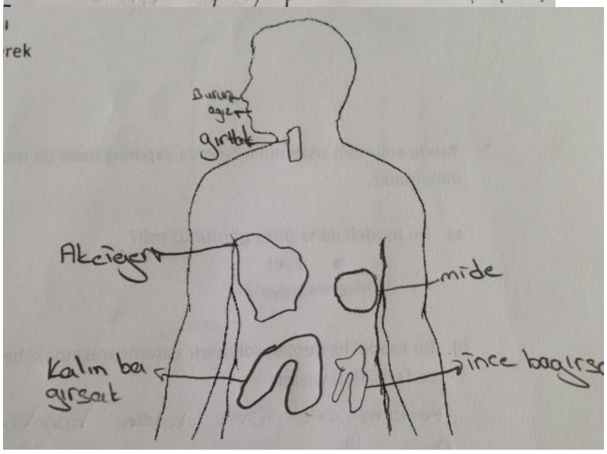












2. Yukarıdaki soruda yazdığınız organların görevlerini yazınız.

Burun: Nefes ve koku almamızı sağlar. Ağız: Karbondioksiti vermemizi sağlar.
Burun: Havayı alıp verir.
Akciğer: Oksijeni alıp karbondioksiti geri gönderir.
Akciğer: Havayı temizler.
Akciğer: Havayı içine çekip karbondioksiti dışarı gönderir.

Yutak: Oksijenin geçtiği yer / Nefes borusu: Oksijeni akciğere ileten yer. / Akciğer: Oksijenin karbondioksite çevrildiği yer.

3. Nefes alıp verme sırasında gaz alışverişi nerede ve nasıl olur?

Burundan ***oksijen*** *alıp akciğere gider, akciğerden de* ***karbondioksit*** *olarak burundan dışarı çıkar.*
Burundan alırız. Akciğerlere iletiriz. Akciğerler gelen havayı temizleyip kana karıştırırlar. Geri kalanları ise tekrar burunda kirli hava oalrak geri atarlar.

4. Nefes alıp verebilmemiz için diyafram ve kaburga kaslarında olması gereken değişiklikleri açıklayınız. Hava akciğerlere nasıl dolar ve nasıl boşalır?

Nefes alırken diyafram küçülür ve nefes verirken de büyür. Akciğerimize havayı çektiğimiz zaman akciğer dolar verdiğimizde ise boşalır.

5. Uzun süre nefes almazsak ne olur? Sizce vücudumuzun nefes alıp vermeye neden ihtiyacı vardır?

Uzun süre nefes almazsak hücrelerimiz ölür. Vücudumuzda ***kanın*** *tüm hücrelere* ***taşınması*** *için nefes alınması gerekir.*

Uzun süre nefes almazsak beyine kan gider. Bu da ölümcül sonuçlara neden olabilir.

Kan *dolaşımının* ***ilerlemesi*** *için olabilir.*

Çünkü nefes alırken oksijen içimize doluyor böylelikle kanımıza oksijen karışır ve ***kanın pıhtılaşmasını önler.***

Kirli hava dışarı çıkamaz ve tıkanıklığa yol açar. Nefes alıp vermezsek kalbimiz durabilir. Kalbin kanı pompalaması için nefes alıp vermemiz gerekir.

6. Soluduğumuz havanın vücudumuza girdiği noktadan hücrelere kadar aldığı yolu açıklayınız.

Ağız, burun soluk borusu, akciğer, broş, broşçuklar.

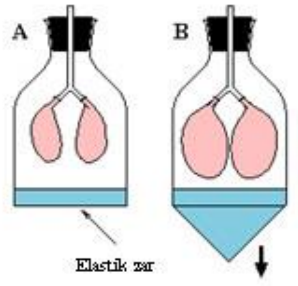
Ağız, yutak, karaciğer
Soluduğumuz havanın vücudumuza girdiği nokta burnumuzdur. Daha sonra soluk borusundan geçerek broşlara yollanır. Oradan akciğerlere, oradan da broşlara yollanarak ***temiz hava süzülür. Kirli hava dışarı atılır. Temiz hava kanımıza karışarak orayı da temizler.*** *Daha sonra da organlarımızın çalışmasını sağlar.*

7. Yanda solunum sisteminin balonla yapılmış basit bir modeli yer almaktadır.

a) Bu modeli daha önce gördünüz mü?

- o Evet
- o Hayır

b) Bu model ile gerçek solunum sistemi arasındaki benzerlikleri ve farklıkları yazınız.



Bu modelde gösterilen pipeti üflediğimizde balon şişiyor. Aynı akciğerlerler gibidir. Havayı içimize çektiğimizde de akciğerler içinde tutar. Bir benzerlik vardır.

A modelinde nefes alıp verme bitmiş, B modelinde ise akciğerlere hava gittiğini görüyoruz.

Bu modelde böbreklerin şiştiği vardır. (ilk soruda böbrekler cevabı verilmiş)

8. Solunum sisteminin sağlığını korumak için,

a) Yapılması gerekenler nelerdir?

Hapşırırken nefesimizi tutmamalıyız.

b) Yapılmaması gerekenler nelerdir?

9. Solunum sistemi ve dolaşım sistemi arasında bir ilişki var mıdır? Açıklayınız.

Yoktur.
Vardır. Solunum sistemi ile dolaşım sistemi aynı anlama gelmektedir.
Vardır. Solunum sistemimiz sayesinde kan dolaşımı sağlanır.
Solunum sistemi nefes almayla olur. Dolaşım sistemi ise bütün vücutta dolaşım olmasıdır.
Evet çünkü nefes alıp vererek kalp çalışır ve dolaşım sistemi görev yapar. Nefes alıp vermezsek solunum sistemi olmaz, bu yüzden dolaşım da olmaz.

10. Solunum sisteminin diğer vücut sistemleri ile ilişkilerini açıklayınız.

Solunum sisteminde nefes alıp veririz, karbondoksit dışarı atılır. Boşaltım sisteminde ise kandaki zehir dışarı atılır. Yani benzerdir.

Hepsi de ağızda başlar. (Tüm sistemler)

Solunum nefes alıp vermemizdir. Diğerleri ise kendiliğinden olan sistemlerdir. ***Solunum sistemini biz kontrol ederiz.***

Solunum sistemi nefes almamızı sağlar.

Solunum sistemimiz sayesinde organlarımıza temiz kan gitmektedir. Onun sayesinde kanımız vücudumuzda dolanır. Onun sayesinde kalbimiz çalışır.

APPENDIX I

SEMI-STRUCTURED INTERVIEW QUESTIONS

DESTEK VE HAREKET SİSTEMİ

1. İskelet sistemimiz olmasaydı ne olurdu? İskelet sisteminin görevlerini düşünerek cevaplayınız.

Verilen cevaplara göre:

Neden et yığını gibi olurduk?

İskeleti olmayan bir hayvan düşünün. Nasıl hareket ediyor?

Koruduğu organlara örnek veriniz.

Kemiğin başka görevi var mıdır?

Kemiğin bölümleri nelerdir? Bu bölümlerin görevleri nedir?

2. Kemik çeşitlerini yazınız ve aşağıdaki resimde birer örnek gösteriniz.

Verilen cevaplara göre:

Bahsettiğiniz çeşitleri nereden öğrendiniz?

Kemikler neye göre gruplandırılıyorlar?

Bu kemik çeşitlerinin birbirinden farklı amaçları veya görevleri var mı?

3. Kemiklerimiz canlı mıdır cansız mıdır? Size bunu düşündüren nedir?

4. İskelet sistemindeki kemiklerin hareketi nasıl sağlanır?

Verilen cevaplara göre:

Sadece eklemler ve kemikler olsaydı hareket edebilir miydik?

Kulağımızı neden hareket ettiremiyoruz?

Cevap beyin veya sinir sistemi ise açıklama istenir.

5. Parmaklarımızı boynumuzdan daha çok hareket ettirebilmemizin veya kollarımızı belimizden daha çok döndürebilmemizin sebebi nedir?

Verilen cevaplara göre:

(Kemik çeşitlerinden bahsedilirse) kısa veya az olmasının ne etkisi vardır?

(Daha çok eklem bulunması denirse) başparmağımızdaki eklemi boynumdan daha çok hareket ettirebiliyorum neden?

6. Kıkırdak nerelerde bulunur ve görevi nedir?

Verilen cevaplara göre:

Burun ve kulaktan başka bir yerde var mı?

Amacı nedir?

7. Kolumuzu istediğimiz gibi hareket ettirebildiğimiz halde iç organlarımızın hareketlerini kontrol edemeyiz. Bunun sebebi nedir?

Verilen cevaplara göre:

(Beyin denirse) iç organlarımızı beyin yönetmez mi?

İç ve dış organlarımızın yapısında ne değişiklik vardır?

Sinir sistemi denirse iç ve dış organların yönetimi neden farklı?

8. Bir yetişkin ile bir bebeğin iskeleti sence farklı mıdır? Neden?

Bu değişim nasıl oluyor?

Neden yetişkinlerde daha az kıkırdak var?

Neden yetişkinlerin kemikleri daha uzun? Kemikler nasıl uzar?

9. Kasların görevi nedir?

10. Kemiklerin ve kasların sağlığı için,

a) Yapmamız gerekenlere örnek veriniz?

Verilen cevaplara göre:

Spor ve açık havanın faydası nedir?

b) Yapmamamız gerekenlere örnek veriniz.

Verilen cevaplara göre:

Ters hareketler yapmanın, ağır kaldırmanın ne zararı olabilir?

11. Sizce iskelet sisteminin,

a) Solunum sistemi ile ilişkisi var mıdır? Açıklayınız.

b) Dolaşım sistemi ile ilişkisi var mıdır? Açıklayınız.

Verilen cevaplara göre:

Kemiklerin organları koruması dışında dolaşım sistemi ile ilgili bir görevi var mı?

Damarlarımız nerede bulunur? İskelet sisteminin kan ile ilgili bir görevi var mıdır?

Size dolaşım sistemi ile ilgili ek bir soru sormak istiyorum: kan nerede üretilir?

DOLAŞIM SİSTEMİ

1. Dolaşım sisteminin vücudumuz için önemi nedir?

Verilen cevaplara göre:

Cevap kanı temizlerse: Kanın temizlenmesini nasıl sağlar?

Dolaşım sistemi ile gerçekleşen olaylar nelerdir?

2. Dolaşım sisteminin tüm elemanlarını ve görevlerini yazınız.

Verilen cevaplara göre:

Akciğer ise: Akciğerin görevi nedir?

Kalp kanı süzer denirse açıklama istenir.

Kalp kan üretir denirse açıklama istenir.

Sindirim sistemi ile karşıtıysa her organın dolaşım sistemi için önemi sorulur.

Böbrekler ise: Böbrekler kanı nasıl süzer? Kandaki hangi maddeyi süzer?

3. Vücudumuzda kan nerede üretilir?

Verilen cevaplara göre:

Kalpte kanın üretilmesinin ayrıntılarını açıklayınız.

4. Kan nelerden oluşur? Yapısında bulunanları yazınız.

Verilen cevaplara göre:

Bu saydıklarınızın görevleri nelerdir?

Besinler kana nasıl geçer? Besinlerin kana geçmesi nerede gerçekleşir?

Oksijen/Karbondioksit kana nasıl geçer?

Kirli kan ve temiz kan ifadeleri kullanılırsa açıklama istenir. Kirli ve temiz diye nitelendirdiğiniz kanların ne farkı vardır? Yapısı faklı mıdır? Rengi farklı mıdır?

5. Kanın vücudun farklı organlarına taşıdığı maddeler nelerdir?

Verilen cevaplara göre:

Bu saydıklarınızı nereden alır nerelere taşır?

Kirli ve temizkan ifadeleri geçtiyse:Hangi maddeleri taşırlar?

6. *Kanın damarlarda hareket etmesini sağlayan nedir?Açıklayınız.*

7. *Verilen cevaplara göre:*

Solunum ve kanın taşıdığı oksijen ile ilgili cevaplarda açıklama istenir.

8. Kalp rahatsızlığı olan bir insanda kalbin düzenli çalışmaması vücudu neden güçsüz düşürür?

Verilen cevaplara göre:

Vücuttan aşırı derecede kan kaybetmenin vücuda zararı ne olur?

Kan dolaşamazsa ne olur.

Kan azalırsa ne olur?

9. Damar çeşitlerini yazınız ve görevlerini açıklayınız.

Verilen cevaplara göre:

Damarlar hangi özelliklerine göre ayrılırlar?

Toplar damarın görevi nedir? Vücudumuzdaki tüm toplar damarların görevi bu mudur?

Atar damarın görevi nedir? Vücudumuzdaki tüm atar damarların görevi bu mudur?

Atar ve toplar damar arasında ne fark vardır? Atar damarın taşıdığı kan ile toplar damarın taşıdığı kan arasında ne fark vardır?

Şah damarının görevi nedir?

10. Yukarıdaki soruda bahsettiğiniz damarların hangisinin kesilmesi daha tehlikelidir? Neden?

11. Bademcikler hangi sisteme aittir ve ne işe yararlar?

Verilen cevaplara göre:

Lenf sisteminin görevi nedir?

Neden

12. Kalbin bölümlerini göstererek küçük dolaşım ve büyük dolaşımı çizmeye çalışın. Kalp, akciğer ve vücut arasında gerçekleşen kan akışlarını oklarla gösterin.

Verilen cevaplara göre:

Küçük dolaşım hangi organlar arasında olur? Amacı nedir?

Büyük dolaşım hangi organlar arasında olur? Amacı nedir?

Dolaşım esnasında hangi damarlar nereden ne tür kanı nereye götürür?

Kan kalbin içinde nasıl hareket eder?

Kalbin sağ ve sol kısımları arasında geçiş olur mu?

13. Koştuğumuzda kalp atışımızda bir değişiklik olur mu? Neden?

SOLUNUM SİSTEMİ

1. Solunum sisteminin organlarını yazınız ve şemada çizerek gösteriniz.

Verilen cevaplara göre:

Ağzın görevi nedir? Burunun görevi nedir?

Ağzın dahil olduğu başka bir sistem var mı?

2. Yukarıdaki soruda yazdığınız organların görevlerini yazınız.

Verilen cevaplara göre:

Akciğerin görevi nedir? Nefes alınıp verildiğinde akciğerde ne olur?

Alınan ve verilen soluktaki gazların açıklanması istenir:

Soluduğumuz havanın içersinde ne(ler) var?

Burundan giren havada neler var?

Akciğerdeki havada neler var?

Verdiğimiz solukta neler var? Karbondioksit nereden geldi?

3. Solunum nedir?

Solunum nefes alıp verme ile aynı şey midir?

4. Uzun süre nefes almazsak ne olur? Sizce vücudumuzun nefes alıp vermeye neden ihtiyacı vardır?

Verilen cevaplara göre:

Soluk almak ne işe yarar?

Akciğere ulaştıktan sonra soluduğumuz havaya ne olur?7

5. Soluduğumuz havanın vücudumuza girdiği noktadan hücrelere kadar aldığı yolu açıklayınız.

6. Nefes alıp verme sırasında gaz alışverişi nerede ve nasıl olur?

Verilen cevaplara göre:

Az önceki soruda soluduğumuz havanın hücrelere ulaşması için gerçekleşmesi gereken gaz alışverişi nerede gerçekleşir?

Akciğerde hava kana nasıl geçer?

7. Nefes alıp verebilmemiz için diyafram ve kaburga kaslarında olması gereken değişiklikleri açıklayınız. Hava akciğerlere nasıl dolar ve nasıl boşalır?

Verilen cevaplara göre:

Soluk verme sırasında vücutta neler olur? Vücutta hangi yapılar soluk verme sırasında rol oynar (boşaltim sistemi cevabı gelirse niçin oyle dusundugu sorulur?)

Diyaframın vücuttaki yerini gösteriniz.

Normal halinde ve kasılmış halinde diyafram nasıldır? Nefes alındığında ve verildiğinde şekli nasıldır?

Kaburgada bulunan kaslar nefes alıp vermeye nasıl yardımcı olur?

Yanda solunum sisteminin balonla yapılmış basit bir modeli yer almaktadır.

a) Bu modeli daha önce gördünüz mü?

- Evet
- Hayır

b) Bu model ile gerçek solunum sistemi arasındaki benzerlikleri ve farklıklar nelerdir?

Verilen cevaplara göre:

Normalde akciğerler 2 bölümden mi oluşur?

Soluk borusu iki broşa mı ayrılır?

Akciğerlerin içinde ne vardır? Bu modelde akciğerlerin içi nasıldır?

Sağ ve sol akciğerlerin boyu bu modelde nasıl gerçekte nasıldır?

Diyafram nefes alma anında nasıl olmalıdır?

8. Solunum sisteminin sağlığını korumak için,

a) Yapılması gerekenler nelerdir?
b) Yapılmaması gerekenler nelerdir?

9. Solunum sistemi ve dolaşım sistemi arasında bir ilişki var mıdır? Açıklayınız.

Verilen cevaplara göre:

Nefes alıp verme kanın damarda hareketini nasıl sağlar? Başka bir mekanizma olabilir mi?

Nefesin kan üretimi ile ne ilişkisi var?

Küçük dolaşım nedir?

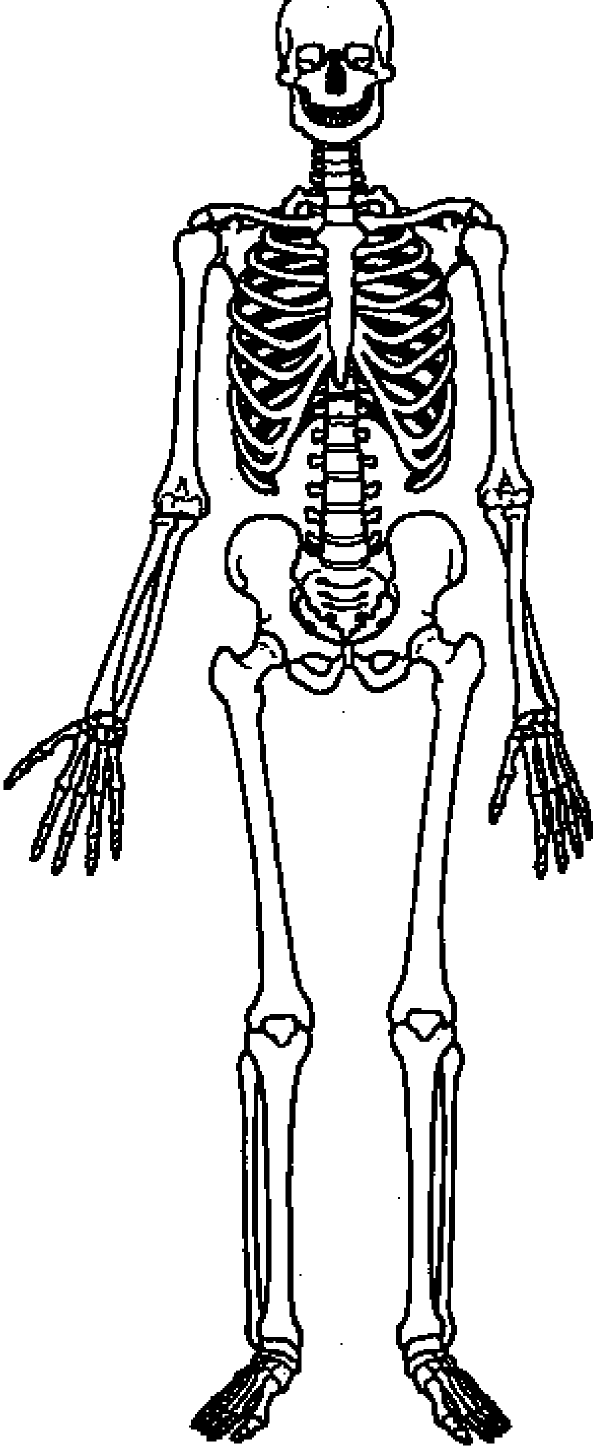
Kirli kan ve temiz kan ifadeleri kullanıldıysa açıklama istenir.

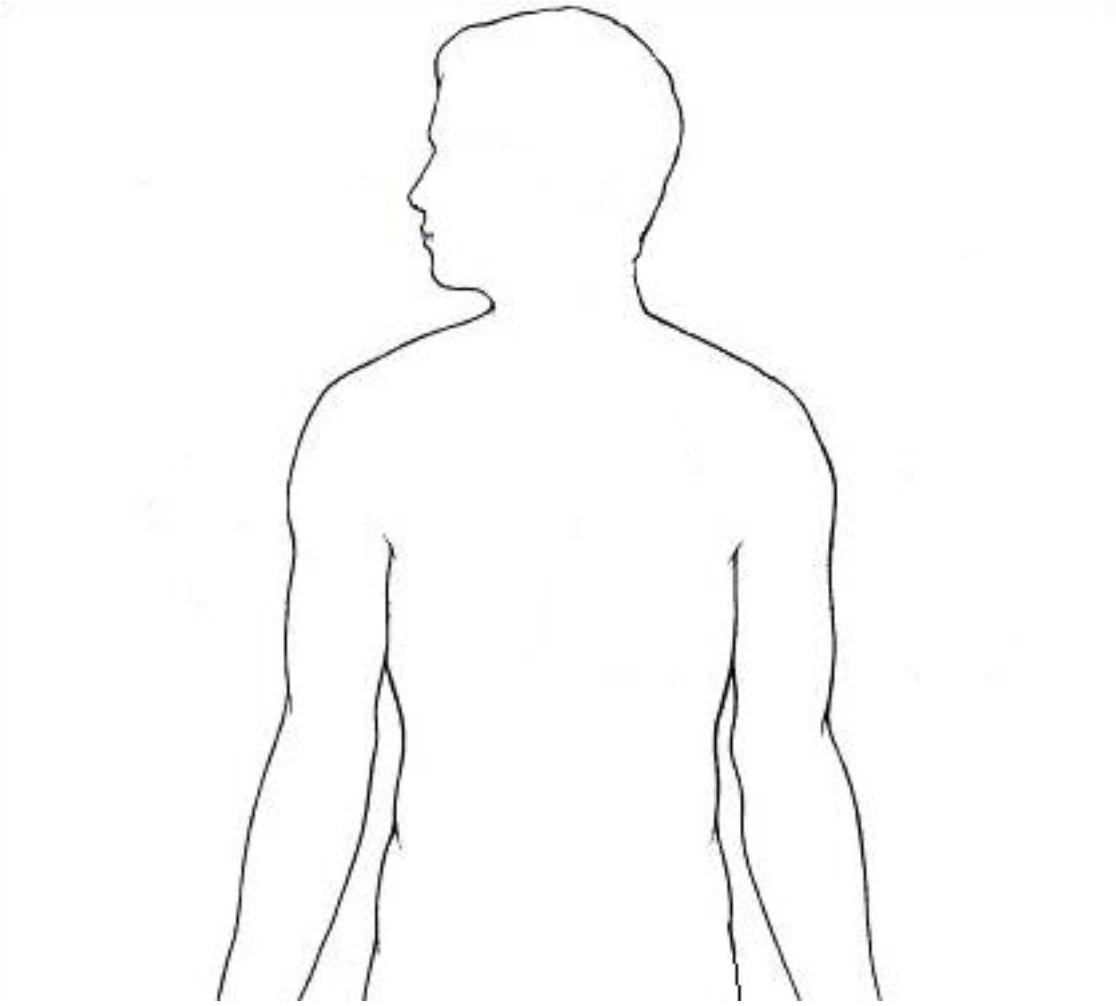
Soluk aldiğımızda vücudumuza esas olarak ne(ler) (hangi madde(ler) kazanıdırılır? Soludugumuz hava içersindeki bu madde(ler) vücudumuza nasıl dağıtılır?

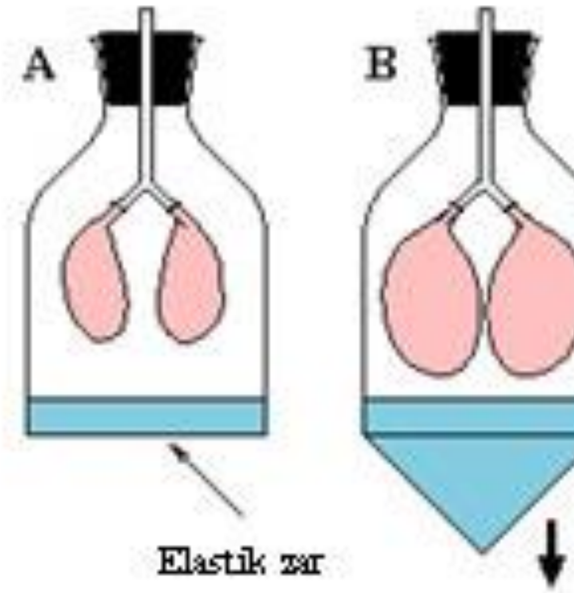
10. Solunum sisteminin diğer vücut sistemleri ile ilişkilerini açıklayınız.

Soluk almanın ne faydası vardır?

11. Koştuğumuzda soluk alışımızda bir değişiklik olur mu? Neden?



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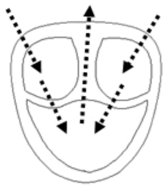
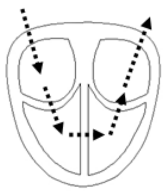
APPENDIX J

COMPILED MISCONCEPTIONS FOR CONCEPTUAL INVENTORY ITEM DEVELOPMENT

Kavram	Kavram Yanılgısı
Kemikler Canlıdır	Kemikler canlıdır. Çünkü hareket edebiliyor.
	Kemikler cansızdır. Çünkü biz hareket ettirmezsek kendi başına hareket edemezler.
	Kemikler cansızdır. Ama içinde bulunan damarlar canlıdır.
Kemik Çeşitleri	Yassı kemik: oynamayan kemiktir.
	Uzun kemik: oynar kemiktir.
	Kısa kemik: yarı oynar kemiktir.
	Parmak kemikleri kısa kemiktir.
	Omurga uzun kemiktir.
Destek Hareket Sistemi & Diğer Sistemler	Dolaşım sistemi ile ilişkilidir çünkü damarlar vücudumuza kemiklerin içinden yayılır.
Kemiklerin Görevi	Kemiklerimiz olmasaydı dokunup temas ettiğimiz hiçbir şeyi hissedemezdik.
Kasların Görevleri	Bazı kaslarımız akyuvar ve alyuvar hücreleri üretmekle görevlidir.
	Oksijence fakir kan kaslarımızda temizlenir.
	Kemikleri ve kıkırdakları korumak kaslarımızın görevlerindendir.
Destek ve Hareket Sistemi & Büyüme	Bebek ile yetişkin insan iskeleti arasında hiçbir fark yoktur.
	Yetişkinlerin bebeklerden daha fazla kemiği vardır çünkü büyüdükçe yeni hücreler ve yeni kemikler üretilir.
	Yetişkinlerin kemikleri daha incedir çünkü uzadıkça incelmiştir.
Eklemler	Parmaklarımızı boynumuzdan daha çok hareket ettirebiliyoruz çünkü boynumuzda hayati damarlar vardır ama parmaklarımızda yoktur.
	Parmaklarımızı boynumuzdan daha çok hareket ettirebiliyoruz çünkü parmaklarımızda boynumuzdan daha çok eklem vardır.
	Parmaklarımızı boynumuzdan daha çok hareket ettirebiliyoruz çünkü parmaklarımızdaki kemikler boynumuzdaki kemiklerden daha incedir.
Kas çeşitleri	Kol ve bacaklarımızın hareketini kontrol edebiliyoruz ama iç organlarımızın hareketini kontrol edemiyoruz çünkü kol ve bacaklarımızı sinir sistemi yönetir, iç organlarımızın sinir sistemi ile bir ilişkisi yoktur.
	Kol ve bacaklarımızın hareketini kontrol edebiliyoruz ama iç organlarımızın hareketini kontrol edemiyoruz çünkü kol ve bacaklarımız beyin tarafından, iç organlarımız ise kalp tarafından yönetilir
	Kol ve bacaklarımızın hareketini kontrol edebiliyoruz ama iç organlarımızın hareketini kontrol edemiyoruz çünkü kol ve bacaklarda kemik ve kas vardır, iç organlarımızda ise yoktur.
Destek ve Hareket Sisteminin Sağlığı	Bol bol su içmek.
Kalbin Görevi	Kalp kan üretir.
	Kalp her atışında yeni kan hücreleri üretir.
	Kalp her atışında kirli kanı temizler, temiz kanı vücut organlarına gönderir.

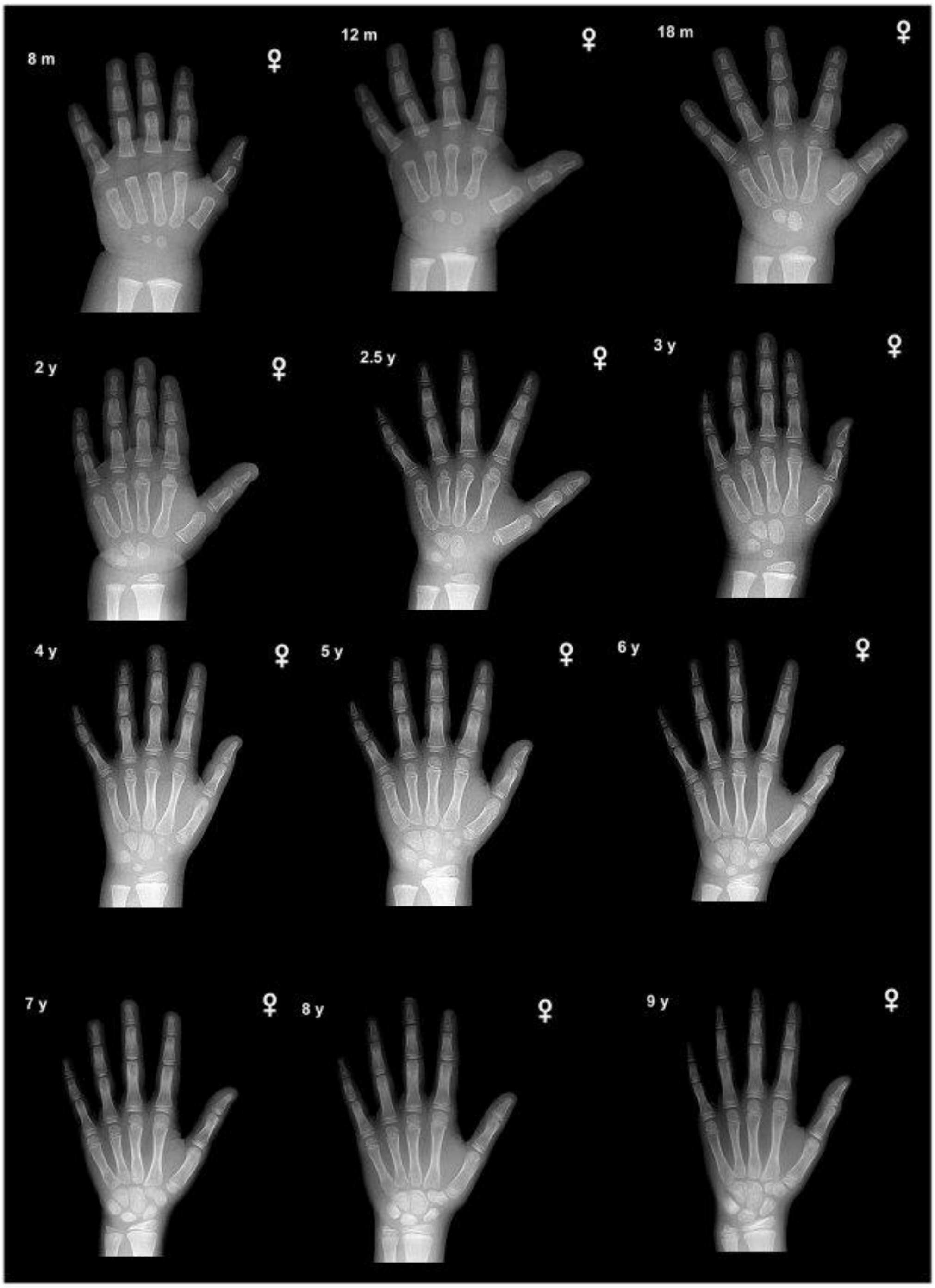
	Kalp her atışında kandaki karbondioksiti süzer ve atılması için akciğere gönderir.
	Kalp düzgün çalışmazsa kişinin vücudundaki kan hücrelerinin miktarı azalabilir.
Kalbin Yapısı ve Kanın Kalpte İzlediği Yol	 Kalp 3 odacıklıdır. Kan kalbe sol kulakçıktan girer, karıncığa dolar, oradan sağ kulakçığa geçer ve sağ kulakçıktan çıkar.
	 Kalp 3 odacıklıdır. Kan kalbe sol kulakçıktan ve sağ kulakçıktan girer, karıncığa dolar oradan da damarlar yoluyla çıkar.
	 Kalp 4 odacıklıdır. Kan kalbe sol kulakçıktan girer, sol karıncığa karıncığa dolar, oradan sağ karıncığa geçer, son olarak sağ karıncığa geçerek dışarı çıkar.
Egzersiz & Kalp Atışı	Kalp atışı değişmez çünkü destek hareket sistemi ile dolaşım sisteminin bir ilişkisi yoktur.
	Kalp atışı artar çünkü aldığımız nefes sayısı artmıştır.
	Kalp atışı azalır çünkü iskelet kasları yorulur, kalp kasları yavaşlayarak bunu dengeler.
Kanın Yapısı ve	Kandaki alyuvarlar kanın pıhtılaşmasını sağlar.
Görevi	Oksijen kanda gaz kabarcığı şeklinde serbest olarak taşınır.
	İçinde glikoz gibi maddeler olan kana kirli kan denir.
	Vücudumuzda bulunan oksijence zengin kan kırmızı, oksijence fakir kan mavidir.
Damarlar	Vücudumuzda besinleri taşıyan kan kırmızı, atık maddeleri taşıyan kan mavidir.
	Vücudumuzda bulunan atardamarlar kırmızı, toplardamarlar ise mavidir.
Damar Çeşitleri ve	Bütün atardamarlar oksijence zengin kanı taşır.
Görevleri	Bütün toplardamarlar oksijence fakir kanı taşır.
	Şahdamar bir damar çeşididir.
Kan Dolaşımı	Nefes alınca vücuda giren hava kanı damarlar içinde itiyor.
	Soluduğumuz oksijenin kana karışması kanın akışkan olmasını sağlıyor.
	Beyin sinirler yoluyla kan hücrelerine hareket etme emrini gönderiyor.
Kanın Vücutta izlediği yol	Kan kalpten damarlar yoluyla ayrılır, vücut hücrelerine gider ve hücrelerin çevresine dolar.
	Kan kalpten damarlar yoluyla ayrılır, hücrelere gider ve geldiği aynı damarla kalbe geri döner.
	Kan kalpten damarlar yoluyla ayrılır, hücrelere gider, başka damarlarla akciğere gider ve temizlendikten sonra kalbe döner.

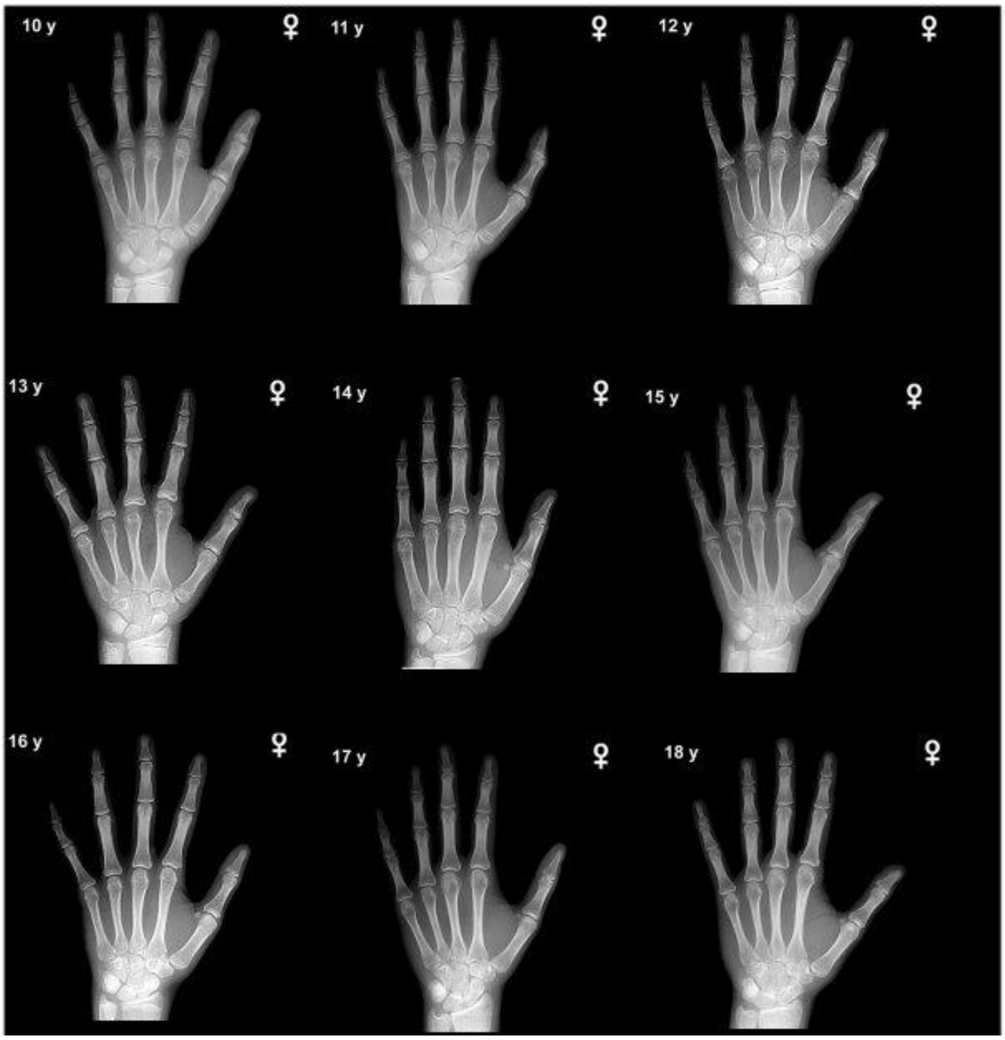
Dolaşım Sistemi & Diğer Sistemler	Sindirim sistemi ile ilişkilidir çünkü dolaşım sistemi bazı besinleri parçalayarak sindirime yardımcı olur.
Solunum Sistemi Organları ve Görevleri	Burun: Oksijeni alır. / Ağız: Karbondioksiti verir.
	Burun: Havadaki oksijeni ayırarak akciğerlere sadece oksijen gitmesini sağlamak.
	Burun: Havadaki karbondioksiti ayırmak ve akciğerlere ulaşmasını engellemek.
	Burun: Çevremizdeki nesnelerin kokusunu almak.
	Böbrekler: Karbondioksiti vücuttan atmakla görevlidir
	Karaciğer: Kirli ve temiz havayı ayırarak akciğerlere yardımcı olur.
	Kalp: Oksijen ve karbondioksit taşınmasında görevlidir.
Akciğerin Görevi	Oksijeni alıp karbondioksite çevirmek ve vücuttan atmak ile görevlidir.
	Nefes ile alınan oksijence zengin havayı depolamak ile görevlidir
	Solunumu gerçekleştirmek ile görevlidir.
Gaz alışverişi ve Soluk ile Alınan-Verilen Gazlar	Nefes ile alınan havadaki oksijen akciğerler tarafından süzülür, akciğerlerde kalan hava karbondioksit olarak atılır.
	Solunum esnasında karaciğerde karbondioksit biriktirilir ve verilen nefesle atılır.
	Kalbin sağ karıncığında biriken oksijence fakir kandaki karbondioksit akciğerlere gönderilir ve nefesle atılır.
	Alınan nefesteki karbondioksit miktarı ile verilen nefesteki karbondioksit miktarı aynıdır.
	Alınan nefeste sadece oksijen, verilen nefeste ise sadece karbondioksit bulunur.
	Alınan nefeste oksijen ve karbondioksit bulunur ama verilen nefeste sadece karbondioksit bulunur.
Soluk Alma	Burnumuzdan hava almamız sayesinde akciğerlere hava dolar.
	Akciğerlerde bulunan kaslar akciğerleri genişleterek içlerine hava dolmasını sağlar.
	Akciğerlere hava kalbin kanı pompalaması sırasında oluşan basınç sayesinde dolar.
Solunum	Solunum nefes alıp vermek demektir.
	Solunum oksijen alıp karbondioksit vermek demektir.
	Solunum nefesin alınıp nefesteki oksijenin süzülmesi ve kalan havanın nefes verilerek atılması demektir.
Nefes alıp Vermenin Önemi	Çünkü nefes alıp vermek kanın damarlarda dolaşmasını sağlar.
	Çünkü aldığımız nefesteki oksijen kana karışmazsa kan pıhtılaşır ve bu yüzden kan dolaşımı engellenir.
	Çünkü nefes alıp vermezsek atmosferdeki karbondioksitli havayı temizleyemeyiz.
Egzersiz & Nefes ve Kalp Atışı	Koşma sırasında nefes alışveriş hızının atması damar basıncını yükseltmiştir, bu da kalp atışını hızlandırmıştır.
	Koşma sırasında kalp atışının hızlanması, nefes alışverişinin hızlanmasına neden olmuştur.
	Koşma sırasında, nefes alışverişinin artması kana karışan oksijen miktarını artırmıştır, bu kanı daha da sıvılaştırmıştır ve kanın akışkanlığı arttığı için kalp atışı da artmıştır.
Solunum Sistemi & Diğer Sistemler	Boşaltım sistemi ile ilişkilidir çünkü havanın alınması solunum sisteminin, verilmesi ise boşaltım sisteminin görevidir.

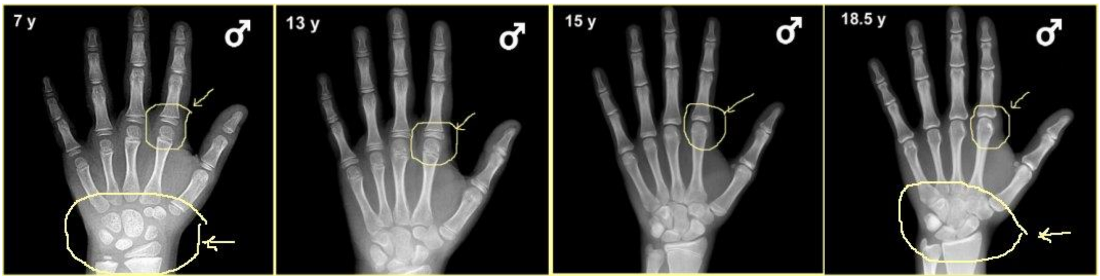
APPENDIX K

7E-LCI MATERIALS RELATED TO BONES

X-rays of Hands at Different Ages




10 y
♀
11 y
♀
12 y
♀
13 y
♀
14 y
♀
15 y
♀
16 y
♀
17 y
♀
18 y
♀


7 y
♂
13 y
♂
15 y
♂
18.5 y
♂

TAVUK KEMİKLERİNİ İNCELEYELİM
(Öğretmen Kopyası)

Amaç: Öğrencilere kemik çeşitlerini, kemiğin yapısını, kemiğin büyüdüğünü keşfettirebilmek.

Hedef Öğrenciler: 6. Sınıf Fen ve Teknoloji dersi öğrencileri

Bilimin Doğası ve Bilimsel Süreç Becerileri Kazanımları:
(observing, communicating, comparing and contrasting, inferring, classifying, manipulating materials.)

- Kemikleri yapılarına göre sınıflandırır.
- Gözlem yapar.
- Gözlemlere dayanarak çıkarım yapar.
- Kemikler arasında karşılaştırmalar yapar.
- Kararlarını ve gözlemlerini yazılı ve sözlü olarak grup arkadaşlarıyla paylaşır.
- Verilen materyalleri gerektiği gibi kullanır.

Ünite Kazanımları:

- Kemiğin kısımlarını ve görevlerini belirtir.
- Kemikleri kısa, uzun ve yassı kemik olarak sınıflandırır ve örnekler verir.
- Kemiğin canlı olduğunu açıklar.
- Kemiğin büyüyebildiğini belirtir.

Araç Gereç:

- Çeşitli tavuk kemikleri ve büyükbaş hayvan kemiği
- Eldiven
- Büyüteç
- Çalışma kağıdı

Gerekli Bilgiler:

İnsan vücudunda yapı bakımından üç çeşit kemik bulunur.

1. Uzun kemikler

- Boyu eninden uzun olan kemiklerdir.
- Vücudun hareketini sağlayan kemiklerdir.
- Kollarımızda bacaklarımızda ve parmaklarımızda bulunur.
- Sarı ilik ve kemik kanalı vardır.

2. Kısa kemikler

- Boyu, eni ve genişlikleri hemen hemen aynı olan kemiklerdir.
- Sarı ilik ve kemik kanalı yoktur.
- El ve ayak bilek kemikleri kısa kemiklerdir.

3. Yassı kemikler

- Yassı görünümlü kemiklerdir.
- Sarı ilik ve kemik kanalı yoktur.
- Göğüs, kafatası ve kaburga kemikleri yassı kemiklerdir.

❖ Omurgamızdaki omur kemikleri yaygın olarak kısa kemik olarak bilinmektedir. Ancak omurlarımız yukarıda bahsedilen 3 sınıftan farklı olarak düzensiz kemikler (irregular bones) sınıfında yer alır.
❖ El ve ayak parmak kemikleri kısa kemik olarak düşünülmektedir. Ancak parmak kemiklerimiz uzun kemik sınıfına girmektedir.

Kemiklerin Yapısı:

Kemikler canlı hücrelerden, proteinlerden ve inorganik bazı maddelerden (kalsiyum, fosfor, sodyum, magnezyum) oluşmuşlardır.

Kemiklerin Büyümesi:

Kemik çok kuvvetli bir bağ dokusundan oluşmaktadır. Kemiği sertleştiren bağ dokusunun üzerinde depolanan kalsiyumdur. İskelet sisteminin birçok yerinde kemik parçalayan hücreler (osteoklast) eski kemiği yok ederken, kemik yapan hücreler (osteoblast) yeni kemik oluştururlar. Çocuklukta kemik oluşturan hücreler daha hızlı çalışırken yaş ilerledikçe bu hız dengelenir, ileri yaşlarda ise bu hücrelerin hızı azalır.

Etkinliklerin Açıklaması ve Gerekli Bilgiler:

- Bu etkilikler öğrencilerin gözlemler yaparak kemikleri sınıflandırmasını, kemik çeşitlerini ve yapısını anlamasını ayrıca kemiklerin büyüdüğünü kavramasını sağlamak için düzenlenmiştir.
- Bu etkinlikte öğrenciler 5 er kişilik gruplara ayrılacaktır.
- Öğrencilere 3 farklı poşette yer alan tavuk kemikleri inceletilerek gözlem yaptırılacaktır.
- Yapacakları gözlemler çalışma kâğıtlarındaki sorular tarafından yönlendirilecektir.
- Tartışma sorularını grup arkadaşlarıyla tartışarak cevaplandıracaklardır.
- Her gözlemden sonra gruplar fikirlerini öğretmen kontrolünde sınıf ile paylaşacak ve öğretmen gerekli kısımlarda açıklamalar yapacaktır.

Öğrencilerin Çalışma Kâğıtlarında Bulunan Tartışma Soruları:

1. Kemik Poşetindeki Kemikleri Gözlemleyelim.

- Kemiklerin şekilleri nasıl? Kaç farklı şekilde kemik var? Boyları farklı mı?
- Kemikleri sınıflandırın. Kemikleri kaç gruba ayırdınız? Hangi özelliklerine göre ayırdınız? Neden?
- Kemikler ne renk?
- Kemikleri tuttuğunuzda ne hissediyorsunuz? Kemikler sert mi yumuşak mı?
- Bu tavuk kemiklerinin görevleri nedir? Tavuğa sağladıkları faydalar nedir?
- İnsan kemikleri ve tavuk kemiklerini düşünelim. Aralarındaki farklar ve benzerlikler nelerdir?

2. Kemik Poşetini Gözlemleyelim.

- İki tavuk bacak kemiği arasındaki farklar ve benzerlikler nelerdir?
- Renkleri nasıl?
- Boyları nasıl?
- Sertlikleri nasıl?

- Şekilleri nasıl?
- Bu kemiklerden biri genç bir tavuğun diğeri daha yaşlı bir tavuğun kemiğidir. Sizce hangisi genç tavuğa ait?
- Neden böyle düşünüyorsunuz? Bu çıkarımı hangi gözlemlerine dayanarak yaptınız?
- Genç tavuk yaşlı tavuğun yaşadığı kadar yaşasaydı kemiği yaşlı tavuğun kemiği gibi olur muydu? Neden? Yaş ilerledikçe kemikler nasıl değişir?
- Kendi kemiklerinizi düşünün. Siz 5 yaşındayken sahip olduğunuz kemiklerle şimdi sahip olduğunuz kemikler aynı mı?

3. Kemik Poşetini Gözlemleyelim.

- Kemiğin dışını inceleyelim.
- Rengi:
- Sertliği:
- Uzunluğu:
- Orta kısmı ve uç kısımları arasındaki farklar:
- Kemiğin iç kısmı dış kısmı ile aynı mıdır? İç kısmın şeklini ve yapısını tahmin edin.
- Kırık kemikleri inceleyelim. İç kısmın yapısı nasıl?
- Kemiğin içinde ne var?
- Kemiğin dışı ve içi aynı yapıda mıdır? Tahmininiz doğru çıktı mı? Açıklayın.
- Kemiğin içindeki boşlukların amacı nedir?
- Kemiğin içinde görünen yumuşak yapı nedir? Bu yapının görevi nedir?
- Tavuk bacak kemiklerini büyükbaş hayvan kemikleri ile karşılaştıralım.
- Benzerlikler neler?
- Farklılıklar neler?

ETKİNLİK 1: Poşetlerdeki Tavuk Kemikleri

İsim:___________________________ Sınıf: __________

Grup Arkadaşlarım:___________________________________

Amaç: Tavuk kemiklerini incelemek.

Araç Gereç: Gerekenler öğretmen tarafından verilecektir.

Etkinliğin Yapılışı:

- 5 er kişilik gruplar oluşturun.
- Size verilen kemik poşetlerini inceleyin yaptığınız gözlemleri çalışma kâğıdına yazın.
- Tartışma sorularınızı grubunuzla tartışın ve yanıtlarınızı çalışma kâğıdına yazın.

1. KEMİK POŞETİ (Amaç: Kemiklerin büyüdüğünü kavrama)

Gözlemler İki tavuk bacak kemiği arasındaki farklar ve benzerlikler nelerdir? Renkleri nasıl? Boyları nasıl? Sertlikleri nasıl? Şekilleri nasıl? Diğer…

Tartışma Soruları:

Bu kemiklerden biri genç bir tavuğun diğeri daha yaşlı bir tavuğun kemiğidir. Sizce hangisi genç tavuğa ait?

Neden böyle düşünüyorsunuz? Bu çıkarımı hangi gözlemlerinize dayanarak yaptınız?

Genç tavuk yaşlı tavuğun yaşadığı kadar yaşasaydı kemiği yaşlı tavuğun kemiği gibi olur muydu? Neden? Yaş ilerledikçe kemikler nasıl değişir?

Kendi kemiklerinizi düşünün. Siz 5 yaşındayken sahip olduğunuz kemiklerle şimdi sahip olduğunuz kemikler aynı mı?

Bu iki kemikten birinin resmini aşağıda ayrılan yere çizin.

Tavuk iskeletindeki tüm kemiklerin şekli sizce çiziminizdeki gibi midir?

2. KEMİK POŞETİ (Amaç: Kemikleri sınıflandırma ve çeşitleri öğrenme)

Gözlemler
Kemiklerin şekilleri nasıl? Kaç farklı şekilde kemik var? Boyları farklı mı?   Kemikler ne renk?

Tartışma Soruları
Bu tavuk kemiklerinin görevleri nedir? Tavuğa sağladıkları faydalar nedir?   Kemikleri sınıflandırın. Kemikleri kaç gruba ayırdınız? Hangi özelliklerine göre ayırdınız? Neden?

Diğer gruplardaki arkadaşlarınızın sınıflandırmasını öğrenin. Sizin sınıflandırmanızdan farklı mı?

İnsan kemikleri ve tavuk kemiklerini düşünelim. Aralarındaki farklar ve benzerlikler nelerdir?

Sizin tavuk kemiklerini sınıflandırdığınız gibi insan kemikleri de sınıflandırılmaktadır. Yapılan sınıflandırmada insan kemikleri kaç çeşide ayrılmıştır?

İsim:___________________________ Sınıf: _______________

Grup Arkadaşlarım:___________________________________

İSKELETİMİZİ OLUŞTURALIM

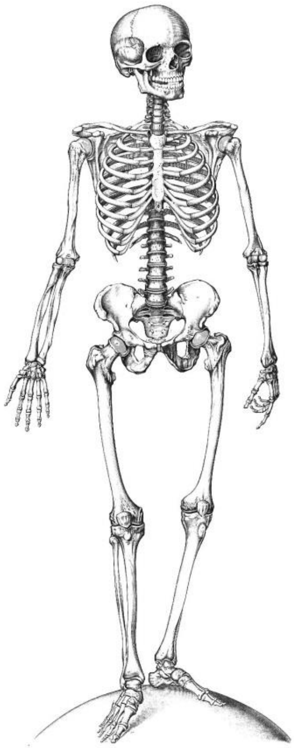
Amaç: Vücudumuzda farklı yapılarda kemik olduğunu fark etmek ve vücudumuzdaki kemikleri tanımak.

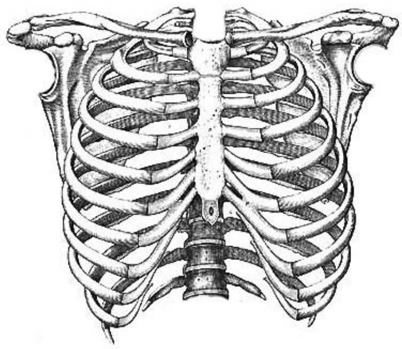
Araç Gereç: Karton, parçalanmış iskelet resmi, hamur yapıştırıcı

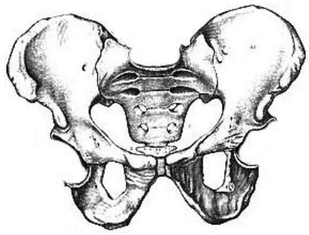
Etkinliğin Yapılışı:

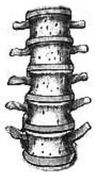
- 3 er kişilik gruplar olun.
- Size verilen dosyalarda bulunan kemikleri resimlerini inceleyin.
- Kemikleri karton üzerinde birleştirerek insan iskeleti oluşturmaya çalışın.
- İncelediğiniz kemik resimlerin adlarını düşünün.

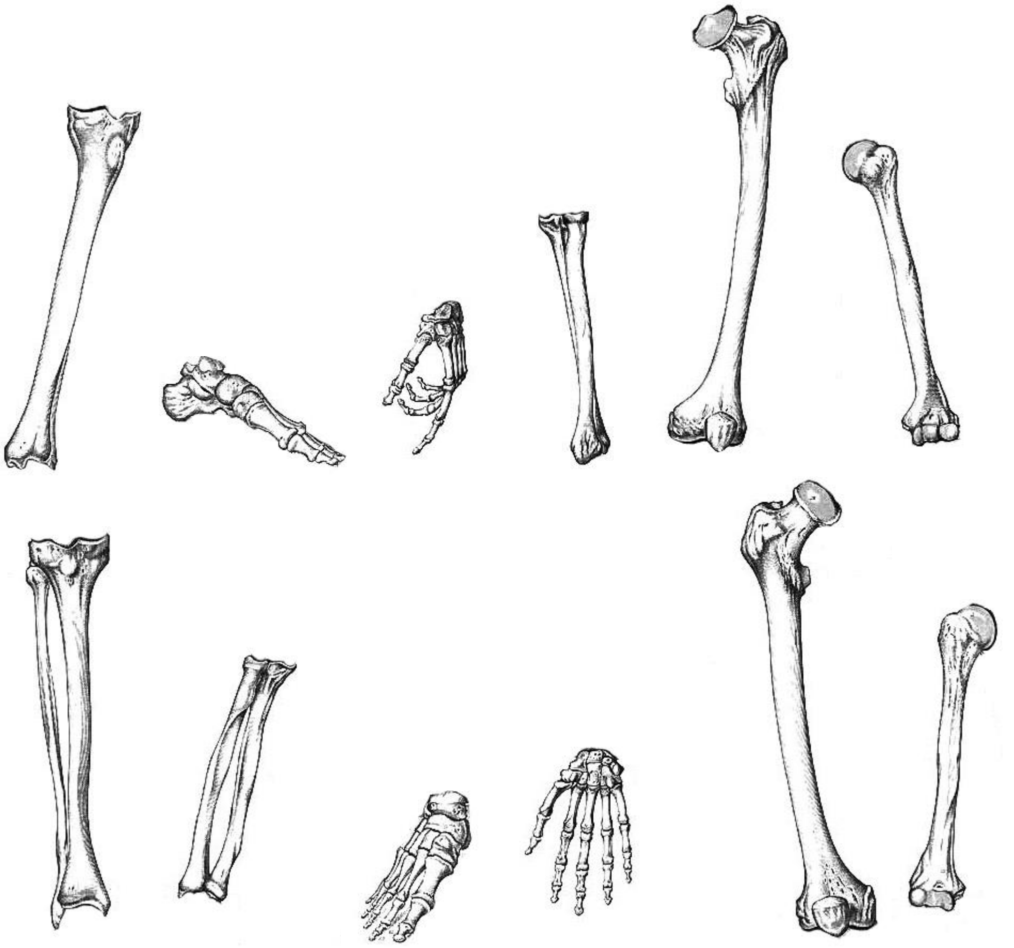
Skeleton Puzzle











İsim:___________________________ Sınıf: ________________

Grup Arkadaşlarım:___________________________________

İSKELETİMİZİ BOYAYALIM

Amaç: Vücudumuzdaki kemik çeşitlerini ve bazı kemiklerin adlarını öğrenmek.

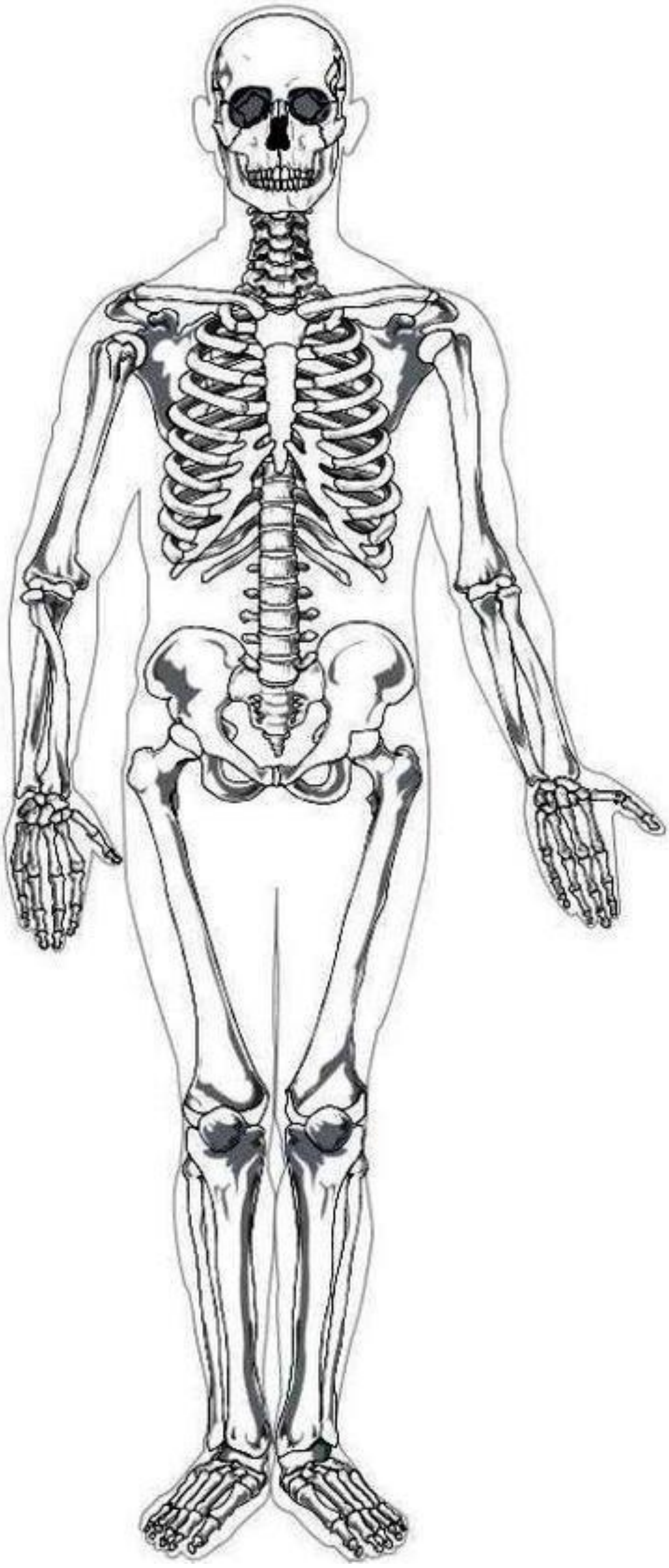
Araç Gereç: Renkli boya kalemleri, İskelet resmi

Etkinliğin Yapılışı:

- Bireysel olarak size verilen iskelet resmini inceleyin.
- Kemik çeşitlerini aşağıda belirtilen şekilde boyayın.

⇒ Uzun kemikleri **Sarı**ya boyayalım.
⇒ Kısa kemikleri **Kırmızı**ya boyayalım.
⇒ Yassı kemikleri **Mavi**ye boyayalım.
⇒ Kıkırdak olduğunu düşündüğümüz noktaları **Yeşil**e boyayalım.
⇒ Çeşidini bilmediğimiz kemikleri

- İskelet üzerinde bildiğiniz kemiklerin isimlerini ok çıkartarak yazın.
- Yazdığınız kemiklerin adlarını sınıf arkadaşlarınız ile paylaşın.
- Arkadaşlarınızdan öğrendiğiniz yeni kemik adları da iskeletinize ekleyin.



3. KEMİK POŞETİ (Amaç: Kemiğin iç ve dış yapısını incelemek)

Gözlemler Kemiğin dışını inceleyelim. Rengi: Sertliği: Orta kısmı ve uç kısımları arasındaki farklar:

Tartışma Sorusu Kemiğin iç kısmı dış kısmı ile aynı mıdır? İç kısmın şeklini ve yapısını tahmin edin.

Gözlemler: Kırık kemikleri inceleyelim. İç kısmın yapısı nasıl? Kemiğin içinde neler var?

Kemiğin dışı ve içi aynı yapıda mıdır? Tahmininiz doğru çıktı mı? Açıklayın.

Aşağıdaki bölmeye kemiğin iç kısmını gösteren bir resim çizin.

Tartışma Soruları:

Kemikler bu kadar hafifken vücut ağırlığını nasıl taşıyabiliyor?

Kemiğin içindeki boşlukların amacı nedir?

Kemiğin içinde görünen yumuşak yapı nedir? Bu yapının görevi nedir?

Kemiğin dışının böyle sert olmasını sağlayan nedir?

İsim:___________________________ Sınıf: _____________

Grup Arkadaşlarım:_____________________________________

KEMİKLER NEDEN BÖYLE SERT?

Amaç: Kemiğin sertliğini yapısında bulunan kalsiyum mineralinden kaynaklandığını keşfettirebilmek.

Hedef Öğrenciler: 6. Sınıf Fen ve Teknoloji dersi öğrencileri

Bilimin Doğası ve Bilimsel Süreç Becerileri Kazanımları:

(observing, communicating, hypothesizing, defining variables, designing experiment, inferring, manipulating materials.)

- Gözlem yapar.
- Gözlemlere dayanarak çıkarım yapar.
- Hipotez kurar.
- Değişkenleri belirler.
- Deney kurar.
- Kararlarını ve gözlemlerini yazılı ve sözlü olarak grup arkadaşlarıyla paylaşır.
- Verilen materyalleri gerektiği gibi kullanır.

Ünite Kazanımları:

- Kemiğe sertliğini verenin yapısındaki kalsiyum minerali olduğunu açıklar.

Araç Gereç:

- Tavuk kemiği
- Sirke
- Su
- 2 kavanoz
- Çalışma kâğıdı

Etkinliğin Yapılışı:

- 3 er kişilik gruplar oluşturun.
- Size verilen çalışma kâğıdına verilen araştırma problemi için bir deney düzeneği kurun.
- Deney düzeneğinizi ve tahmini sonuçlarınızı grubunuzla tartışın ve yanıtlarınızı çalışma kâğıdına yazın.

Deney Tasarlama Çalışma Kâğıdı

Önbilgi: Sirke asidi kalsiyum mineraline zarar verir.

Araştırma Sorusu	Tavuk kemiği sirkeli suda bekletilince ne olur?
Hipotez	
Bağımlı Değişken	
Bağımsız Değişken	
Kontrol Değişken	
Araç-Gereç	
Deneyin Yapılışı	

Tahminler	
Gözlemler	
Sonuç	

APPENDIX L

7E-LCI MATERIALS RELATED TO JOINTS AND MUSCLES

Tavuk İskeletinde Eklemler

(Öğretmen Kopyası)

Amaç: Öğrencilerin eklemlerin önemini, eklemlerde bulunan kıkırdak ve kıkırdak sıvısının görevini ve eklem çeşitlerini kavratabilmek.

Hedef Öğrenciler: 6. Sınıf Fen ve Teknoloji dersi öğrencileri

Bilimin Doğası ve Bilimsel Süreç Becerileri Kazanımları:
(observing, inferring, comparing, manipulating materials, communicating)

- Gözlem yapar.
- Gözlemlere dayanarak çıkarım yapar.
- Kararlarını grup arkadaşlarıyla paylaşır.

Ünite Kazanımları:

- Eklemlerin önemini belirtir.
- Elemlerde bulunan kıkırdağın görevini açıklar.
- Eklem yerlerinde bulunan sıvın görevini belirtir.
- Eklem çeşitlerini açıklar.

Araç Gereç:

- Çeşitli tavuk kemikleri
- Eldiven
- Büyüteç
- Çalışma kağıdı

Gerekli Bilgiler:

Eklem iki kemiğin, vücut bölümlerinin hareket edebilmesini sağlamak için, birleştiği kısma verilen isimdir.

Hareket yeteneklerine göre eklemler üç çeşittir:

Oynar Eklem:

Kol ve bacaklarda olduğu gibi hareket yeteneği fazla olan eklemlerdir.

Kol ve bacak kemikleri bağlantı yerlerindeki eklemler, oynar eklemlerdir. Bunlar, iki bağlantı kemiğinin, eklem yerlerinde istenen hareketi verecek şekilde oynayabilmesini sağlamış olurlar. Böylece, bu eklemlerin bulunduğu kemikler, çeşitli hareket yeteneğine sahip eklemler özelliğini kazanmış olurlar. Oynar eklemlerdeki kemiklerden birinin başı, öbür kemiğin çukuruna girmiş şekildedir. İki kemik, birbirlerine eklem bağları ile bağlanmıştır. Kemiklerin birbirlerine sürtünmeleri sırasında aşınmalarım önlemek için, bu eklem yüzlerinde kıkırdak yastıkları ve buraları yumurta akı bir madde ile sıvayarak kaygan hale getiren eklem kesecikleri bulunur.

Oynamaz Eklem:

Kafatasını oluşturan kemikler arasında oynamaz eklem görülür. Bu kemikler, girinti ve çıkıntılarla birbirlerine oynamaz eklemlerle sıkıca bağlanırlar. Buradaki eklem yerleri, bir testerenin dişleri gibi birbirlerine geçme şeklindedir. Kemikler, bu girinti ve çıkıntılarla, birbirlerine oynamayacak şekilde eklenmiş durumdadırlar.

Yarı Oynar Eklem:

Omurgadaki omurlar arasındaki eklemler, yarı oynar eklemlerdir. Sınırlı olarak hareket ederler.

ETKİNLİK 1:

Tavuk Eklemleri

İsim:___________________________ Sınıf: _____________

Grup Arkadaşlarım:____________________________________

Amaç: Tavuk kemiklerindeki eklemleri incelemek.

Araç Gereç: Gerekenler öğretmen tarafından verilecektir.

Etkinliğin Yapılışı:

- 5 er kişilik gruplar oluşturun.
- Size verilen kemik poşetlerini inceleyin yaptığınız gözlemleri çalışma kâğıdına yazın.
- Tartışma sorularınızı grubunuzla tartışın ve yanıtlarınızı çalışma kâğıdına yazın.

Gözlemler:

Tavuk kemiklerini gözlemleyiniz.

İki kemiğin birleştiği noktada ne var?

İki kemiğin birleştiği kısımdaki yapıyı gözlemleyelim.

Rengi:

Şekli:

Kemiğe göre sertliği:

Kemikler her yöne katlanabiliyor mu? Neden?

Tartışma Soruları:

Bu kemiklerin hareket etmesi nasıl sağlanıyor?

Eklem yerlerinde bulunan kıkırdak ne işe yarıyor?

Kıkırdak olmasaydı kemikler hareket ettikçe zarar görür müydü?

Kıkırdak hareket ettikçe zarar görmez mi? İki kıkırdak arasını inceleyin. Kıkırdağın zarar görmesini engelleyen bir yapı olabilir mi?

İsim:__________________________ Sınıf: ______________

Grup Arkadaşlarım:__________________

ETKİNLİK 2:

SÜRTÜNMEYİ AZALTALIM

Amaç: Eklemlerdeki kıkırdağın görevini bir analoji ile kavrayabilmek.

Araç Gereç: Ahşap plaka/bloklar, şeffaf poşet/streçfilm, deterjan.

Etkinliğin Yapılışı:

- 3 er kişilik gruplar oluşturun.
- İlk olarak ahşap blokları birbirine bastırarak sürtün ve aradaki sürtünmeyi hissedin.
- Bu defa ahşap blokları poşet ile kaplayın ve tekrar birbirine sürtün.
- Son olarak kaplanmış ahşaplar arasına biraz deterjan dökün ve tekrar birbirine sürtün.

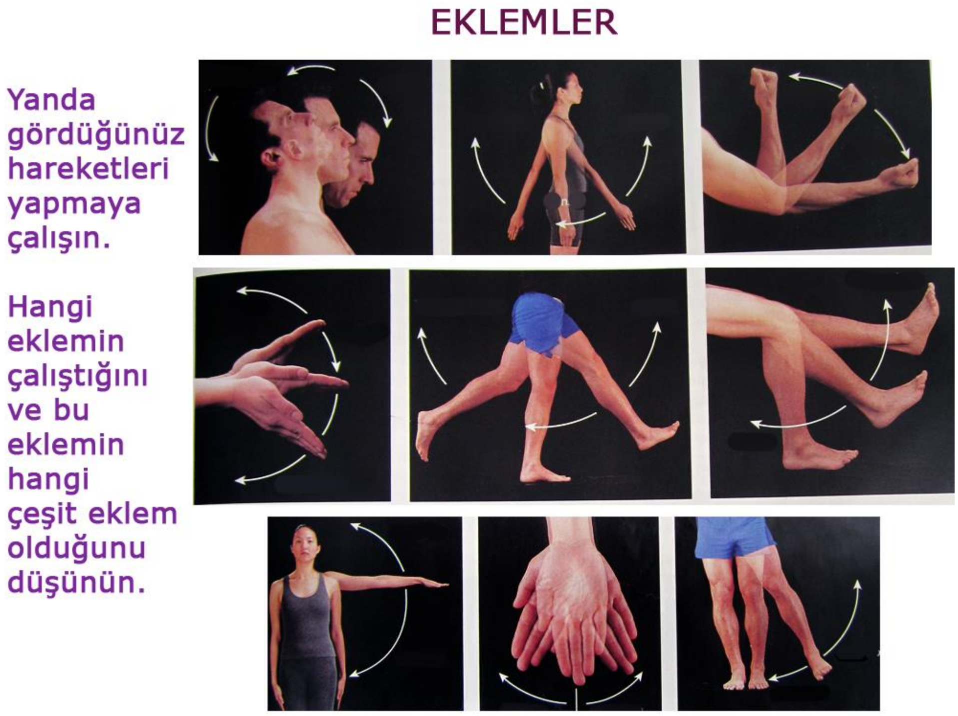
Sorular:

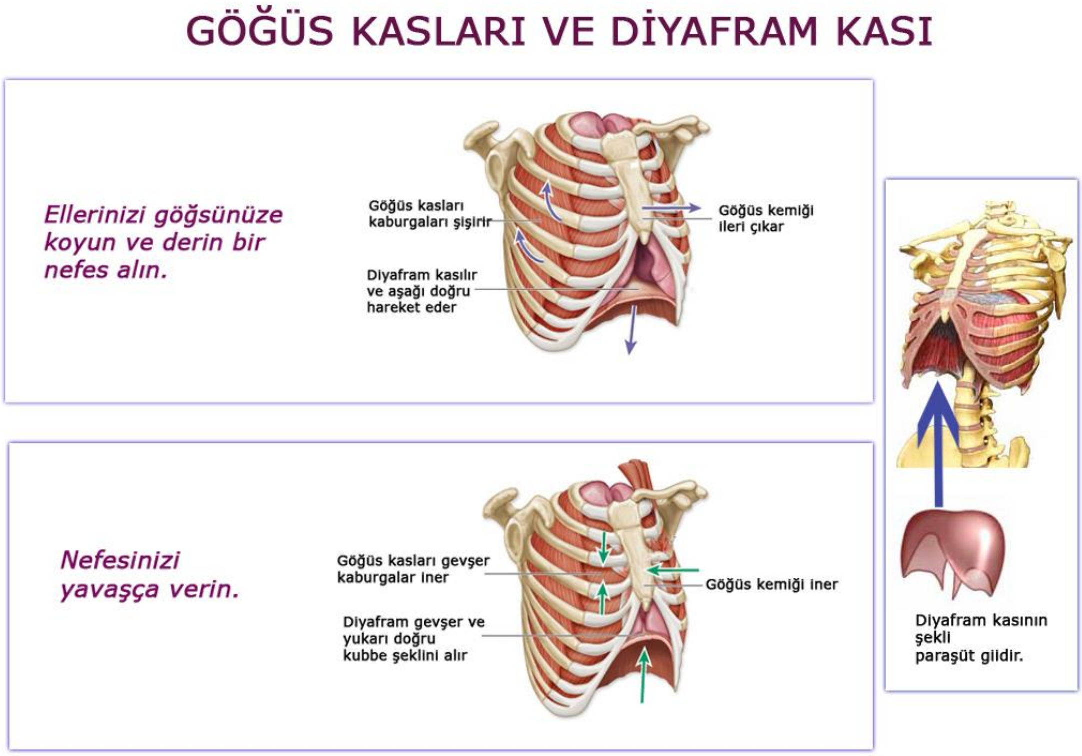
Hissettiğiniz sürtünme miktarlarını büyükten küçüğe doğru sıralayın.

Etkinlikte verilen materyaller sizce vücudumuzdaki hangi yapıları ifade etmektedir?

Materyal	**Vücudumuzdaki Yapı**
Ahşap bloklar	
Şeffaf poşet	
Deterjan	

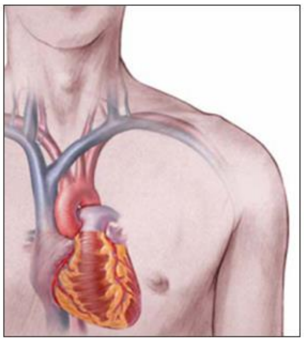
JOINTS AND MUSCLE STATION POSTERS

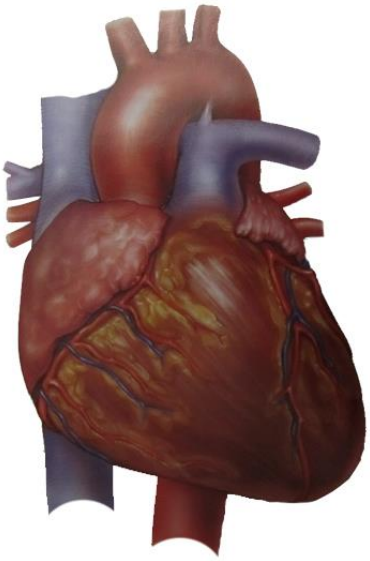




KALP KASI

Elinizi sol göğsünüze koyun.
Kalbinizin atışını hissedin.





Kalp, kalp kası olarak bilinen özel bir tip çizgili kastan oluşmuş kendiliğinden kasılma özelliğine sahip bir organdır.

YÜZ KASLARI

Mimiklerimizi yüz kaslarımız sayesinde yapıyoruz

Yukarıdaki mimikleri yüzünüzde yapın.
Hangi kaslarınızı kullandığınızı yandaki resimden bulmaya çalışın.

EXAMPLE OF AN ARM MODEL

Source: Steve, 1999

APPENDIX M

7E-LCI MATERIALS RELATED TO CIRCULATORY SYSTEM

DOLAŞIM SİSTEMİNİN TARİHÇESİ

Milattan önce dolaşım sistemi hakkında çok az şey biliniyordu. Bilim insanları özellikle ölü hayvanlar üzerinde incelemeler yapıyordu. Ölümden sonra, kan toplardamarlarda toplandığından, atardamarlar boş görünmektedir. Bunu gözlemleyen bilim insanları atardamarların hava ile dolu olduğunu düşünmüş ve bu damarların hava dağıtma görevine sahip olduğu kanısına varmışlardı.

Ancak Erasistratus adlı bilim insanı canlıların atardamarı kesildiğinde atardamardan da kan geldiğini gözlemlemişti. Buradan da atardamardan çıkan havanın yerini toplardamardaki kanın doldurduğunu düşünüp, iki damar arasında bir şekilde bir geçiş olacağı fikrini ortaya atmıştı.

Milattan sonraki dönemlerde yaşayan bilim insanları ise yaptıkları incelemelerden damarların kan taşıdığı, kanın hareketinin damarların pompalamasıyla sağlandığı ve kanın kalbin sağ ve sol yarısının arasında bulunan gözle görülemeyen küçük gözeneklerden geçtiği çıkarımını yapmışlardı.

1242 yılında **İbn Nefis**, insan vücudundaki kan dolaşımını doğru biçimde tanımlayabilen ilk kişi olmuştu. İbn Nefis kanın kalbin sağ odasından sol odasına varması gerektiğini, fakat bu ikisi arasında doğrudan bir geçiş (yolu) bulunmadığını belirtmiş kanın damarlar yoluyla kalp ve akciğer arasında yol aldığını açıklamıştır.

Figür 1. İbn Nefis

Figür 2. William Harvey

Ancak dolaşım sisteminin yaygın olarak kabulü 1628 yılında **William Harvey** sayesinde gerçekleşti. Bilginin gözlemlere dayalı olması gerektiğini savunan Harvey, insan vücudunda dolaşım sistemini inceleme fırsatı buldu. Yaptığı uzun incelemelerden sonra insan dolaşım sistemini keşfettiğini duyurdu ve bu konuda "(Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus)" isimli bir kitap yayımladı. Bu kitap sayesinde Harvey'in açıkladığı dolaşım sistemi tıp dünyasında kabul edildi. Kitabı yayınladığında Harvey dolaşım sistemi ile ilgili her şeyi keşfettiğini düşünmekteydi.

Gerçekte ise Harvey, kanın, atardamarlardan toplardamarlara geçişini kanın etteki deliklerden geçmesiyle gerçekleştiğini tahmin etmiştir. Bu konudaki doğru açıklamayı Harvey'den 30 yıl sonra **Malpighi** yapabilmiştir çünkü yeni icat edilmiş mikroskop yardımıyla atardamarlar ve toplardamar sistemlerini birleştiren kılcal damarları gözlemleyebilmiştir.

Figür 3. Marcello Malpigi

Figür 4. Laennec

1816 yılında Laennec'in icat ettiği ilk *stetoskop* ile kalbin sesi daha kolay duyulmaya başlanmıştır. Bu sayede dolaşım sistemi ile ilgili rahatsızlıklar daha kolay teşhis edilmektedir.

Günümüzde de dolaşım sisteminin yapısı ve rahatsızlıkları ile ilgili araştırmalar devam etmektedir. Özellikle MR (emar) makinelerinin icadı gibi teknolojik gelişmeler dolaşım sistemini daha ayrıntılı incelenebilmesini sağlamıştır.

Figür 5. MR makinesi

KALBİMİN ATIŞ HIZINI DEĞİŞTİREBİLİR MİYİM?

Amaç: Öğrencilere egzersizin kalp atış hızı üzerine etkisini öğretebilmek.

Hedef Öğrenciler: 6. Sınıf Fen ve Teknoloji dersi öğrencileri

Bilimin Doğası ve Bilimsel Süreç Becerileri Kazanımları:

- Kalp atışını duyarak gözlem yapar.
- Deney tasarlar.
- Ölçüm yapar.
- Gözlemlere dayanarak çıkarım yapar.
- Kararlarını ve gözlemlerini yazılı ve sözlü olarak grup arkadaşlarıyla paylaşır.
- Verilen materyalleri gerektiği gibi kullanır.

Araç Gereç:

- Saat
- Steteskop
- Çalışma kağıdı

Öğrencilere aşağıdaki iki resim gösterilerek hangi çocuğun kalp atışının daha hızlı olmasını bekledikleri sorulur.

Tahminlerinin doğru olup olmadığını test edebilmeleri için bir deney yapacakları söylenir. Deneyi yapabilmek için öncelikle kalp atışının nerelerden ölçülebildiği sorulur. Boyun, bilek ve göğüs cevapları alındığında deney tasarlama kağıtları öğrencilere dağıtılır.

Öğrencilerden 3'er kişilik gruplar oluşturarak deney tasarlamaları istenir.

Gerektiğinde aşağıdaki yönergeler verilebilir.

- Gruptan bir kişiyi yazmak, bir kişiyi süre tutmak ve bir kişiyi de deneyi yapmak ile görevlendirin.
- Yaptığınız her ölçümü tabloya yazın.
- Deneyi yapacak öğrencinin 30 saniye boyunca kalp atışını ölçün.
- Öğrenci 1 dakika boyunca zıpladıktan sonra 30 saniye boyunca kalp atışını ölçün.
- Öğrenci 1 dakika dinlendikten sonra 30 saniye boyunca kalp atışını ölçün.
- Tabloyu doldurduktan sonra grafik çizin.

Sınıftaki tüm öğrencilerin ölçümlerini tahtada hazırladığınız bir tabloya alın ve tüm sınıfın verilerinden genel bir sonuca ulaşmalarını isteyin.

Sınıf: İsimler____ ___

KALP ATIŞIMI DEĞİŞTİREBİLİR MİYİM?

Deney Tasarlama Çalışma Kâğıdı

Araştırma Sorusu	Egzersizin kalp atış hızına bir etkisi var mıdır?
Hipotez	
Ölçülen Değişken	
Değiştirilen Değişken	
Kontrol Değişken	
Araç-Gereç	
Deneyin Yapılışı	
Tahminler	

Gözlemler

	________ saniyedeki kalp atışı sayısı	60 saniyedeki kalp atışı sayısı
Deneye başlamadan önce		
________saniye egzersizden sonra		
________saniye dinlendikten sonra		

Sonuç:

KALBİN YAPISINI İNCELEYELİM

(Öğretmen Kopyası)

Amaç: Kalbin yapısını, kulakçıkları, karıncıkları ve kapakçıkları incelemek.

Hedef Öğrenciler: 6. Sınıf Fen ve Teknoloji dersi öğrencileri

Bilimin Doğası ve Bilimsel Süreç Becerileri Kazanımları:

(observing, communicating, inferring, manipulating materials.)

- Gözlem yapar.
- Gözlemlere dayanarak çıkarım yapar.
- Kararlarını ve gözlemlerini yazılı ve sözlü olarak grup arkadaşlarıyla paylaşır.
- Verilen materyalleri gerektiği gibi kullanır.

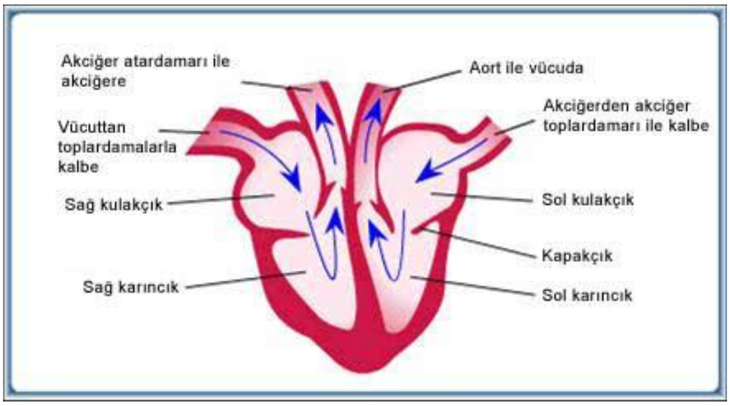
Ünite Kazanımları:

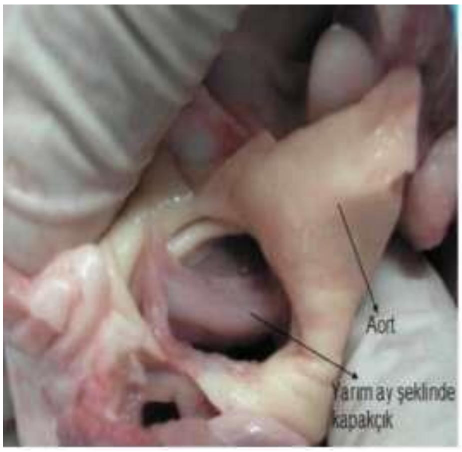
- Kalbin yapısı ve görevini açıklar.

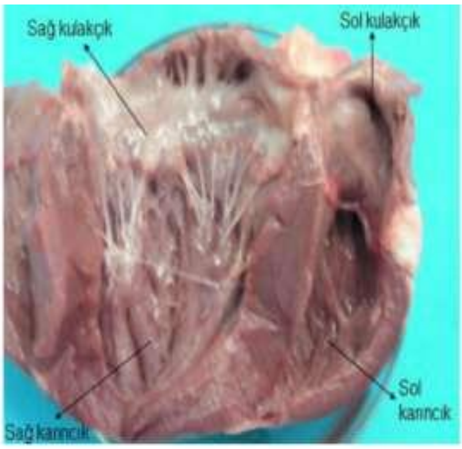
Araç Gereç:

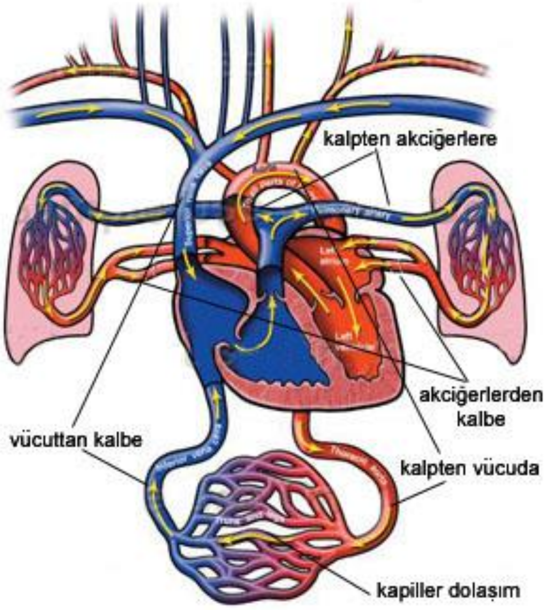
- Koyun kalbi
- Eldiven
- Büyüteç
- Disseksiyon küveti
- Çalışma kağıdı

Gerekli Bilgiler:









ETKİNLİK:

KALBİN YAPISINI İNCELEYELİM

İsim:______________________ Sınıf: _____________

Grup

Arkadaşlarım:____

Amaç: Kalbin yapısını incelemek.

Araç Gereç: Gerekenler öğretmen tarafından verilecektir.

Etkinliğin Yapılışı:

- 5 er kişilik gruplar oluşturun.
- Size verilen bütün ve ortadan ikiye ayrılmış kalbi inceleyin yaptığınız gözlemleri çalışma kâğıdına yazın.
- Tartışma sorularınızı grubunuzla tartışın ve yanıtlarınızı çalışma kâğıdına yazın.

Gözlemler: Bütün Kalp Size verilen bütün kalbi inceleyin. Rengi nasıl? Şekli nasıl? Sertliği nasıl? Üzerinde kaç adet delik var? Diğer…

İncelediğiniz kalbin şeklini aşağıdaki bölmeye çizin.

Tartışma Soruları:

Kalbin üst kısmında bulunan delikler nedir?

Bu deliklerin adlarını tahmin etmeye çalışın.

Kalbin yapısını oluşturan kas nasıl bir kastır? Özelliği ve çalışma prensibi nasıldır?

Gözlemler: Bölünmüş Kalp

Size verilen bölünmüş kalbi inceleyin.

İç kısmın rengi nasıl?

İç kısmın sertliği nasıl?

İç kısımda kaç adet bölüm var?

Kalbin alt bölümünde bulunan kasın kalınlığı ile üst kısmında bulunan kasın kalınlığı aynı mıdır?

Diğer…

İncelediğiniz kalbin şeklini aşağıdaki bölmeye çizin.

Tartışma Soruları:

Kalbin içinde gördüğünüz bölümler nelerdir?

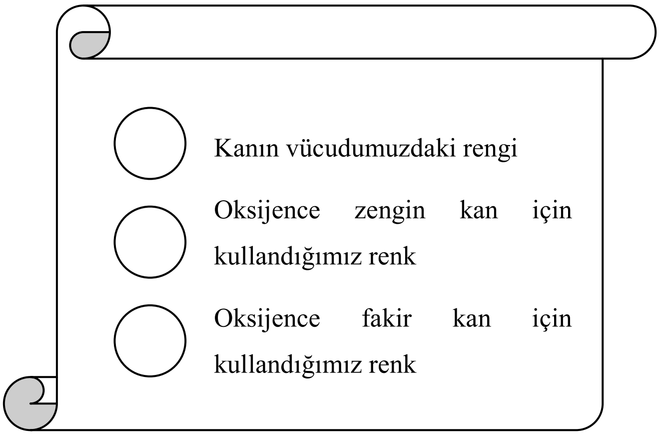
Sizce hangi damar hangi bölüm ile bağlanmaktadır?

Alt ve üst bölümler arasında yer alan kapaklara ne ad verilir ve görevleri nedir?

Kalbin alt bölümünde bulunan kasın kalınlığı ile üst kısmında bulunan kasın kalınlığı neden farklıdır?

Çizdiğiniz bölünmüş kalp resmine dönün ve kalbin bölümlerinin adlarını ok çıkartarak yazın.

Dolaşım Sistemini Boyayalım



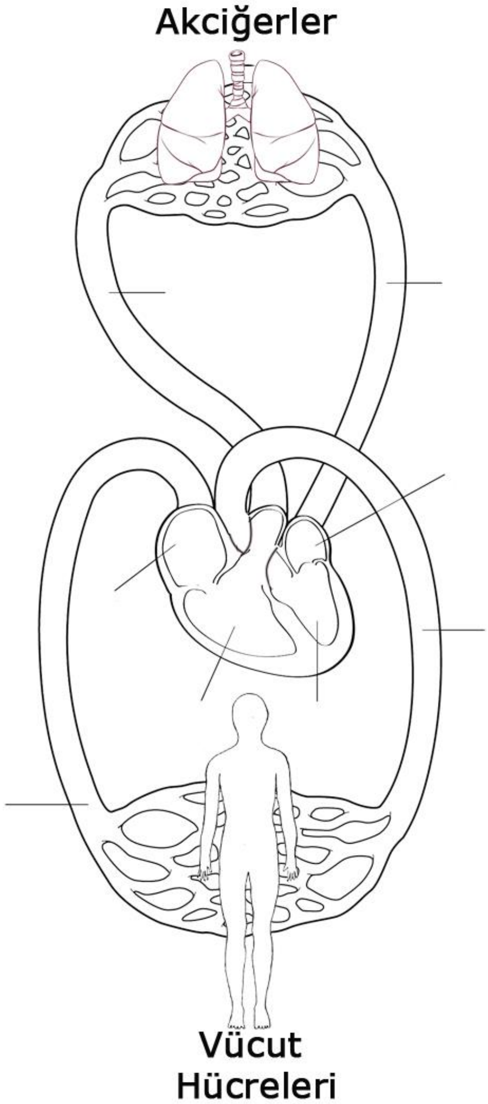
Kanın vücudumuzdaki rengi

Oksijence zengin kan için kullandığımız renk

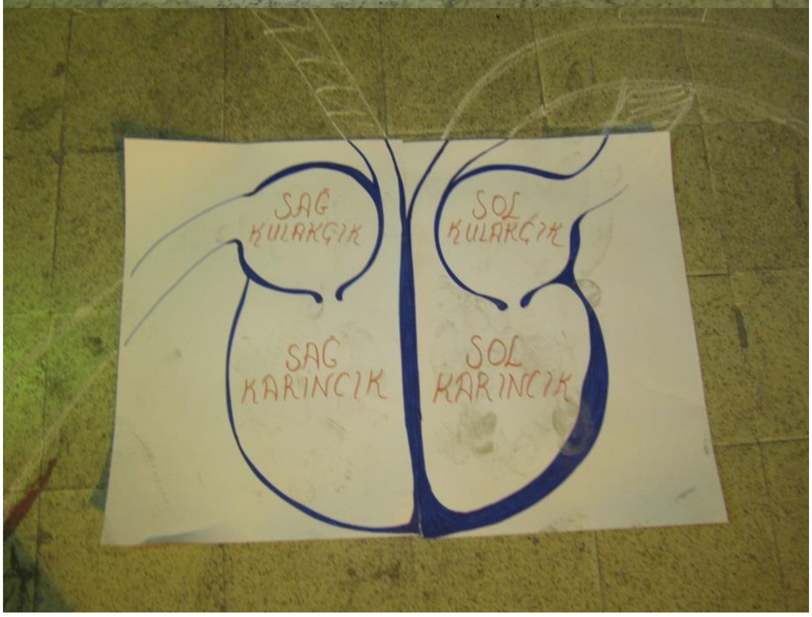
Oksijence fakir kan için kullandığımız renk

Önce boyayalım.

Sonra okla gösterilen yerleri adlandıralım.



THE PHOTOS RELATED WİTH FLOOR-MAP



KAN ÇİZELGESİ

İsimler ____

Sınıf______

Kanımız neler yapar?

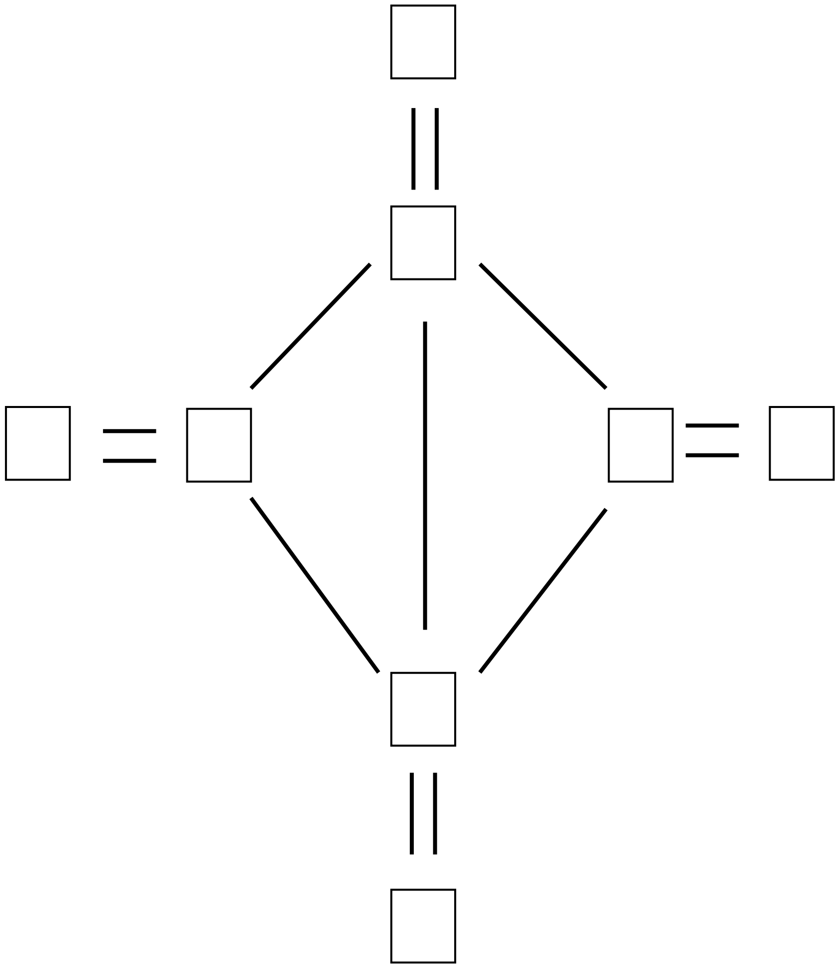
	Alyuvar	Akyuvar	Kan Pulcukları	Plazma
Yapısındaki hemoglobin sayesinde akciğerlerden hücrelere oksijen taşır				
Vücuttaki virüslerle savaşır				
Vücuttaki bazı mikropları içine alarak yok eder.				
Yapısındaki hemoglobin sayesinde karbondioksiti hücrelerden uzaklaştırır.				
Kanın pıhtılaşmasını sağlar				
Besinleri organlara iletir				
Atık maddeleri uzaklaştırır				

İsimler ____

Sınıf______

KAN GRUPLARI ŞEMASI

Aşağıdaki şemaya dört kan grubunu yerleştiriniz ve kan grupları arasındaki kan alışverişini göstermek için okları tamamlayınız.



KANIMIZIN MODELİNİ YAPALIM

Amaç: Kanın yapısında bulunanları bir model ile öğrenmek.

Hedef Öğrenciler: 6. Sınıf Fen ve Teknoloji dersi öğrencileri

Araç Gereç:

- Şeffaf plastik veya cam bardak
- Su
- Sarı gıda boyası
- Kırmızı boncuk
- Küçük renksiz boncuk
- Beyaz boncuk
- Çalışma kağıdı

Modelin Yapılışı:

1. Bardağın neredeyse tamamını kırmızı boncuklar ile doldurun.
2. Daha sonra birkaç tane beyaz boncuk ekleyin (yaklaşık 5 adet).
3. Üzerine bir tutam küçük boncuk ekleyin.
4. Bardağın üzerini kapatıp çalkalayarak boncukları karıştırın.
5. Boncukların üzerine bardak dolana kadar sarı gıda boyası ile boyanmış su doldurun.

İşte kanımız da bu bardakta görünen modele benziyor. Sizce kullandığımız malzemeler kanın yapısında neyi temsil etmektedir?

MODELDE	**KANDA**	**Buna neye dayanarak karar verdiniz?**
Sarı Su		
Kırmızı Boncuk		
Beyaz Boncuk		
Küçük Renksiz Boncuk		

Şimdi sınıfça hazırladığımız kan modeli ile vücudumuzda bulunan kanın yapısı arasındaki benzerlikleri ve farklılıkları tartışalım.

APPENDIX N

7E-LCI MATERIALS RELATED TO RESPIRATORY SYSTEM

ETKİNLİK 1

(Öğretmen)

AKCİĞERLERİMİN KAPASİTESİ

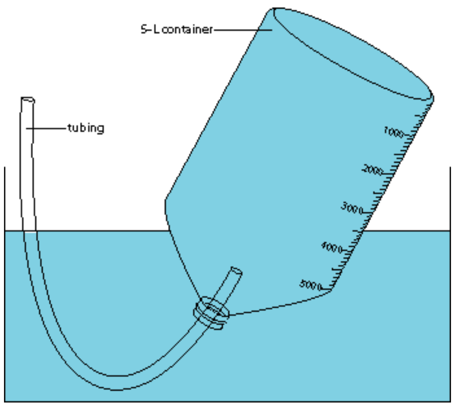
Amaç: Akciğerlerin kapasitesini bir düzenek ile ölçmek.

Hedef Öğrenciler: 6. Sınıf Fen ve Teknoloji dersi öğrencileri

Bilimin Doğası ve Bilimsel Süreç Becerileri Kazanımları:

(observing, inferring, measuring, communicating)

- Gözlem yapar.
- Gözlemlere dayanarak çıkarım yapar.
- Ölçüm yapar.
- Kararlarını ve gözlemlerini tablolaştırır, yazılı ve sözlü olarak grup arkadaşlarıyla paylaşır.



Ünite Kazanımları:

- Nefes alındığında akciğerlere hava dolduğunu, verildiğinde ise akciğerlerdeki havanın geri verildiğini açıklar.
- Nefes verildiğinde akciğerlerdeki havanın tamamen boşalmadığını belirtir.

Araç Gereç:

- Ölçülü kap
- Büyük plastik kap
- Pipet
- Su

Deneyin Yapılışı:

1. Ölçülü kabı(şişeyi) ağzına kadar su ile doldurun.
2. Büyük kabı da bir miktar su ile doldurun.
3. Ölçülü kabı ağzından hava almayacak şekilde elinizle kapatarak şekildeki gibi ters çevirip büyük kabın içine yerleştirin.
4. Pipeti de kullanarak yandaki düzeneği kurun.

Öğrencilerin aşağıdaki ölçümleri yaparak tabloyu doldurmalarını isteyin:

1. Öncelikle normal nefes alın ve pipetten üflerken normal nefes verin. Ölçümünüzü tabloya yazın.
2. Daha sonra normal nefes alın, normal nefes verin ve akciğerde kalan havayı pipete üfleyin. Ölçümünüzü tabloya yazın.
3. Şimdi derin bir nefes alın ve tüm kuvvetinizle pipete üfleyin. Ölçümünüzü tabloya yazın.

Tahmini sonuçlar:

	Hacim (ml.)
Normal verilen nefesteki hava miktarı	150-250
Normal nefesten sonra akciğerlerde kalan hava miktarı	100-150
Derin nefes ile üflenen hava miktarı	250-350

Tartışma Soruları:

Sizce nefesimizi verdiğimizde akciğerlerimizin tamamı boşalıyor mu?

Derin nefes aldığımızda akciğerlerimize dolan hava miktarı ile normal nefeste alınan hava miktarı aynı mıdır?

Nefes verdiğimizde ölçülü kabın içine dolan havada ne veya neler var?

ETKİNLİK 1

AKCİĞERLERİMİN KAPASİTESİ

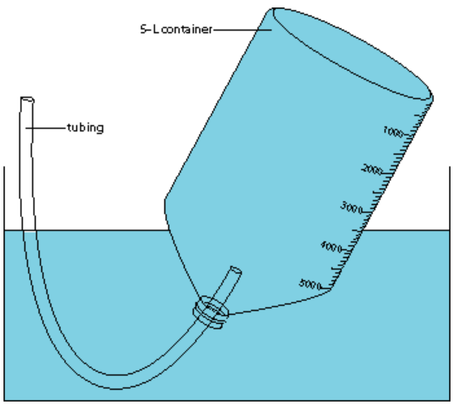
Amaç: Akciğerlerin kapasitesini bir düzenek ile ölçmek.

Araç Gereç:

- Ölçülü kap
- Büyük plastik kap
- Pipet
- Su

Deneyin Yapılışı:

1. Ölçülü kabı(şişeyi) ağzına kadar su ile doldurun.
2. Büyük kabı da bir miktar su ile doldurun.
3. Ölçülü kabı ağzından hava almayacak şekilde elinizle kapatarak şekildeki gibi ters çevirip büyük kabın içine yerleştirin.
4. Pipeti de kullanarak yandaki düzeneği kurun.



Ölçümler:

1. Öncelikle normal nefes alın ve pipetten üflerken normal nefes verin. Ölçümünüzü tabloya yazın.
2. Daha sonra normal nefes alın, normal nefes verin ve akciğerde kalan havayı pipete üfleyin. Ölçümünüzü tabloya yazın.
3. Şimdi derin bir nefes alın ve tüm kuvvetinizle pipete üfleyin. Ölçümünüzü tabloya yazın.

Sonuçlar:

	Hacim (ml.)
Normal verilen nefesteki hava miktarı	
Normal nefesten sonra akciğerlerde kalan hava miktarı	
Derin nefes ile üflenen hava miktarı	

Tartışma soruları:

Sizce nefesimizi verdiğimizde akciğerlerimizin tamamı boşalıyor mu?

Derin nefes aldığımızda akciğerlerimize dolan hava miktarı ile normal nefeste alınan hava miktarı aynı mıdır?

Nefes verdiğimizde ölçülü kabın içine dolan havada ne veya neler var?

KALP ATIŞIMI DEĞİŞTİREBİLİR MİYİM?

Deney Tasarlama Çalışma Kâğıdı

Amaç: Egzersizin nefes alışverişine etkisini kavrayabilmek.

Araştırma Sorusu	Egzersizin nefes alışveriş hızına bir etkisi var mıdır?
Hipotez	
Ölçülen Değişken	
Değiştirilen Değişken	
Kontrol Değişken	
Araç-Gereç	
Deneyin Yapılışı	
Tahminler	

GÖZLEMLER:

	________ saniyedeki nefes alış sayısı	60 saniyedeki nefes alış sayısı
Deneye başlamadan önce		
____________ Egzersizden sonra		
__________ Dinlendikten sonra		

SONUÇ:

AKCİĞERLERİN YAPISINI İNCELEYELİM

(Öğretmen Kopyası)

Amaç: Akciğerin yapısını, soluk borusunu, bronş ve bronşçukları incelemek.

Hedef Öğrenciler: 6. Sınıf Fen ve Teknoloji dersi öğrencileri

Bilimin Doğası ve Bilimsel Süreç Becerileri Kazanımları:

(observing, inferring, communicating)

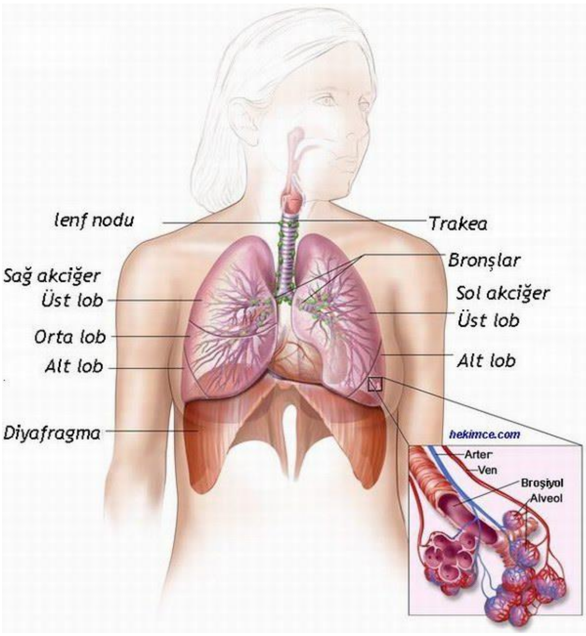
- Gözlem yapar.
- Gözlemlere dayanarak çıkarım yapar.
- Kararlarını ve gözlemlerini yazılı ve sözlü olarak grup arkadaşlarıyla paylaşır.

Ünite Kazanımları:

- Akciğerin yapısı ve görevini açıklar.
- Akciğerlerdeki gaz alışverişini açıklar.

Araç Gereç:

- Dikine ortadan ikiye kesilmiş ve üzerine kesikler atılmış koyun akciğeri
- Fermuarlı buzdolabı poşeti
- Eldiven
- Büyüteç
- Çalışma kağıdı



Gerekli Bilgiler:

Sağ akciğer 3 bölümden sol akciğer ise 2 bölümden oluşmuştur. Sol akciğer daha az yer kaplar çünkü sol kısımda kalp bulunmaktadır.

Soluk borusu bronşlara, bronşlar ise bronşçuklara ayrılır. Bronşçukların ucunda alveol adlı hava kesecikleri bulunur.

Alveollerin çevresi kılcal kan damarları ile çevrilidir ve gaz alışverişi alveoller ile kılcal damarlar arsında gerçekleşir.

Çalışma Kağıdında Bulunan Tartışma Soruları:

- Akciğerlerin içi boş mudur? İçinin yapısı nasıldır?
- Sizce hava akciğerlerde nereye dolmaktadır?
- Soluk borusunun nasıl bir yapısı vardır? Yapısında kemik bulunuyor mu?
- Soluk borusu akciğerlere girerken kaç bölmeye ayrılıyor? Soluk borusu ayrıldıktan sonra hangi adı almaktadır?
- Soluk borusu ile hava ileten bu borular aynı kalınlıkta mıdır?
- Akciğerlerin içine girdikçe hava ileten bu boruların kalınlığı değişiyor mu?
- Akciğerlerin görevi nedir?
- Sizce oksijen kana nasıl geçmektedir? Kandaki karbondioksit kandan nasıl alınmaktadır?
- Hava akciğerlere nasıl dolmaktadır? Nefes aldığımızda havanın akciğerlerimize dolmasını nasıl sağlıyoruz?

ETKİNLİK

AKCİĞERLERİ İNCELEYELİM

(Öğrenci Kopyası)

İsim:___________________ Sınıf: _______________________

Grup

Arkadaşlarım:____

Amaç: Soluk borusu ve akciğerlerin yapısını incelemek.

Araç Gereç: Gerekenler öğretmen tarafından verilecektir.

Etkinliğin Yapılışı:

- 6 şar kişilik gruplar oluşturun.
- Size verilen akciğer parçalarını inceleyin yaptığınız gözlemleri çalışma kâğıdına yazın.
- Tartışma sorularınızı grubunuzla tartışın ve yanıtlarınızı çalışma kâğıdına yazın.

Gözlemler:
Size verilen akciğer parçasını inceleyin.
Rengi nasıl?
Şekli nasıl?
Sertliği nasıl?
Diğer…

İncelediğiniz akciğer parçasının şeklini aşağıdaki bölmeye çizin.

Tartışma Soruları:

Size verilen parçadaki akciğer kaç bölümden(lobdan) oluşmaktadır?

Sizce sizdeki parça sağ akciğere mi aittir sol akciğere mi aittir? Buna neye dayanarak karar verdiniz?

Akciğerlerin içi boş mudur? İçinin yapısı nasıldır?

Sizce hava akciğerlerde nereye dolmaktadır?

Soluk borusunun nasıl bir yapısı vardır? Sizce soluk borusu kemikten mi yoksa kıkırdaktan mı oluşmaktadır? Neden böyle düşünüyorsunuz?

Soluk borusu akciğerlere girerken kalınlığı değişiyor mu? Soluk borusu ayrıldıktan sonra hangi adı almaktadır?

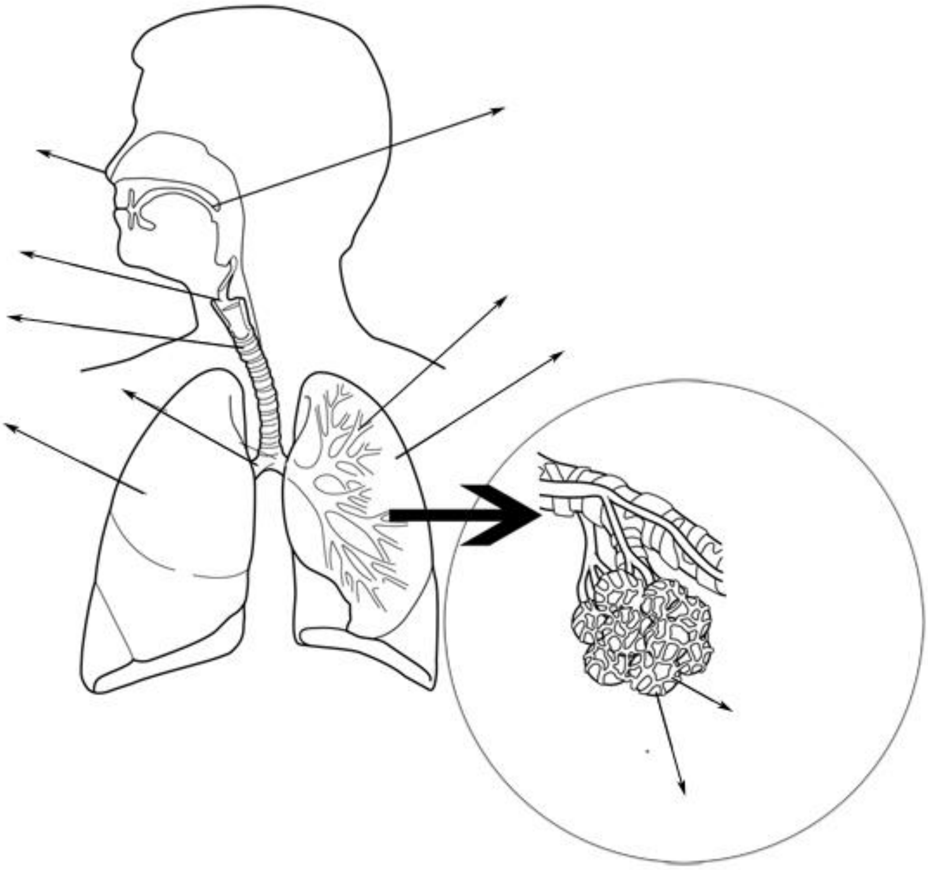
Akciğer üzerindeki kesikleri ayırarak hava ileten boruların devamını bulmaya çalışın. Boruların kalınlığı değişiyor mu?

Sizce bu boruların ilettiği havadaki oksijen kana nasıl geçiyor? Kandaki karbondioksit kandan nasıl alınıyor?   Akciğerlerin görevi nedir?   Hava akciğerlere nasıl dolmaktadır? Nefes aldığımızda havanın akciğerlerimize dolmasını nasıl sağlıyoruz?

SOLUNUM SİSTEMİ ORGANLARI

Amaç: Solunum sisteminin organlarını kavrayabilmek.

Aşağıdaki şekilde gösterilen solunum sistemi organlarının adlarını okların ucuna yazınız.



Havanın vücudumuza girerken ve çıkarken aldığı yolu aşağıya yazınız.

Girerken:

Çıkarken:

ETKİNLİK

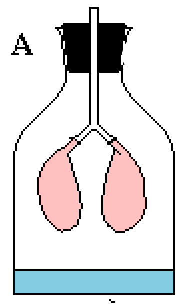
AKCİĞER MODELİ

Amaç: Diyafram ve akciğerlerin çalışma prensibini bir model ile kavrayabilmek.

Araç Gereç:

- 2 adet küçük balon.
- 1 adet büyük balon.
- Pipet.
- Y borusu veya dirsekli pipet.
- Plastik şişe
- Makas
- Oyun hamuru
- Paket lastiği

Modelin Yapılışı:



1. Plastik şişenin altını ve üstünü ortasından keserek ayırın.
2. Y borusunun tekli ucunu pipetin ucuna takın. Veya 2 kıvrımlı pipeti kıvrımları açıkta kalacak şekilde birbirine bağlayın.
3. Y borusunun çiftli ucuna 2 küçük balonu hava sızdırmayacak şekilde bağlayın.
4. Plastik şişenin kapağının ortasında bir delik açın ve şişeye takın
5. Bir ucunda balonlar olan pipetin diğer ucunu bu delikten geçirin. Arada kalan boşluğu oyun hamuru ile kapatın.
6. Şişenin altta kalan açık kısmına büyük balonu gerin ve paket lastiği ile tutturarak modeli yandaki resimde gösterilen son haline getirin.

Gözlemler:

Modelin altına gerilen balonu aşağı doğru çekin. Şişenin içindeki balonlarda bir değişiklik gözlemlediniz mi? Neden?

Modelin altına gerilen balonu içeri doğru itin. Şişenin içindeki balonlarda bir değişiklik gözlemlediniz mi? Neden?

Tartışma Soruları:

Aşağıdaki tabloyu doldurun. Sizce modeldeki malzemeler solunum sistemi ile alakalı hangi yapıları temsil etmektedir.

Modelde	**Vücudumuzda**
Küçük 2 balon	
Pipet	
Şişe	
Alt kısma gerilen balon	

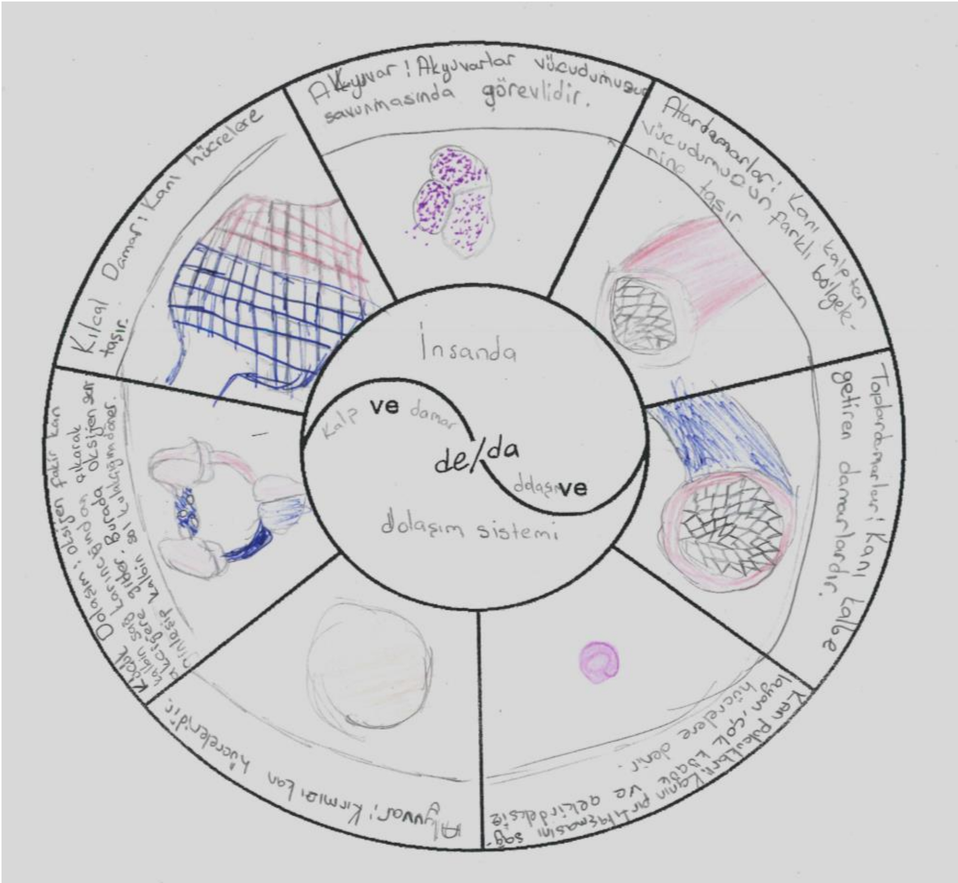
Nefes aldığımızda akciğerlerimize hava dolması nasıl sağlanır?

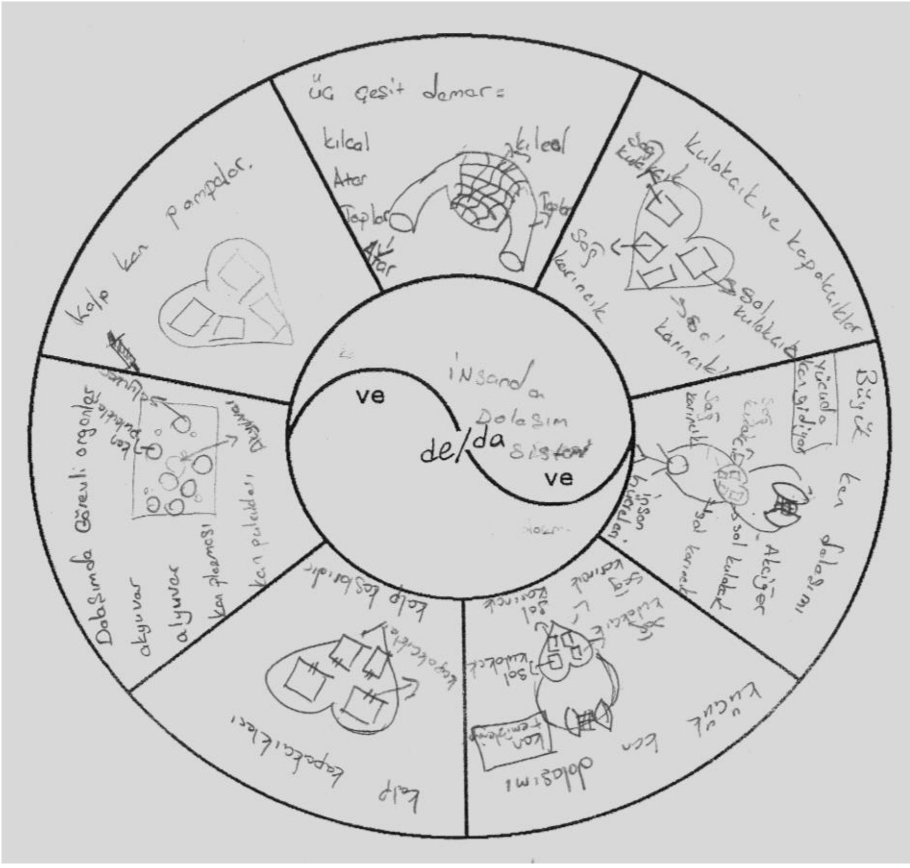
Nefes verdiğimizde akciğerlerimizdeki havanın boşalmasını nasıl sağlıyoruz?

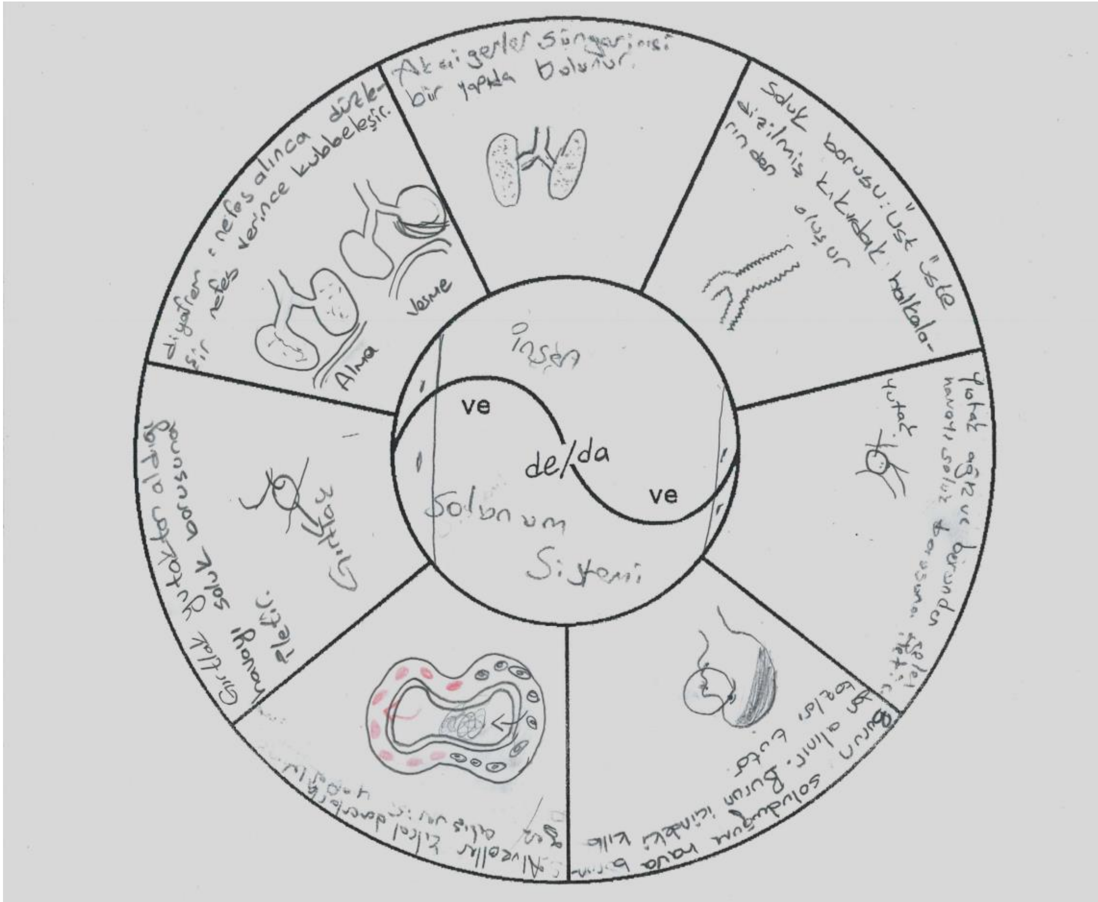
Bu modelde eksik olan ama nefes alıp vermeye yardımcı olan yapı hangisidir?

APPENDIX O

SAMPLES OF ROUNDHOUSE DIAGRAMS COMPLETED BY EXPERIMENTAL GROUP STUDENTS

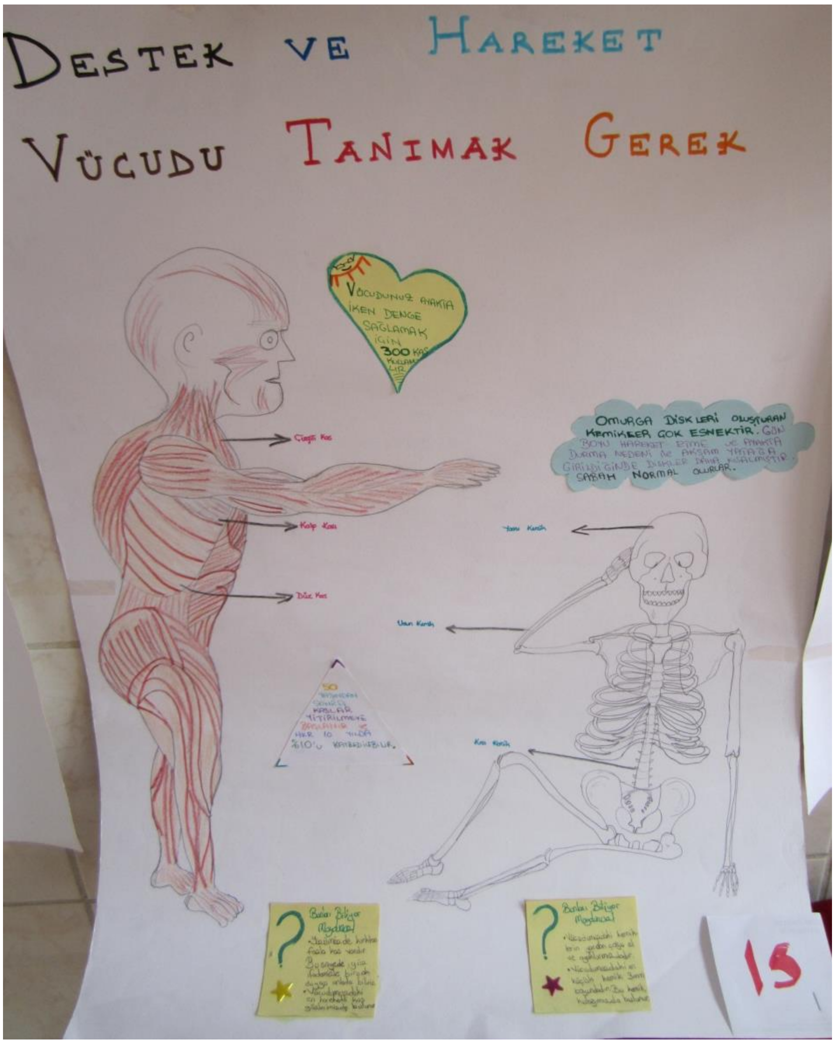

İnsanda
Kalp ve damar
de/da
dolaşım ve
dolaşım sistemi
Akyuvar: Akyuvarlar vücudumuzu savunmasında görevlidir.
Atardamarlar: Kanı kalpten vücudumuzun farklı bölgelerine taşır.
Toplardamarlar: Kanı kalbe getiren damarlardır.
Alyuvar: kırmızı kan hücreleridir.
Kılcal Damar: Kanı hücrelere taşır.


üç çeşit damar:
kılcal
Atar
Toplar
Kulakçık ve kapakçıklar
Kalp kan pompalar.
İnsanda Dolaşım Sistemi
ve
de/da
ve
Büyük kan dolaşımı
Akciğer
Küçük kan dolaşımı
kalp kapakçıkları
Dolaşımda Görevli organlar
akyuvar
alyuvar
kan plazması
kan pulcukları

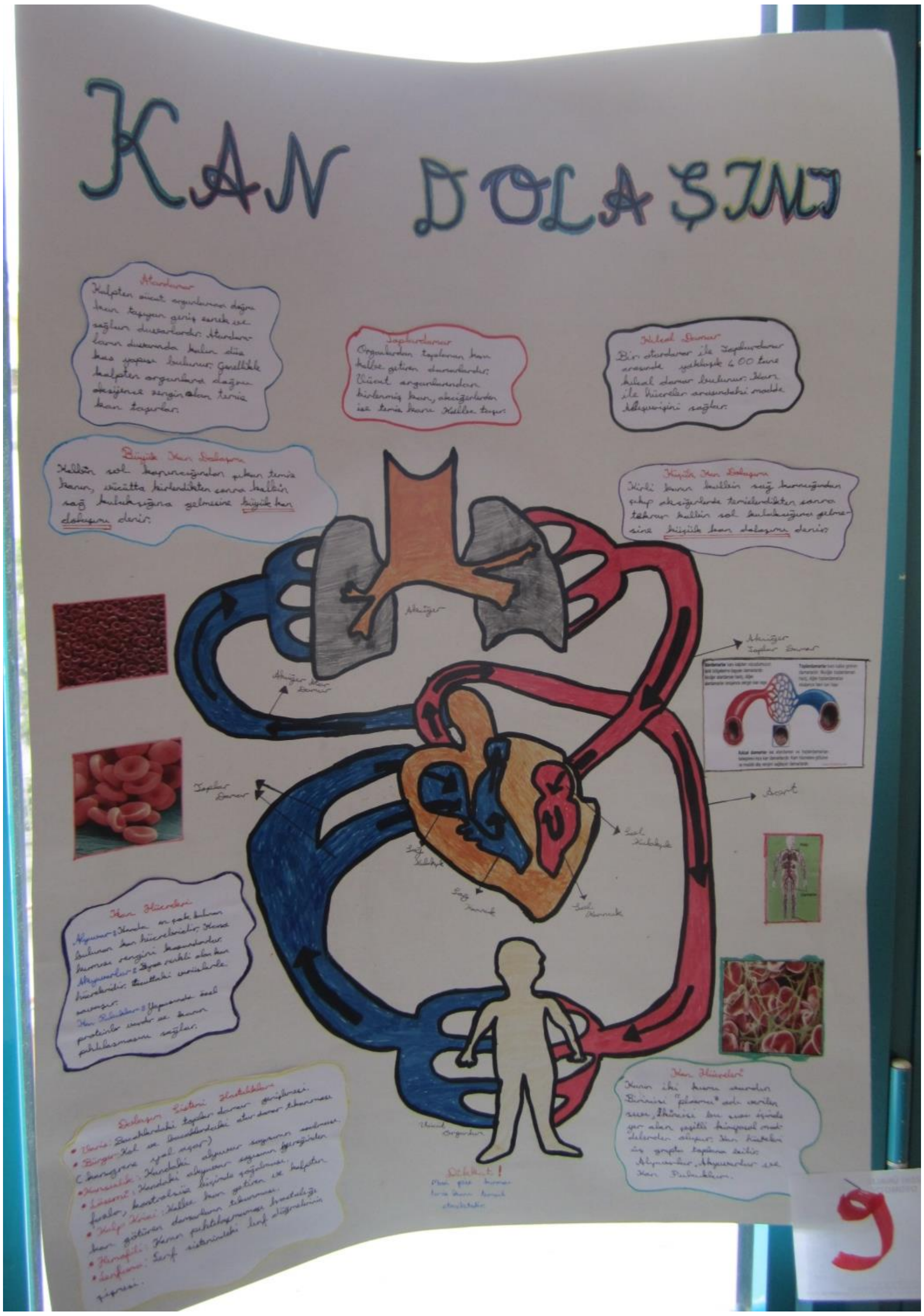

ve
de/da
ve

APPENDIX P

SAMPLES OF POSTERS PRESENTED BY EXPERIMENTAL GROUP STUDENTS




16
DESTEK VE HAREKET SİSTEMİ


KAN DOLAŞIMI

APPENDIX Q

MIXED-ANOVA AND MIXED MANOVA SYNTAXES, AND ASSUMPTIONS

Mixed-ANOVA Extended Sytax for Respiratory System Conceptual Test:

```
GLM resp1 resp2 resp3 BY group
  /WSFACTOR=time 3 Polynomial
  /MEASURE=solunum
  /METHOD=SSTYPE(3)
  /PLOT=PROFILE(time*group)
  /EMMEANS=TABLES(time) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(group) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(group*time)
  /EMMEANS=TABLES(time*group) compare(group) ADJ(BONFERRONI)
  /EMMEANS=TABLES(group*time) compare(time) ADJ(BONFERRONI)
  /PRINT=DESCRIPTIVE ETASQ OPOWER HOMOGENEITY
  /CRITERIA=ALPHA(.05)
  /WSDESIGN=time
  /DESIGN=group.
```

Mixed-MANOVA Extended Sytax MSLQ-Learning Strategies Scales:

```
GLM PreRehersal PostRehersal PreElabor PostElabor PreOrgan PostOrgan PreCritThink
PostCritThink PreSelfRegul PostSelfRegul PreEnviron PostEnviron PreEffrtReg PostEffrtReg
PrePeerLearn PostPeerLearn PreHelpSeek PostHelpSeek BY GroupType
  /WSFACTOR=time 2 Polynomial
  /MEASURE=rehearsal elaboration organization criticalthink selfregul environment effortreg
peerleraning helpseeking
  /METHOD=SSTYPE(3)
  /PLOT=PROFILE(time*GroupType)
  /EMMEANS=TABLES(GroupType) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(time) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(GroupType*time)
  /EMMEANS=TABLES(time*GroupType) compare(GroupType) ADJ(BONFERRONI)
  /EMMEANS=TABLES(GroupType*time) compare(time) ADJ(BONFERRONI)
  /PRINT=DESCRIPTIVE ETASQ OPOWER HOMOGENEITY
  /CRITERIA=ALPHA(.05)
  /WSDESIGN=time
  /DESIGN=GroupType.
```

Zero-order Correlation Tables of Multicollinearity and Singularity Assumptions for Analyses

Zero-order Correlations for SSCI

		SSCI-Time1	SSCI-Time2	SSCI-Time3
Experimental Group	SSCI-Time1	1.00		
	SSCI-Time2	.38**	1.00	
	SSCI-Time3	.29**	.62**	1.00
Comparison group	SSCI-Time1	1.00		
	SSCI-Time2	.38*	1.00	
	SSCI-Time3	.32**	.68**	1.00

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Zero-order Correlations for CSCI

		CSCI-Time1	CSCI-Time2	CSCI-Time3
Experimental Group	CSCI-Time1	1.00		
	CSCI-Time2	.22*	1.00	
	CSCI-Time3	.17	.53**	1.00
Comparison group	CSCI-Time1	1.00		
	CSCI-Time2	.49**	1.00	
	CSCI-Time3	.20*	.47**	1.00

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Zero-order Correlations for RSCI

		RSCI-Time1	RSCI-Time2	RSCI-Time3
Experimental Group	RSCI-Time1	1.00		
	RSCI-Time2	.46**	1.00	
	RSCI-Time3	.46**	.63**	1.00
Comparison group	RSCI-Time1	1.00		
	RSCI-Time2	.57**	1.00	
	RSCI-Time3	.32**	.37**	1.00

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Zero-order Correlations for Motivation Scales

		Pre-IGO	Post-IGO	Pre-EGO	Post-EGO	Pre-TV	Post-TV	Pre-CLB	Post-CLB	Pre-SE	Post-SE	Pre-TA	Post -TA
EG	Pre-IGO	1											
	Post-IGO	.501**											
	Pre-EGO	.413**	.478**	1									
	Post-EGO	.446**	.613**	.316**	1								
	Pre-TV	.516**	.331**	.315**	.369**	1							
	Post-TV	.436**	.662**	.427**	.570**	.504**	1						
	Pre-CLB	.406**	.288**	.306**	.188	.466**	.273*	1					
	Post-CLB	.425**	.537**	.311**	.537**	.388**	.632**	.289**	1				
	Pre-SE	.582**	.412**	.406**	.329**	.709**	.433**	.427**	.329**	1			
	Post-SE	.466**	.550**	.265*	.382**	.431**	.672**	.264*	.466**	.587**	1		
	Pre-TA	.115	.025	.203	.125	-.051	.027	.031	.001	-.026	-.085	1	
	Post-TA	.051	.271*	.067	.076	-.036	.097	.015	.170	.013	.133	.416**	1
CG	Pre-IGO	1											
	Post-IGO	.128	1										
	Pre-EGO	.451**	.189	1									
	Post-EGO	.287**	.401**	.530**	1								
	Pre-TV	.454**	.119	.494**	.308**	1							
	Post-TV	.196	.703**	.354**	.541**	.217	1						
	Pre-CLB	.467**	.026	.463**	.182	.400**	.047	1					
	Post-CLB	.176	.689**	.178	.430**	.210	.647**	.094	1				
	Pre-SE	.466**	.125	.394**	.283**	.587**	.150	.321**	.183	1			
	Post-SE	.298**	.692**	.365**	.570**	.289**	.734**	.045	.658**	.279*	1		
	Pre-TA	.152	-.070	.178	.008	.078	-.128	.300**	-.060	-.099	-.157	1	
	Post-TA	.140	.317**	.096	.349**	.010	.405**	-.034	.256*	.038	.332**	.174	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Zero-order Correlations for Learning Strategies Scales

	Pre-R	Post-R	Pre-E	Post-E	Pre-O	Post-O	Pre-CT	Post -CT	Pre-SR	Post-SR	Pre-TSE	Post-TSE	Pre-ER	Post-ER	Pre-PL	Post-PL	Pre-HS	Post-HS
Pre-R	1																	
Post-R	.236*	1																
Pre-E	.646**	.224*	1															
Post-E	.347**	.578**	.458**	1														
Pre-O	.683**	.233*	.707**	.381**	1													
Post-O	.235*	.570**	.324**	.640**	.365**	1												
Pre-CT	.608**	.132	.699**	.396**	.670**	.341**	1											
Post-CT	.251*	.627**	.319**	.750**	.349**	.654**	.322**	1										
Pre-SR	.700**	.180	.755**	.440**	.688**	.259*	.785**	.279*	1									
Post-SR	.264*	.525**	.412**	.697**	.433**	.516**	.444**	.633**	.417**	1								
Pre-TSE	.389**	.196	.517**	.412**	.435**	.262*	.513**	.317**	.652**	.453**	1							
Post-TSE	.196	.188	.245*	.279**	.277*	.187	.289**	.233*	.371**	.402**	.592**	1						
Pre-ER	.373**	.181	.411**	.376**	.357**	.095	.301**	.234*	.623**	.360**	.631**	.551**	1					
Post-ER	.136	.171	.166	.237*	.271*	.142	.301**	.277**	.331**	.496**	.419**	.606**	.376**	1				
Pre-PL	.608**	.200	.554**	.274*	.684**	.283**	.566**	.246*	.557**	.313**	.316**	.029	.217*	.123	1			
Post-PL	.201	.436**	.194	.451**	.220*	.604**	.226*	.424**	.196	.276**	.174	.037	-.012	-.033	.304**	1		
Pre-HS	.503**	.106	.553**	.417**	.440**	.254*	.576**	.257*	.649**	.201	.505**	.258*	.423**	.161	.551**	.307**	1	
Post-HS	.204	.269*	.188	.340**	.062	.241*	.281**	.265*	.278*	.361**	.362**	.178	.158	.107	.289**	.339**	.391**	1
Pre-R	1																	
Post-R	.448**	1																
Pre-E	.764**	.331**	1															
Post-E	.384**	.614**	.417**	1														
Pre-O	.690**	.268*	.707**	.335**	1													
Post-O	.389**	.724**	.429**	.655**	.418**	1												
Pre-CT	.612**	.319**	.678**	.330**	.591**	.374**	1											
Post-CT	.333**	.667**	.328**	.703**	.269*	.744**	.390**	1										
Pre-SR	.684**	.312**	.698**	.467**	.622**	.388**	.578**	.324**	1									
Post-SR	.322**	.589**	.354**	.730**	.306**	.680**	.260*	.648**	.410**	1								
Pre-TSE	.296**	.186	.280**	.281*	.242*	.281*	.315**	.265*	.588**	.416**	1							
Post-TSE	.070	.285**	.060	.428**	.028	.363**	.198	.447**	.249*	.554**	.436**	1						
Pre-ER	.185	.033	.172	.147	.191	.146	.165	.203	.516**	.244*	.598**	.309**	1					
Post-ER	.099	.184	.176	.311**	.119	.272*	.029	.152	.222*	.520**	.381**	.564**	.297**	1				
Pre-PL	.559**	.080	.627**	.163	.589**	.201	.432**	.105	.443**	.181	.102	-.085	-.028	-.004	1			
Post-PL	.349**	.581**	.290**	.513**	.233*	.616**	.280*	.631**	.192	.455**	.062	.038	-.090	.082	.216	1		
Pre-HS	.254*	.080	.279**	.136	.294**	.273*	.287**	.240*	.348**	.074	.232*	-.008	.172	.018	.226*	.118	1	
Post-HS	.291**	.450**	.163	.554**	.240*	.488**	.210	.488**	.135	.511**	-.004	.323**	-.029	.242*	.232*	.426**	.197	1

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

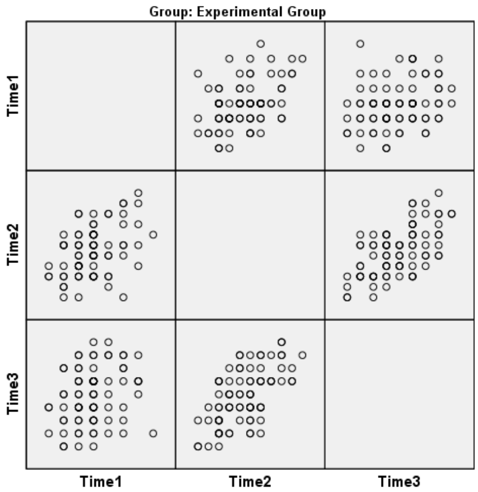
Zero-order Correlations for EBS Scales

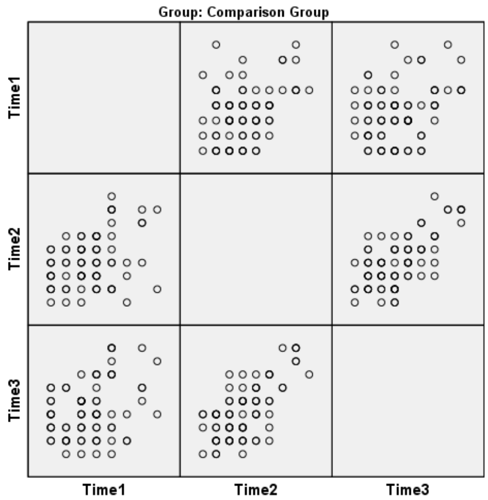
		Pre-S	Post-S	Pre-C	Post-C	Pre-D	Post-D	Pre-J	Post- J
EG	Pre-Source	1	.45**	.70**	.38**	.00	.00	.13	-.15
	Post-Source	.45**	1	.27*	.48**	-.16	-.14	-.01	-.32**
	Pre-Certainty	.70**	.27*	1	.46**	.24*	.17	.36**	.10
	Post-Certainty	.38**	.48**	.46**	1	-.09	.25*	.06	.15
	Pre-Development	.00	-.16	.24*	-.09	1	.13	.52**	.26*
	Post-Development	.00	-.14	.17	.25*	.13	1	.12	.76**
	Pre-Justification	.13	-.02	.36**	.06	.52**	.12	1	.25*
	Post-Justification	-.16	-.32**	.10	.15	.26*	.76**	.26*	1
CG	Pre-Source	1	.25*	.66**	.14	.01	-.05	.09	-.00
	Post-Source	.25*	1	.20	.40**	-.00	-.14	.01	-.18
	Pre-Certainty	.66**	.20	1	.15	.20	.09	.28**	.09
	Post-Certainty	.14	.40**	.15	1	.12	.22	.22	.17
	Pre-Development	.01	-.01	.20	.12	1	.21	.68**	.20
	Post-Development	-.05	-.14	.09	.22	.20	1	.18	.74**
	Pre-Justification	.09	.02	.28**	.22	.68**	.18	1	.21
	Post-Justification	-.00	-.18	.09	.17	.20	.74**	.21	1

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

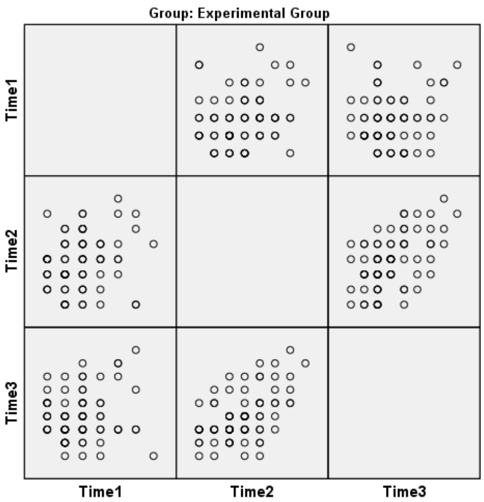
Scatter Plots of Linearity Assumptions for Analyses

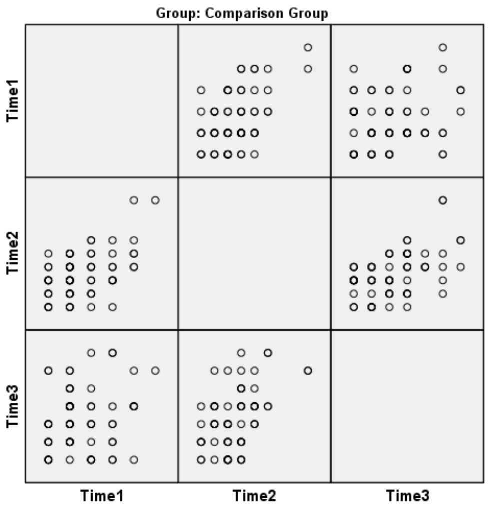
Scatter Plots of Skeletal System Conceptual Inventory:



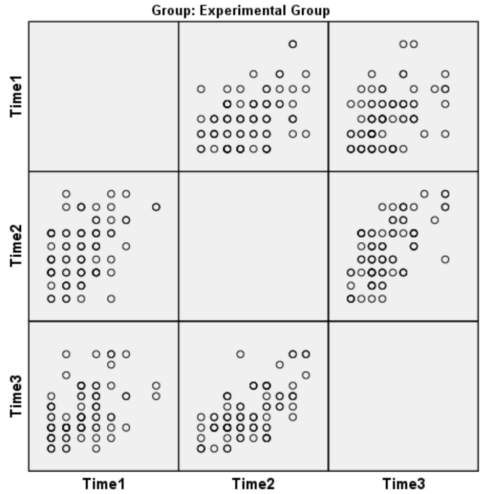


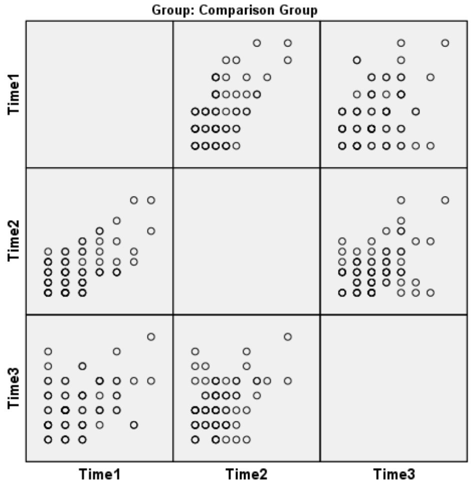
Scatter Plots of Circulatory System Conceptual Inventory:



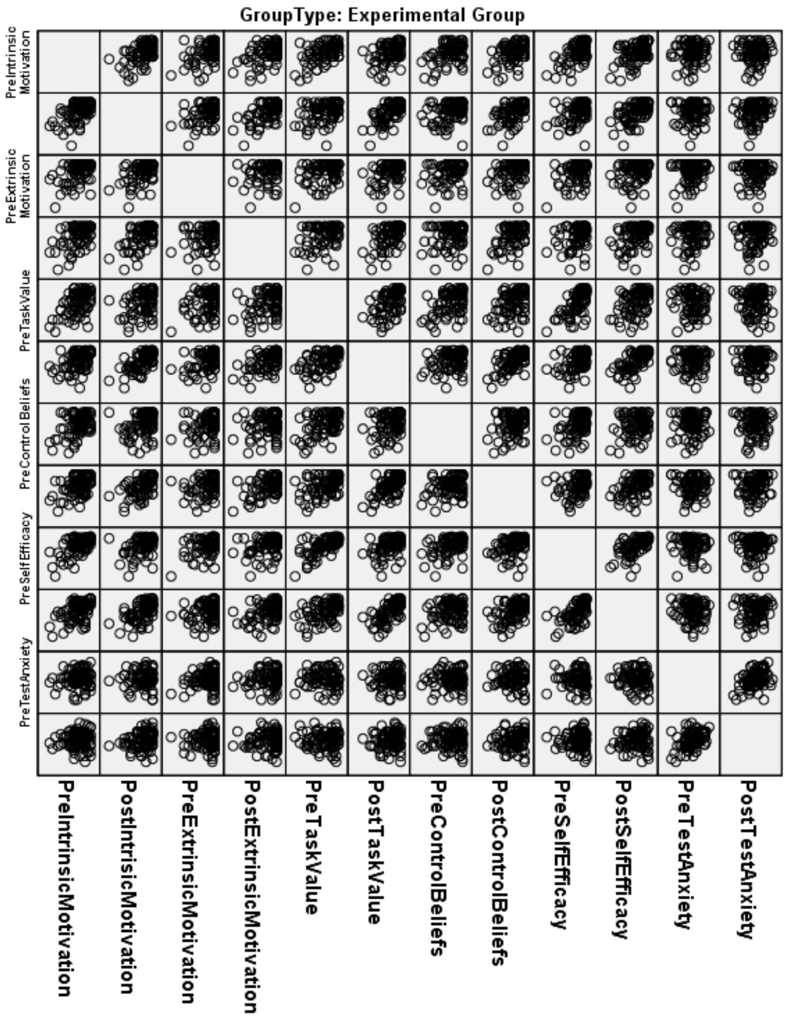


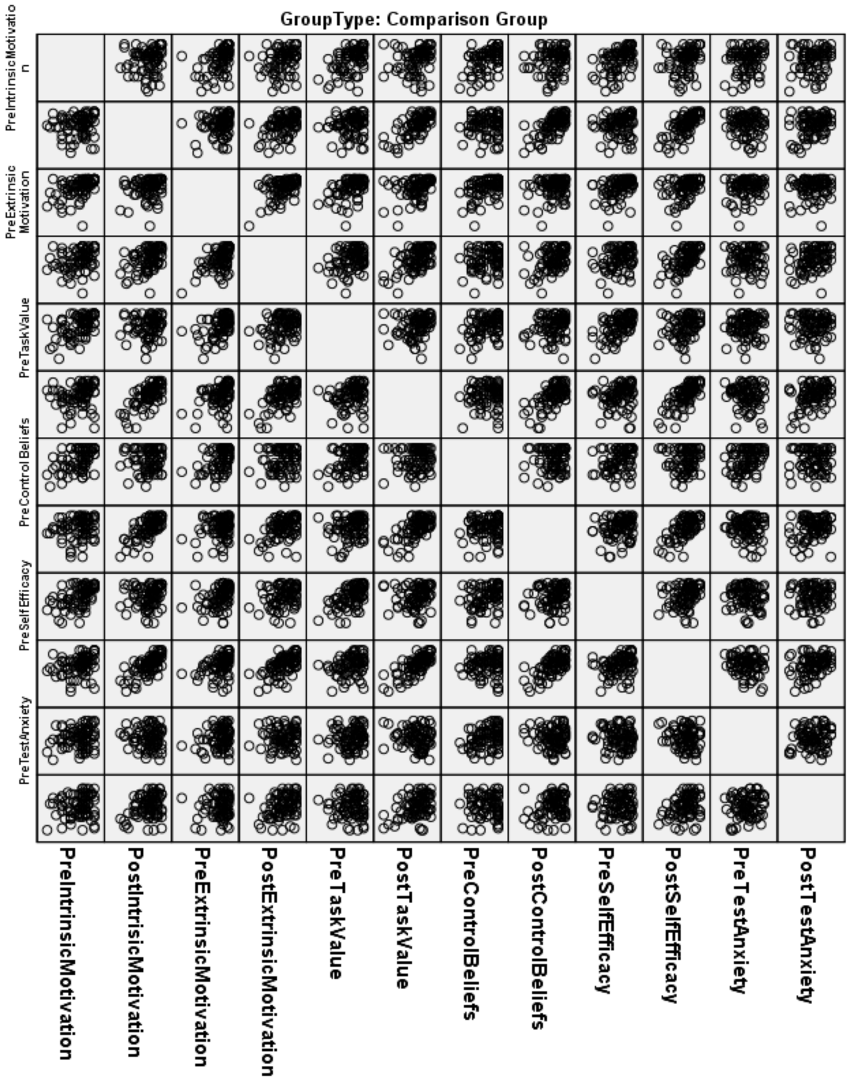
Scatter Plots of Respiratory System Conceptual Inventory:



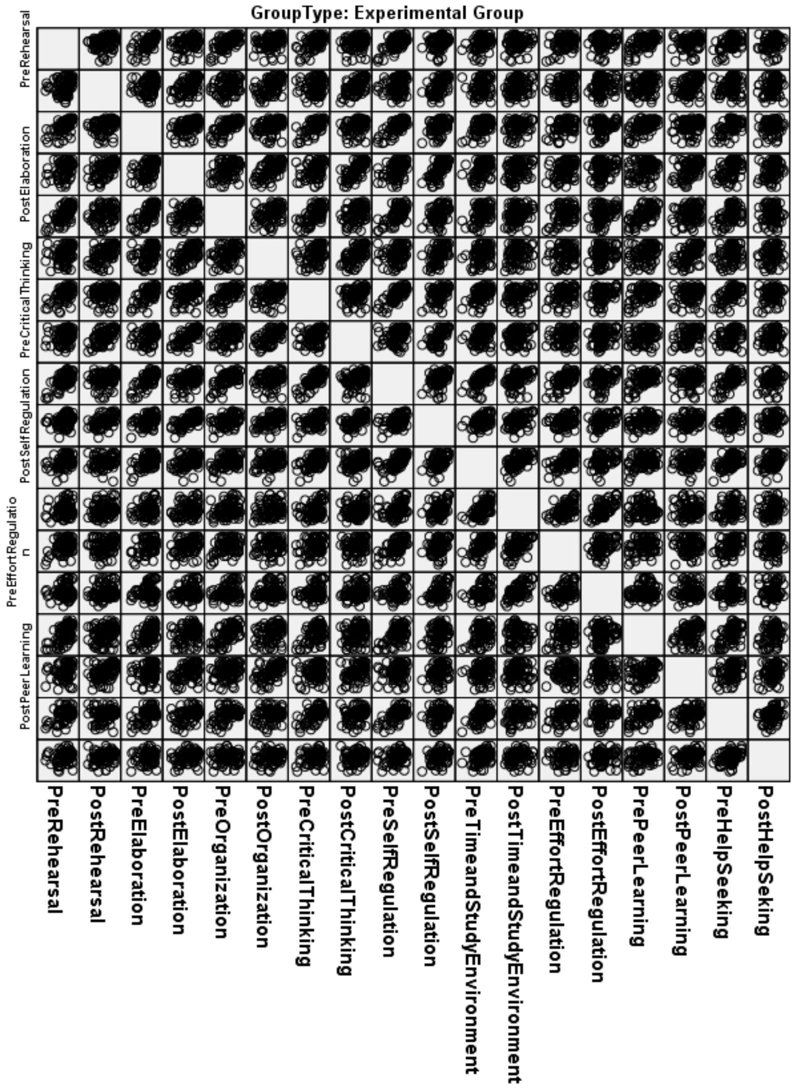


Scatter Plots of Motivation Scales of MSLQ:





Scatter Plots of Learning Strategies Scales of MSLQ: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PreCriticalThinking
PostSelfRegulation
PreEffortRegulation
PostPeerLearning
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PostRehearsal
PreElaboration
PostElaboration
PreOrganization
PostOrganization
PreCriticalThinking
PostCriticalThinking
PreSelfRegulation
PostSelfRegulation
PreTimeandStudyEnvironment
PostTimeandStudyEnvironment
PreEffortRegulation
PostEffortRegulation
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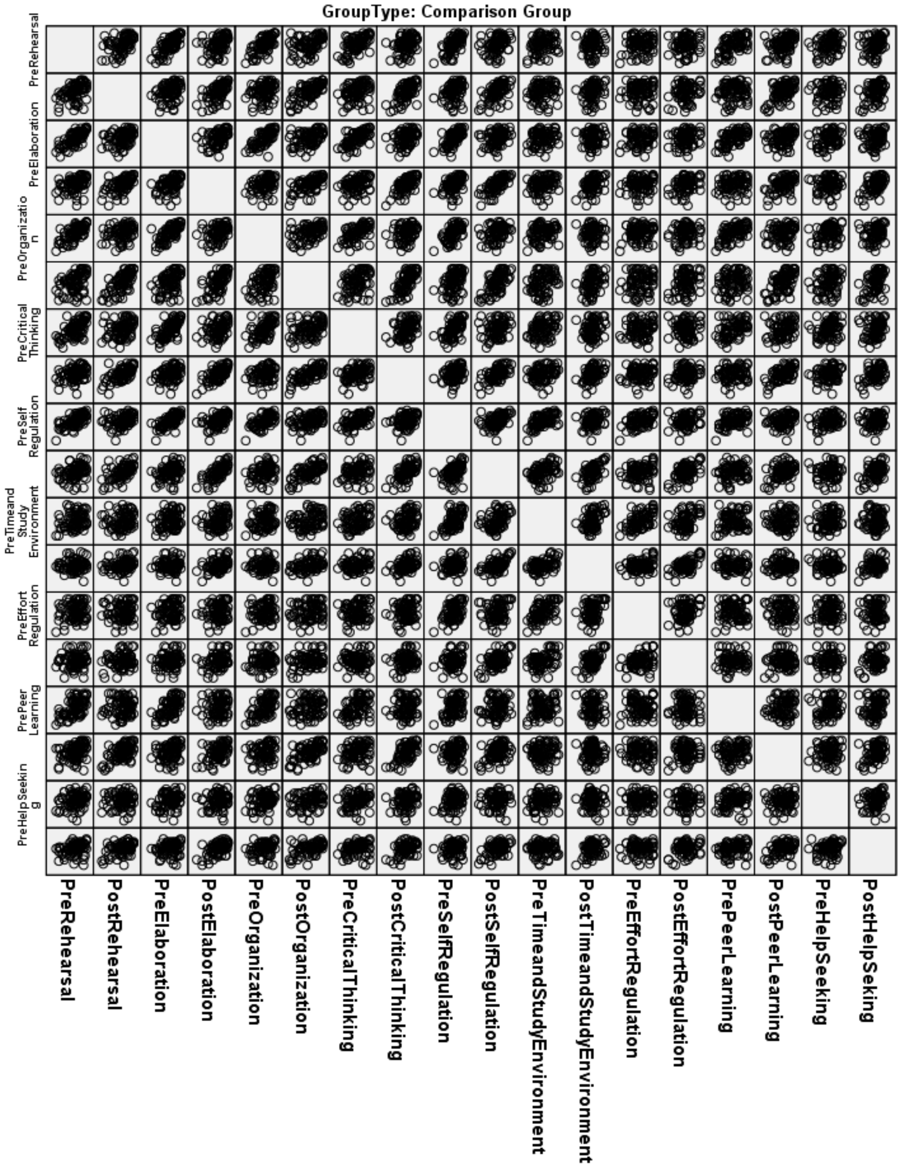
PostPeerLearning
PreHelpSeeking
PostHelpSeking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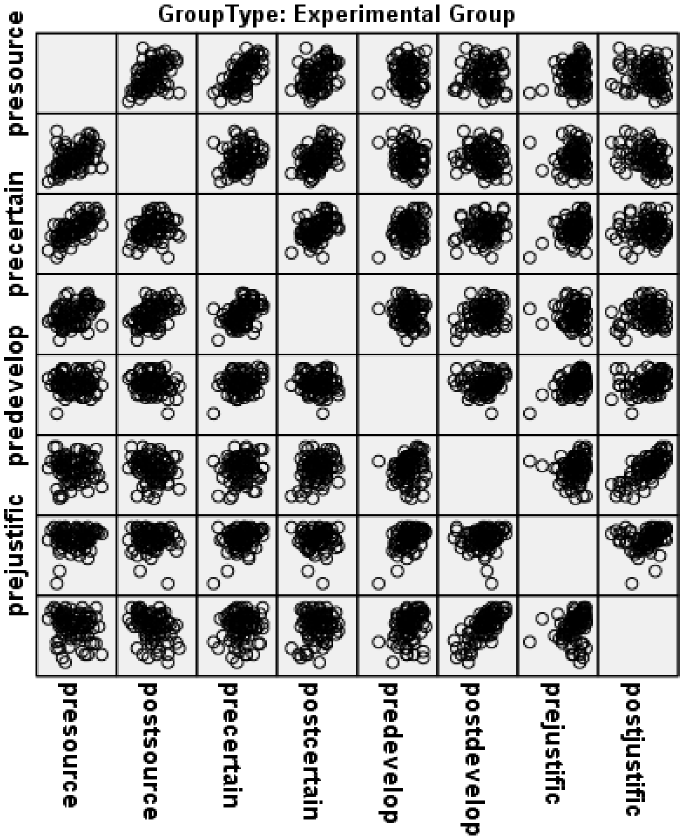
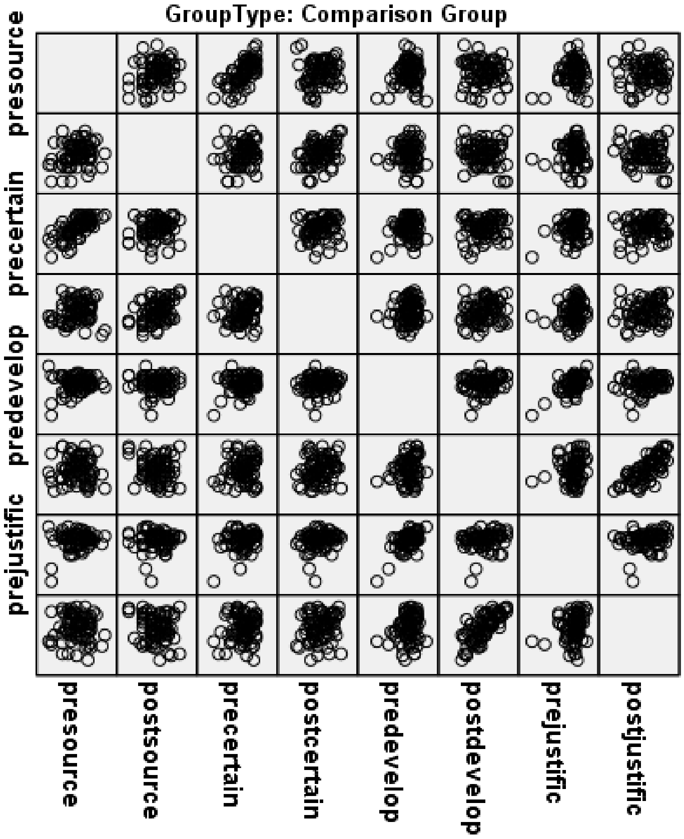
PreElaboration
PreOrganization
PreCritical Thinking
PreSelf Regulation
PreTimeand Study Environment
PreEffort Regulation
PrePeer Learning
PreHelpSeeking
PreRehearsal
PostRehearsal
PreElaboration
PostElaboration
PreOrganization
PostOrganization
PreCriticalThinking
PostCriticalThinking
PreSelfRegulation
PostSelfRegulation
PreTimeandStudyEnvironment
PostTimeandStudyEnvironment
PreEffortRegulation
PostEffortRegulation
PrePeerLearning
PostPeerLearning
PreHelpSeeking
PostHelpSeking

Scatter Plots of EBS:





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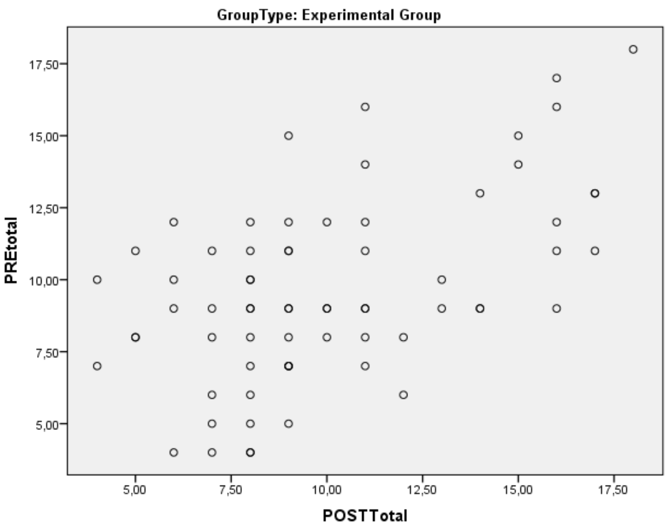

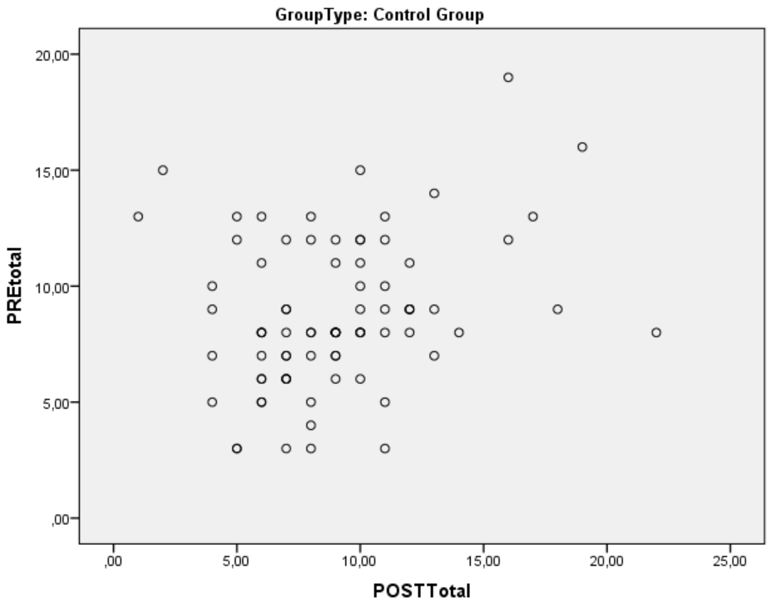
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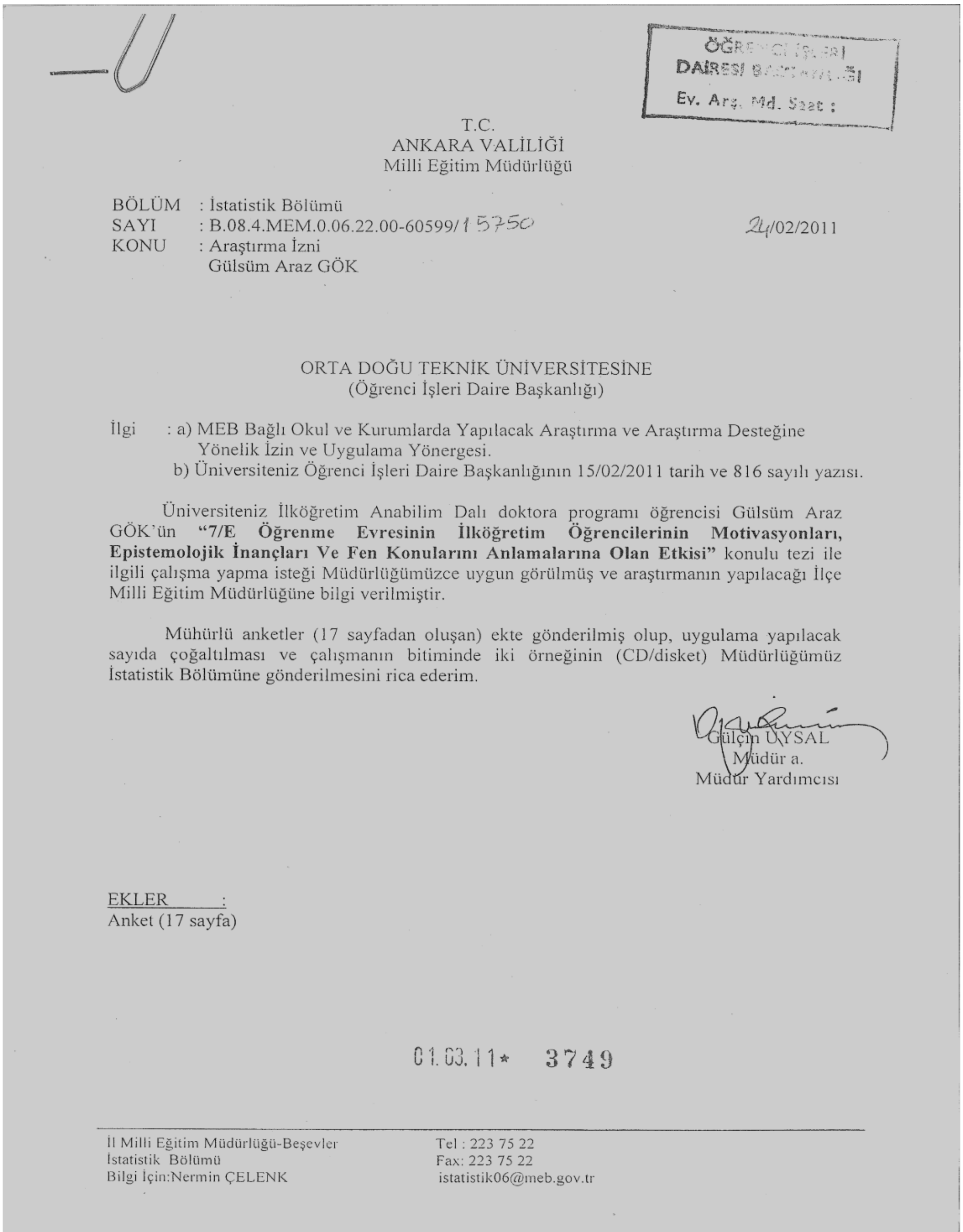
APPENDIX R

MEB UYGULAMA İZİN FORMU



ÖĞRENCİ İŞLERİ DAİRESİ BAŞKANLIĞI
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Milli Eğitim Müdürlüğü

BÖLÜM : İstatistik Bölümü
SAYI : B.08.4.MEM.0.06.22.00-60599/15750 24/02/2011
KONU : Araştırma İzni
Gülsüm Araz GÖK

ORTA DOĞU TEKNİK ÜNİVERSİTESİNE
(Öğrenci İşleri Daire Başkanlığı)

İlgi : a) MEB Bağlı Okul ve Kurumlarda Yapılacak Araştırma ve Araştırma Desteğine Yönelik İzin ve Uygulama Yönergesi.
b) Üniversiteniz Öğrenci İşleri Daire Başkanlığının 15/02/2011 tarih ve 816 sayılı yazısı.

Üniversiteniz İlköğretim Anabilim Dalı doktora programı öğrencisi Gülsüm Araz GÖK'ün **"7/E Öğrenme Evresinin İlköğretim Öğrencilerinin Motivasyonları, Epistemolojik İnançları Ve Fen Konularını Anlamalarına Olan Etkisi"** konulu tezi ile ilgili çalışma yapma isteği Müdürlüğümüzce uygun görülmüş ve araştırmanın yapılacağı İlçe Milli Eğitim Müdürlüğüne bilgi verilmiştir.

Mühürlü anketler (17 sayfadan oluşan) ekte gönderilmiş olup, uygulama yapılacak sayıda çoğaltılması ve çalışmanın bitiminde iki örneğinin (CD/disket) Müdürlüğümüz İstatistik Bölümüne gönderilmesini rica ederim.

Gülçin UYSAL
Müdür a.
Müdür Yardımcısı

EKLER :
Anket (17 sayfa)

01.03.11* 3749

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APPENDIX S

EXTENDED TURKISH SUMMARY

(Genişletilmiş Türkçe Özet)

7E ÖĞRENME DÖNGÜSÜ MODELİNİN 6.SINIF ÖĞRENCİLERİNİN VÜCUDUMUZDA SİSTEMLER KONUSUNU ANLAMALARINA, ÖZ-DÜZENLEME BECERİLERİNE, BİLİMSEL EPİSTEMOLOJİK İNANÇLARINA VE BİLİMSEL SÜREÇ BECERİLERİNE ETKİSİ

Giriş ve İlgili Literatür

Geniş kapsamlı yürütülen PISA ve TIMMS gibi uluslararası çalışmalarda öğrencilerimiz her seferinde genel ortalamamın altında skorlar elde etmekte ve Türkiye ülkeler sıralamasında düşük-performans sergileyen grup kategorisinde yer almaktadır. Öğrencilerin bu tip çalışmalarda uygulanan testlerdeki performansını etkileyen en büyük etmen olarak okullarda kendilerine sunulan eğitim ve sınıf içi uygulamalar gösterilmektedir (Aypar, Erdogan & Sozer, 2007; Ozdemir, 2003). Bu durum, öğrencilere sunulan fen eğitiminde kavramsal anlamaya, kendi kendine öğrenme için güdülenme ve becerilere, dış dünyayı sorgulama ve anlama yetisine ve bunun yanında bilim ve teknolojideki hızlı gelişimleri yakalamayı sağlamaya yönelik bir geliştirmeye ihtiyaç duyulduğunu ortaya koymaktadır. 7E öğrenme döngüsü bu amaç dahilinde uygulanabilecek, yapılandırmacı kurama dayanarak geliştirilmiş bir öğretim yaklaşımıdır.

Son yıllarda gerek ulusal gerekse uluslararası eğitimde gerçekleşen reform hareketleri yapılandırmacı kuram perspektifleri üzerine kurulmuştur. Yapılandırmacı kurama göre öğrenme, yapılandırılmış bilginin dış kaynaklardan kişiye aktarılmasıyla değil bireyin bilgiyi zihninde aktif bir şekilde oluşturmasıyla gerçekleşmektedir (Rowlands & Carson, 2001; Eggen & Kauchak, 1994). Yapılandırmacılık Piaget'in bilişsel gelişim kuramından ilham alınarak şekillendirilmiştir. Piaget'e göre öğrenme bireyin kendisi tarafından, var olan bilgilerin ışında devamlı olarak gerçekleştirilen bir yeniden yapılandırma sürecidir. Bu süreç üç temel kavram ile açıklanabilir (Pulaski, 1980): Özümleme (assimilation), düzenleme (accomodation) ve dengeleme (equilibration). Yeni karşılaşılan deneyimlerin bireyde var olan kavramsal yapılarla uyumlu olması halinde özümleme gerçekleşmektedir. Öte yandan, bu kavramsal yapılar yeni deneyimleri yorumlayabilmek için yeterli değilse var olan yapıları yeniden düzenenleme yoluna gidilir. Çünkü bu aşamada yeni bilgi ile bireysel yapılar arasındaki uyumsuzluktan kaynaklanan bir dengesizlik durumu gerçekleşir. Bilişsel dengeye ulaşabilmek için birey bilişsel yapılarını düzenleme veya geliştirme yoluna gider. Diğer bir ifade ile öğrenme, dengeleme, özümleme ve düzenleme süreçleri ile bireyin zihninde dinamik bir denge oluşturma çabasıdır (Wadsworth, 1971). Açıklanan süreçten de anlaşılacağı üzere, öğrenmede en önemli etken kişinin sahip olduğu bilgilerdir. Yapılandırmacı kuram, var olan bilginin öğrenmeyi destekleme veya engelleme şeklindeki etkilerini savunan Ausubel'in fikirlerini de baz alarak, sınıf ortamlarında öğrencilerin ön bilgilerinin ortaya çıkartılmasının ve öğrenmenin bu bilgiler ışığında gerçekleştirilmesinin önemini vurgulamaktadır. Ayrıca yapılandırmacılık, Vygotsky'nin çalışmalarından da etkilenerek bireyin öğrenme ortamındaki diğer elemanlarla gerçekleştirdiği sosyal etkileşiminin öğrenmedeki önemini de ele almaktadır. Bu ilkeleri göz önünde bulundurarak bir çok öğretim yaklaşımı geliştirilmiştir. Bunlardan bazıları işbirlikli öğrenme (Soyibo & Evans, 2002), bağlamlı öğrenme (Bransford, Sherwood, Hasselbring, Kinzer & Williams, 1990), sorgulamaya dayalı öğrenme yaklaşımı, probleme dayalı öğrenme yaklaşımı, proje temelli öğrenme yaklaşımı (Kirschner, Sweller & Clark, 2006), ve deneyimsel öğrenmedir (Rieman, 1996). 7E öğrenme döngüsünü modeli belirtilen yaklaşımlardan sorgulamaya dayalı öğrenme yakşaımına dayanmaktadır.

Temelde Piage'nin bilişsel gelişim kuramına göre geliştirilmiş olan öğrenme döngüsü ilk zamanlar üç faz olarak şekillendirilmiştir. Bu fazlar sırası ile keşfetme (exploration), kavram tanıtımı (concept inroduction) ve kavram uygulamasıdır (concept application) (Karplus & Their, 1969). Bu modelde ilk olarak öğrencilerin var olan bilgileri öğrenme sürecine dahil edilmektedir. Ayrıca öğrenciler yeni kavramlar ile tanıştırılmadan önce bir keşfetme sürecine dahil olurlar ve öğrenilecek konuda deneyim kazanırlar. Bu deneyimlerin bazılarını ön bilgileri ile anlamlandırabilirken bazı hususları var olan bilgileri ile tanımlayamamaları öğrencide bir öğrenme ihtiyacı doğurur ve bu durumun üzerine yeni kavramların tanıtımına geçilir. Edinilen yeni bilgiler ışığında öğrencilerin anlamlandıramadıkları deneyimleri açıklayabilmeleri sağlanır. Modelin bir diğer zorunluluğu ise öğrenilen yeni bilginin öğrenci tarafından yeni ve farklı durumlara uygulanılarak pekiştirilmesidir. Model uygulandığı yıllar içerisinde yenilenmiş ve uygulayıcılar tarafından farklı fazlar içeren 3E, 4E, 5E, ve 7E gibi genişletilmiş yaklaşımlar geliştirilmiştir. Bunlar arasında en kapsamlı model olan 7E öğrenme döngüsü modeli isminden de anlaşılacağı üzere yedi fazdan oluşmaktadır: ön bilgileri yoklama, merak uyandırma, keşfetme, açıklama, genişletme, değerlendirme ve ilişkilendirme (Eisenkraft, 2003). İlk basamakta öğrencilere sunulan aktiviteler var olan bilgileri ortaya çıkartmak ve yeni öğrenilecek konu ile ilişkilendirmek için hazır hale getirmeyi amaçlamaktadır. Merak uyandırma basamağında ise öğrencilerde öğrenme isteği ve motivasyon oluşturmayı amaçlayan, öğrenilecek bilginin öğrenciler için önemli kılınmasını sağlayan, konuyu gündelik hayat ile ilişkilendiren ısındırma etkinlikleri yer alır. Keşfetme basamağında öğrencilerin yeni bilgiye yönelik deneyimler kazanmasına fırsat verilir. Bu aşamada öğrenciler kendi çabaları ile öğrenilecek konu üzerinde çeşitli bilgi ve beceriler kazanmaya çalışır, ön bilgilerine dayanarak çeşitli açıklamalar geliştiriler ve var olan yapıları ile uyumlu olan deneyimleri özümlerler. Ancak öğrenci sahip olduğu bilgiler ile yeni karşılaştığı deneyimlerini açıklayamazsa bilişsel yapıları yeniden düzenleme yoluna gider ve modelin bir sonraki basamağında öğretmenin yönlendirmeleri ile birlikte doğru açıklamaya ulaşır. Açıklama basamağı adı verilen bu kısımda öğrenciler deneyimlerini öncelikle kendi önbilgileri ile açıklamaya çalışır, deneyimlerini ve düşüncelerini paylaşırlar. Öğretmen burada geleneksel yöntemlerdeki gibi bilgiyi öğrenciye sunan değil öğrenciyi doğru bilgiye yönlendiren bir rol üstlenmektedir. Sınıf içinde oluşturulacak tartışma ortamları, öğrencilerin bilgiye ulaşmasını sağlayacak ek aktiviteler ve gerekli kavramların verilmesi ile öğrencinin bir önceki fazdaki deneyimlerini anlamlandırması sağlanır. Genişletme basamağında öğrencilere yeni öğrendikleri konuyu farklı durumlarda uygulayarak pekiştirme ve ilerletme imkanı verilir. Bu aşamada öğrenci bilişsel düzeyde hem özümleme hem de düzenleme yapabilir (Abraham & Renner, 1986; Marek, Eubanks & Gallaher, 1990; Balci, Cakiroglu & Tekkaya, 2005). Bir sonraki aşama olan değerlendirmede öğrenilen bilgi öğrenciler ve öğretmen tarafından farklı yöntemlerle değerlendirilir. Esasen öğrenmenin takibi öğrenme döngüsünün tüm süreci boyunca gerçekleştirilmelidir. Bu aşama ise resmi olarak kazanılan bilginin değerlendirildiği aşama olarak düşünülebilir. Öğretmenin sağlayacağı dönütlerle öğrencilere kazandıkları deneyimler ve öğrendikleri yeni kavramlar konusunda farkındalık yaratılmalı ve gerekli görünen noktalarda düzeltmeler yapılması sağlanmalıdır. Son aşama olan ilişkilendirme aşaması ise öğrenilen konunun bir sonraki konu ile bağdaştırılmasını amaçlamaktadır. Öğretmen bu amaçla öğrencilere tartışma soruları yöneltebilir veya küçük etkinliklerle bu ilişkiyi kurmalarını sağlayarak öğrencileri bir sonraki konuya hazırlayabilir.

Bu alanda yapılan çalışmalar, öğrenci merkezli bir yaklaşımla, sorgulayarak, keşfederek ve tartışarak öğrenmeye olanak sağlayan öğrenme döngüsü modelinin öğrencilerin gerekli bilgi ve becerileri kazanmalarında geleneksel yöntemlere göre daha etkili olduğunu göstermiştir (Lawson, 1995; Musheno & Lawson, 1999; Ates, 2005; Yilmaz, Tekkaya & Sungur, 2011). Daha ayrıntılı belirtmek gerekirse literatürde öğrenme döngüsü modeli, öğrencilerin kavramsal anlamalarını, öğrenilen bilgiyi akılda tutmalarını, öz-düzenleme becerilerini, bilimsel epistemolojik inançlarını ve bilimsel süreç becerilerini geliştirmede etkin bir yöntem olarak ileri sürülmektedir (Ebrahim, 2004; Aydemir, 2012; Kaynar ve diğ., 2009; Lavoie, 1999; Anagun & Yasar, 2009). Bahsedilen becerilerin ve inançların öğrenme sürecindeki değeri ve öğrencilerin fen başarısına olan etkileri aşikardır (Pintrich & Garcia, 1991; Yumusak ve diğ., 2007; Hofer,2001).

Öz-düzenleme, farklı kuramsal bakış açılarına sahip bir çok araştırmacı tarafından çalışılmış ve modellenmiştir. Bu araştırmacılardan Pintrich (2005) öz düzenleme kavramını kısaca bireyin öğrenme esnasında kendisine belirli hedefler koyarak, kendi gelişimini gözlemleyerek, süreci devamlı olarak düzenleyerek, kendi biliş, güdü ve davranışlarını kontrol ederek, koyduğu hedefler ve çevresindeki dış faktörlerin yönlendirmesiyle aktif olarak yol aldığı etkin ve yapılandırmacı bir süreç olarak tanımlamıştır. Geliştirdiği modelde Pintrich öz-düzenleme sürecini dört alan başlığı altında ele almıştır. Bunlar biliş, motivasyon, davranış ve içeriktir. Literatürde bu alanların öğrenci başarısıyla yakından ilişkili olduğunu gösteren bir çok çalışma bulunmaktadır (Pintrich, 1989; Pintrich & De Groot, 1990; Pintrich & Garcia, 1991; Yumusak ve diğ., 2007). Dolayısı ile sınıf ortamında verilen eğitim ile öz-düzenleme becerilerinin geliştirilmesi önem kazanmaktadır. Bu çalışmada öz-düzenleme becerileri Pintrich ve arkadaşları tarafından geliştirilen Öğrenmede Güdüsel Stratejiler Anketi ile belirlenmekte, dolayısı ile güdülenme ve öğrenme stratejileri başlıkları altında ele alınmaktadır.

Öz düzenleme becerilerinin yanısıra öğrencilerin fen başarısını etkileyen bir etmen de öğrencilerin bilginin doğasına ve bilginin kazanımına yönelik inançlarıdır. Epistemolojik inançlar olarak ifade edilen bu inançları Shommer (1990) beş boyutlu bir inaçlar sistemi olarak açıklamıştır. Bu boyutlar bilginin örgütlenmesi, bilginin kesinliği, bilginin kaynağı, bilgi kazanımının kontrolü ve bilgi kazanımının hızı olarak listelenmektedir. Shommer'e göre bu boyutlar birbirinden bağımsız olarak çeşitlenmektedir. Örneğin bir boyutta sofitike inaçlara sahip olan bir birey diğer boyutta naif inançlar sergileyebilmektedir. Benzer bir yaklaşımla Conley ve arkadaşları (2004) epistemolojik inançlar sistemini bilginin kaynağı, bilginin kesinliği, bilginin gelişmesi ve bilginin doğrulanması olarak dört boyut alında açıklamışlardır. Bilginin kaynağı boyutunda birey bilgiyi öğretmen veya kitaplar gibi dış faktörlerden kaynaklanır olarak gördüğünde naif, kaynak olarak bilgiyi kendi gözlemlerine mantığına daynadırdığında ise sofitike inançlara sahip olduğu kabul edilir. Bilginin kesinliği boyutunda inaçlar, basit yapıda bilgiye ve tek doğru cevabın var olmasına inanmak ile bilginin karmaşık yapısına ve çoğul gerçekliğe inanmak şeklinde naifden sofistike inançlara doğru bir değişim gösterir. Bilginin gelişmesi boyutunda inançlar, bilgi zaman içinde değişmez veya bilginin değişen gelişen ve evrimleşen bir doğası vardır şeklindedir. Bilginin doğrulanmasında ise inançlar deneyler ve kanıtlar bilginin doğrulanmasında gereklidir veya gerekli değildir şeklinde çeşitlenir. Alanda yapılan çalışmalar öğrencilerde bu boyutların yıllar içinde daha sofistike hale geldiğini (Schommer, Calvert, Gariglietti, & Bajaj, 1997; Schommer, 1998; Cano, 2005) ve akademik başarıları ile doğrudan ilişkili olduğunu göstermektedir (Walker, 1997; Schommer-Aikins, Mau, Brookhart & Hutter, 2000; Cano, 2005; Hofer, 2000; Conley, Pintrich et al., 2004). Epistemelojik inançlar üzerine yapılan deneysel çalışmalar ise bilime yönelik sofistike inançların geliştirilmesinin çeşitli öğretim yaklaşımlarıyla mümkün olabildiğini göstermektedir (Smith ve diğ., 2000).

Öğrencilerin sınıf içi fen başarılarlarını etkileyen bir diğer değişken ise bir deney veya problem çözme esnasında bilim insanlarının izlediği basamakların bilgisine ve uygulama yeteneğine sahip olmaktır. Bilimsel süreç becerileri olarak adlandırılan bu kavram temel ve bütünleştirilmiş bilimsel süreç becerileri olarak ikiye ayrılmaktadır (Rezba ve diğ., 2007). Temel bilimsel süreç becerileri doğal hayatı ve çevrede olanları yorumlamak için kullanılan gözlem yapma, sınıflama, verileri kaydetme, ölçüm yapma, sayıları kullanma, sonuç çıkarma ve tahmin yapabilme gibi becerilerdir. (AAAS, 1989; Rezba ve diğ., 2007). Bütünleştirilmiş bilimsel süreç becerilerinden ise daha ziyade deney ortamlarında yararlanılmaktadır ve bu becerileri öğrenebilmenin ön şartı temel becerilere sahip olmak olarak görülmektedir (Okey ve diğ., 1982). Bu beceriler değişkenleri belirleme, değişkenleri tanımlama, hipotez kurma,deney tasarlama ve son olarak verileri yorumlama ve grafik çizme olarak sıralanmıştır (Okey ve diğ., 1982). Bu becerilere sahip öğrenciler bir bilim insanının bakış açısıyla, günlük hayatta karşılaştıkları problemleri dahi çözerken bilimsel metodlar izleyen, devamlı sorgulayan, araştıran ve bilimsel bilgiyi günlük hayatlarına entegre edebilen bireyler olarak yetişirler (MoNE, 2006).

Literatürde bilimsel süreç becerilerinin fen eğitimindeki önemini vurgulayan bir çok çalışma yer almaktadır (Padilla, 1990; Bailer, Ramig, & Ramsey, 1995; Rezba ve diğ., 2007). Ayrıca bilimsen süreç becerilerinin geliştirilmesinin, öğrencilerin bu becerileri sınıf içinde uygulamasına ve pratik yapmasına olanak sağlayan eğitim metodlarıyla gerçekleştirilebildiğine dikkat çekilmiştir (Griffiths & Thomson, 1993; Germann, Aram & Burke, 1996; Dogruöz, 1998; Özdemir, 2004; Anagun & Yasar, 2009).

Öz-düzenleme becerilerinin, bilimsel epistemolojik inançların ve bilimsel süreç becerilerinin akademik başarıyı etkilediği ve aynı zamanda kendi başlarına akademik başarı kadar önemli kazanımlar oldukları düşünüldüğünde, okullarda verilen eğitim ile öğrencilere bilimsel bilgiyi kavratmak kadar bu beceri ve inaçları geliştirilmek de önem kazanmaktadır. Bu bağlamda tavsiye edilen metodlar genel olarak öğrenci merkezli, öğrencilerin keşfederek, sorgulayarak ve tartışarak kendi öğrenmelerini yapılandırabildikleri, hipotezler kurup kendi tasarladıkları deneylerle bu hipotezleri test edebilecekleri öğretim yaklaşımlarıdır. Öğrenciler bilgiyi aktif bir şekilde yapılandırmalı ve öğrenme işlemi öğrencinin kendi sorumluluğunda olmalıdır. 7E öğrenme döngüsü bu öğrenme ortamını öğrencilere sağlayabilecek bir öğretim metodudur.

Bu çalışmanın amacı, 7E öğrenme döngüsünü modeli ile geleneksel öğretim yönteminin altıncı sınıf öğrencilerinin kavramsal anlama, öz-düzenleme becerileri, bilimsel epistemolojik inançları ve bilimsel süreç becerileri üzerindeki karşılaştırmalı etkinliğinin araştırılmasıdır. Bu çerçevede geliştirilen altı adet ana araştırma sorusu ve yardımcı araştırma soruları aşağıda verilmiştir.

- 6. sınıf öğrencilerinin insan vücudunda sistemler (iskelet, dolaşım ve solunum sistemleri) konusuna yönelik ön bilgileri, öz-düzenleme becerileri, öğrenme stratejileri, bilimsel epistemolojik bilgileri ve bilimsel süreç becerileri ne düzeydedir?

- 7E öğrenme döngüsü ve geleneksel öğretim yönteminin altıncı sınıf öğrencilerinin insan vücudunda sistemler konusundaki kavramsal anlamalarına etkisi ne düzeydedir?
    - Uygulama ve zaman değişkenlerinin etkileşiminin öğrencilerin insan vücudunda sistemler konusundaki kavramsal anlamaları üzerine istatistiksel açıdan anlamlı bir etkisi var mıdır?
    - 7E öğrenme döngüsü ve geleneksel öğretim yöntemi ile öğrenim gören öğrencilerin insan vücudunda sistemler konusundaki kavramsal anlamaları arasında uygulamadan önce, uygulamadan sonra ve uygulama tamamlandıktan bir ay sonra istatistiksel açıdan anlamlı bir fark var mıdır?
    - 7E öğrenme döngüsü ve geleneksel öğretim yöntemi ile öğrenim gören öğrencilerin insan vücudunda sistemler konusundaki kavramsal anlamalarında zaman içerisinde istatistiksel açıdan anlamlı bir değişim var mıdır?
- 7E öğrenme döngüsü ve geleneksel öğretim yönteminin altıncı sınıf öğrencilerinin motivasyonlarına (içsel hedef yönelimi, dışsal hedef yönelimi, konu değeri, öğrenme inançlarını kontrol etme, öz-yeterlik ve sınav kaygısı) etkisi ne düzeydedir?
    - Uygulama ve zaman değişkenlerinin etkileşiminin öğrencilerin motivasyonları üzerine istatistiksel açıdan anlamlı bir etkisi var mıdır?
    - 7E öğrenme döngüsü ve geleneksel öğretim yöntemi ile öğrenim gören öğrencilerin motivasyonları arasında uygulamadan önce, uygulamadan sonra ve uygulama tamamlandıktan bir ay sonra istatistiksel açıdan anlamlı bir fark var mıdır?
    - 7E öğrenme döngüsü ve geleneksel öğretim yöntemi ile öğrenim gören öğrencilerin motivasyonlarında zaman içerisinde istatistiksel açıdan anlamlı bir değişim var mıdır?
- 7E öğrenme döngüsü ve geleneksel öğretim yönteminin altıncı sınıf öğrencilerinin öğrenme stratejilerine (tekrarlama, ayrıntılandırma, örgütleme, kritik düşünme, biliş-üstü öz düzenleme, zaman ve çalışma çevresinin

düzenlenmesi, çabanın düzenlenmesi, arkadaştan öğrenme ve yardım arama) etkisi ne düzeydedir?

- Uygulama ve zaman değişkenlerinin etkileşiminin öğrencilerin öğrenme stratejileri üzerine istatistiksel açıdan anlamlı bir etkisi var mıdır?
- 7E öğrenme döngüsü ve geleneksel öğretim yöntemi ile öğrenim gören öğrencilerin öğrenme stratejileri arasında uygulamadan önce, uygulamadan sonra ve uygulama tamamlandıktan bir ay sonra istatistiksel açıdan anlamlı bir fark var mıdır?
- 7E öğrenme döngüsü ve geleneksel öğretim yöntemi ile öğrenim gören öğrencilerin öğrenme stratejilerinde zaman içerisinde istatistiksel açıdan anlamlı bir değişim var mıdır?

• 7E öğrenme döngüsü ve geleneksel öğretim yönteminin altıncı sınıf öğrencilerinin bilimsel epistemolojik inançlarına (bilginin kaynağı, bilginin kesinliği, bilginin gelişmesi ve bilginin doğrulanması) etkisi ne düzeydedir?

- Uygulama ve zaman değişkenlerinin etkileşiminin öğrencilerin bilimsel epistemolojik inançları üzerine istatistiksel açıdan anlamlı bir etkisi var mıdır?
- 7E öğrenme döngüsü ve geleneksel öğretim yöntemi ile öğrenim gören öğrencilerin bilimsel epistemolojik inançları arasında uygulamadan önce, uygulamadan sonra ve uygulama tamamlandıktan bir ay sonra istatistiksel açıdan anlamlı bir fark var mıdır?
- 7E öğrenme döngüsü ve geleneksel öğretim yöntemi ile öğrenim gören öğrencilerin bilimsel epistemolojik inançlarında zaman içerisinde istatistiksel açıdan anlamlı bir değişim var mıdır?

• 7E öğrenme döngüsü ve geleneksel öğretim yönteminin altıncı sınıf öğrencilerinin bilimsel süreç becerilerine (değişkenleri belirleme, değişkenleri tanımlama, hipotez kurma,deney tasarlama ve verileri yorumlama ve grafik çizme) etkisi ne düzeydedir?

- Uygulama ve zaman değişkenlerinin etkileşiminin öğrencilerin bilimsel süreç becerileri üzerine istatistiksel açıdan anlamlı bir etkisi var mıdır?

- 7E öğrenme döngüsü ve geleneksel öğretim yöntemi ile öğrenim gören öğrencilerin bilimsel süreç becerileri arasında uygulamadan önce, uygulamadan sonra ve uygulama tamamlandıktan bir ay sonra istatistiksel açıdan anlamlı bir fark var mıdır?
- 7E öğrenme döngüsü ve geleneksel öğretim yöntemi ile öğrenim gören öğrencilerin bilimsel süreç becerilerinde zaman içerisinde istatistiksel açıdan anlamlı bir değişim var mıdır?

Yöntem

Bu çalışmada katılacak öğrencilerin rastgele seçimi mümkün olamadığından dolayı yarı-deneysel araştırma deseni (quasi-experimental design) kullanılmıştır (Fraenkel & Wallen, 2006). Çalışmaya katılan 6 sınıfın, deney grubunda veya karşılaştırma grubunda yer alması rastgele seçilerek belirlenmiştir. Ancak seçim esnasında, iki bayan fen bilgisi öğretmeni tarafından öğrenim gören bu sınıfların dağılımda her öğretmene en az bir deney ve bir kontrol grubu düşmesine özen gösterilmiştir. Deney grubundaki sınıflarda İskelet Sistemi, Dolaşım Sistemi ve Solunum Sistemi konuları 7E öğrenme döngüsü modeline göre işlenirken karşılaştırma grubundaki sınıflarda aynı konular geleneksel yöntemlerle öğretilmiştir. Öğrencilerin iskelet, dolaşım ve solunum sistemlerinde kavramsal anlama düzeyleri her bir konu için ayrı ayrı test edilmiştir. Konulara yönelik testler ilgili konu işlenirken ön test (pre-test), son test (post-test) ve takip testi olarak üç farklı zamanda uygulanmıştır. Öte yandan öğrencilerin motivasyonu, öğrenme stratejileri, bilimsel epistemolojik inançları ve bilimsel süreç becerileri çalışmanın başında ve sonunda uygulanan ön test ve son testler ile yordanmıştır. Çalışmanın deseni Tablo 1 de kısaca özetlenmekdedir.

Tablo 1. Çalışmanın Deseni

	Deney Grubu	Karşılaştırma Grubu
Ön Test	Destek ve Hareket Sistemi Kavram Testi Öğrenmede Güdüsel Stratejiler Anketi Epistemolojik İnançlar Anketi Bilimsel Süreç Becerileri Testi	Destek ve Hareket Sistemi Kavram Testi Öğrenmede Güdüsel Stratejiler Anketi Epistemolojik İnançlar Anketi Bilimsel Süreç Becerileri Testi
Uygulama	Destek ve Hareket Sistemi 7E Öğrenme Döngüsü	Destek ve Hareket Sistemi Geleneksel Yöntem
Son Test	Destek ve Hareket Sistemi Kavram Testi	Destek ve Hareket Sistemi Kavram Testi
Ön Test	Dolaşım Sistemi Kavram Testi	Dolaşım Sistemi Kavram Testi
Uygulama	Dolaşım Sistemi 7E Öğrenme Döngüsü	Dolaşım Sistemi Geleneksel Yöntem
Son Test	Dolaşım Sistemi Kavram Testi	Dolaşım Sistemi Kavram Testi
Ön Test	Solunum Sistemi Kavram Testi	Solunum Sistemi Kavram Testi
Uygulama	Solunum Sistemi 7E Öğrenme Döngüsü	Solunum Sistemi Geleneksel Yöntem
Son Test	Solunum Sistemi Kavram Testi	Solunum Sistemi Kavram Testi
Takip Testi	Destek ve Hareket Sistemi Kavram Testi Dolaşım Sistemi Kavram Testi Solunum Sistemi Kavram Testi	Destek ve Hareket Sistemi Kavram Testi Dolaşım Sistemi Kavram Testi Solunum Sistemi Kavram Testi

Evren ve Örneklem:

Bu çalışmanın hedef evreni, Ankara ilindeki devlet okullarında eğitim gören tüm 6. sınıf ortaokul öğrencilerinden oluşmaktadır. Ulaşılabilir evren ise Keçiören ilçesindeki devlet okullarında okuyan 6. sınıf ortaokul öğrencileridir. Bu evrenden bir ortaokulda 2010-2011 sonbahar döneminde öğrenim gören 185 öğrenci (91 kız, 94 erkek) uygun örnekleme yöntemi ile seçilerek çalışma örneklemi oluşturulmuştur. Öğrencilerin çoğunluğu orta düzeyde ekonomik gelire sahip ailelerden gelmektedir.

Veri Toplama Araçları

Çalışmada (i) Destek ve Hareket Sistemi Kavram Testi, (ii) Dolaşım Sistemi Kavram Testi, (iii) Solunum Sistemi Kavram Testi, (iv) Öğrenmede Güdüsel Stratejiler Anketi, (v) Epistemolojik İnançlar Anketi, ve (vi) Bilimsel Süreç Becerileri Testi olmak üzere altı veri toplama aracı kullanılmıştır.

Kavram Testleri: Öğrencilerin destek ve hareket sistemi, dolaşım sistemi ve solunum sistemi konularında kavramsal anlamalarını ölçmek üzere üç adet kavram testi araştırmacı tarafından geliştirilmiştir. Kavram testlerininin geliştirilmesi yoğun bir ön araştırma gerektirmektedir. Çünkü kavram testlerinde öğrencilere yöneltilen çoktan seçmeli soruların çeldiricileri, öğrencilerde var olan kavram yanılgılarından oluşmaktadır. Bu sebeple her bir maddenin geliştirilmesi için konu ile ilgili kavram yanılgıları, litelatür taraması ile başlatılan ve öğrencilerden açık uçlu sorular ve görüşmeler yoluyla veri toplanması ile devam ettirilen bir araştırma süreci ile derlenmiştir. Daha ayrıntılı belirtmek gerekirse kavram testlerinin geliştirilmesinde Figure 1'de belirtilen basamaklar izlenmiştir. Her bir test 10 adet çoktan seçmeli madde içermektedir ve her bir maddenin sonunda öğrencilere verdikleri cevaptan emin olup olmadıkları sorulmaktadır. Bu amaçla öğrencilerin ilgili kavramları ne derece öğrendiklerinin ölçülmesi hedeflenmiştir. Doğru cevap vermiş kabul edilmek için öğrenciler, seçenekler arasından bilimsel olarak doğru kabul edilen cevabı seçmeli ve verdikleri cevaptan emin olduklarını ifade etmelidirler. Uzman görüşü ve pilot çalışma yapıldıktan sonra testler ilgili konu işlenmeden önce, işlendikten sonra ve konunun tamamlanmasından bir ay sonra olmak üzere üç kere uygulanmıştır.Uygulamada elde edilen güvenilirlik katsayıları KR-20 ile hesaplanmıştır ve Tablo 2 de sergilenmektedir.

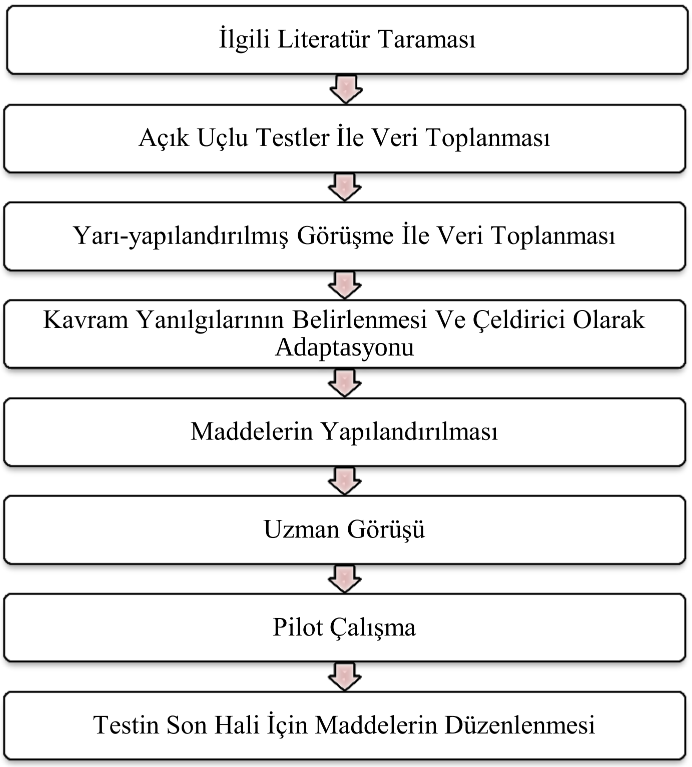

Figure 1. Kavram Testlerinin Gelişim Süreci

Table 1.2 Kavram testlerinin KR-20 değerleri

	Hareket ve Destek Sistemi Kavram Testi	Dolaşım Sistemi Kavram Testi	Solunum Sistemi Kavram Testi
Pilot Çalışma	0.57	0.54	0.56
Ön test	0.42	0.49	0.50
Son test	0.62	0.57	0.67
Takip Testi	0.59	0.51	0.64

Öğrenmede Güdüsel Stratejiler Anketi: Öğrencilerin özdüzenleme becerilerini ölçmek amacıyla Pintrich ve arkadaşları (1993) tarafından geliştirilen toplamda 81 maddeden oluşan bu ölçek çalışmanın başında ve sonunda olmak üzere iki defa uygulanmıştır. Anket iki ana bölümden oluşmaktadır. Birinci bölüm, öğrencilerin motivasyonel inaçlarını ölçmeye yönelik 6 alt boyut içeririken ikinci bölüm, öğrencilerin kullandıkları öğrenme stratejilerini ölçen 9 alt boyut içermektedir. Alt boyutlardaki tüm maddeler 7li likert tipinde (1: Beni hiç yansıtmıyor, 2: Beni tam olarak yansıtıyor) yanıtlanmaktadır. Anketin Türkçe'ye çevirisi ve adaptasyonu Sungur (2004) tarafından gerçekleştirilmiş ve geçerliliği bir çok çalışma tarafından kanıtlanmıştır. Uygulama sonrası elde edilen veriler doğrulayıcı faktör analizi ile incelenmiş ve anketin faktör yapısı orjinali ve dilimize çevrilmiş hali ile uyumlu bulunmuştur. Faktör analizi sonuçlarının karşılaştırmalı değerlendirimi Tablo 1.3de sunulmaktadır. Ayrıca güvenilirlik araştırması için her bir alt boyuta yönelik Alpha katsayıları hesaplanmış ve değerlerin .63 ile .94 arasında değiştiği bulunmuştur.

Table 1.3 CFA indices related with MSLQ

		$\chi 2/df$	GFI	RMR	RMSEA	CFI	SRMR
Motivasyon Alt Boyutu	Orjiinal (Pintrich, et al., 1991)	3.49	0.77	0.07	-	-	-
	Çeviri (Sungur, 2004)	5.30	0.77	0.11	-	-	-
	Bu Çalışmanın Ön Test Uygulaması	1.62	0.81	0.19	0.056	0.94	0.072
	Bu Çalışmanın Son Test Uygulaması	1.77	0.79	0.07	0.065	0.94	0.072
Öğrenme Stratejileri Alt Boyutu	Orjiinal (Pintrich, et al., 1991)	2.26	0.78	0.08	-	-	-
	Çeviri (Sungur, 2004)	4.50	0.71	0.08	0.08	-	-
	Bu Çalışmanın Ön Test Uygulaması	1.93	0.65	0.36	0.08	0.93	0.092
	Bu Çalışmanın Son Test Uygulaması	1.86	0.66	0.08	0.08	0.92	0.083

Epistemolojik İnançlar Anketi: Katılımcıların bilimsel epistemolojik inançlarını belirlemek amacıyla dört boyuttan oluşan Epistemolojik İnançlar Anketi uygulanmıştır. Bu anket Conley ve arkadaşları (2004) tarafından geliştirilmiş çeviri ve adaptasyonu ise Özkan (2008) tarafından yapılmıştır. Ankette her maddesi beşli likert tipinde yanıtlar içeren toplam 26 madde bulunmaktadır. Anketin içerdiği alt boyutlar bilginin kaynağı, bilginin kesinliği, bilginin gelişmesi ve bilginin doğrulanması şeklindedir. Bilginin kaynağı boyutunda bilginin öğretmen gibi dış faktörlerden kaynaklandığına yönelik maddeler vardır. Bilginin kesinliği boyutunda ise tek doğrunun varlığına inanmayı ölçen maddeler bulunmaktadır. Bilginin gelişmesi boyutu ile bilimin değişen ve gelişen yapısına olan inaç ölçülmektedir. Son olarak bilginin doğrulanması boyutu bireylerin bilginin doğruluğunu neye dayanarak kabul ettiklerini ve bu süreçte deneylerin yerini sorgulamaktadır. Bahsi geçen boyutlardan bilginin kaynağı ve kesinliği boyutlarında düşük değerler elde etmek sofistike inanç olarak kabul edilirken, bilginin gelişmesi ve doğrulanması boyutlarında yüksek değerler elde etmek sofistike inanç sayılmaktadır. Anket bu çalışmanın başında ve sonunda ön test ve son test olarak uygulanmıştır. Belirtilen boyutlar için hesaplanan Alpha güvenilirlik değerleri sırasıyla .76, .61, .58, .83 şeklinde bulunmuştur. Ayrıca elde edilen veriler doğrulayıcı faktör analizine tabi tutulmuş ve anektin dörtlü faktör yapısı doğrulanmıştır. Faktör analizinde elde edilen CFA değerleri geliştirilen anketin ilk sunulan değerleri ile karşılaştırmalı olarak Tablo 1.4de sunulmaktadır.

Table 1.4 CFA indices related with EBQ

	Orjinal EİA (Conley ve diğ., 2004)	EİA Ön test	EİA Son test
$\chi 2/df$	1.35	1.73	1.72
CFI	0.90	0.92	0.93
S-RMR	-	0.099	0.096
RMSEA	0.038	0.062	0.063

Bilimsel Süreç Becerileri Testi: Öğrencilerin bilimsel süreç becerilerini test etmek amacıyla Okey ve arkadaşları (1982) tarafından geliştirilen ve Türkçe'ye çeviri ve adaptasyonu Ozkan ve arkadaşları (1989) tarafından yapılan Bilimse Süreç Becerileri Testi kullanılmıştır. Testin aslı 36 adet çoktan seçmeli sorudan oluşmaktadır. Orta öğretim seviyesindeki yaş gruplarına da uygulayabilmek amacıyla test, Can (2008) tarafından 26 maddeye düşürülmüş ve 7. sınıfta okuyan 227 öğrenciye uygulanarak geçerliliği sağlanmıştır. Testin güvenilirliğini ölçmek amacıyla hesaplanan KR20 değerleri orjinal ve Türkçe versiyonları için .86 ve .81 olarak rapor edilmişken kısaltılmış 26 maddelik versiyon için .80 şeklinde rapor edilmiştir. Ancak bu çalışmada testin ön test ve son test uygulamalarından elde edilen verilerden hesaplanan KR-20 değerleri daha düşük çıkmıştır (.44 ve .51). Bu çalışmanın bir sınırlılığı olarak kabul edilmektedir.

Uygulama

Karşılaştırma grubundaki öğrenciler Destek ve Hareket Sistemi, Dolaşım Sistemi ve Solunum Sistemi konularını ilköğretim Fen ve Teknoloji Dersi müfredatında ve ders kitaplarında tavsiye edilen şekilde işlemişlerdir. 2006 yılında Fen ve Teknoloji ders müfredatı yapılandırmacı yaklaşıma göre yenilenmiş ve öğrencilerde kendi kendine öğrenmeyi geliştiren, keşfederek, yaparak ve yaşayarak bilgi kazanımını hedef alan bir müfredat halini almıştır. Bu nedenle ders kitabında yer alan açıklamalar ve aktiviteler öğretmen merkezli değil öğrenci merkezlidir. Ancak bu çalışamdaki öğretmenler uygulama esnasında spesifik olarak belli teknikleri kullanmışlardır. Bunlar genellikle, öğrencilere kısa cevaplı sorular sormak, konu ile ilgili animasyonlar ve videolar izlemek, kitaptaki bilgileri sınıftaki öğrencilere yüksek sesle okuttuktan sonra konuyu açıklamak ve tavsiye edilen aktiviteleri, öğrencileri konuyu keşfetme sürecine katmak yerine verilen bilgileri doğrulamak amacıyla uygulamak veya öğrencilere uygulatmak şeklinde sıralanabilir. Öte yandan deney grubundaki öğrenciler aynı konuları 7E öğrenme döngüsüne göre hazırlanan ders planları ve aktiviteler ile öğrenmişlerdir. Bu bağlamda 7E öğrenme döngüsü modelini temel alan, Destek ve Hareket Sistemi için kemikler konusunda ve kaslar ve eklemer konusunda iki ayrı ders planı, Dolaşım Sistemi için kan ve dolaşım konularında iki ayrı ders planı ve son olarak Solunum Sistemi konusunda da bir adet ders planı hazırlanmıştır. Örnek olarak ilk konunun 7E öğrenme döngüsüne göre işlenilişi aşağıda verilmiştir. Diğer konularda da kemikler konusundaki işleyişe benzer bir şekilde 7E öğrenme döngüsü modeli uygulanmıştır.

7E-Öğrenme Döngüsü (Kemikler)

E1: Önbilgileri ortaya çıkartma (Elicit)

İlk olarak öğrencilere bir apartman inşaatının resmi gösterilmiştir. İnşaatta görülen demirlerin ne işe yaradığı ve vücudumuzu bu apartmana benzetecek olursak demirlerin görevini gören yapının ne olduğu sorulmuştur. İskeletimiz cevabı alındığında demirler ile iskeletimiz arasındaki benzerlikler ve farklar tartışılmıştır. Daha sonra öğretmen tahtayı ikiye bölerek her bir bölmeye "Ne biliyoruz?" ve "Ne öğrenmek istiyoruz?" yazarak öğrencilerin bu konuda sahip oldukları bilgileri ve merak ettikleri konuları listelemiştir. Son olarak öğrencilerden iskelet sistemi ile ilgili önbilgilerini kullanarak aşağıdaki soruları tartışmaları ve yanıtlamaları istenmiştir.

- Nasıl ayakta durabiliyoruz? Nasıl hareket edebiliyoruz? Uzandığımız bir şeyi elimize nasıl alabiliyoruz?
- Beyniniz ve kalbimiz gibi hayati organlarımızı dış etkilere karşı koruyan nedir?
- Vücudumuzda bulunan kemiklerin hangilerini hatırlıyorsunuz? Vücudumuzdaki en büyük kemik neredEdir? En küçük kemik nerededir?
- Kemiklerimiz canlı mıdır yoksa cansız mı? Neden böyle düşünüyorsunuz?
- Kemiklerin kendisi hafifken vücudumuzun ağırlığını nasıl taşır?
- Kemiklerimiz olmasa ne olurdu?

Öğretmen öğrencilerin bu soruları tartışmalarını sağlamış, iskelet sistemi ile ilgili sahip oldukları ön bilgiler ortaya çıkartıldığında bir sonraki aşamaya geçmiştir.

E2: İlgiyi çekme (Engage)

Öncelikle öğrencilere gerçek röntgen sonuçları gösterilir ve röntgende gösterilen kemiklerin vücudun neresinde olduğunu tahmin etmeleri istenmiştir. Ayrıca gösterilen röntgenlerde kırık olan kemikleri bulmaları beklenmiştir. Bu kırıkların nasıl iyileşeceği ve iyileşmesi için nasıl bir tedavi uygulanması gerektiği öğrencilerle tartışılmıştır. Röntgenler incelendikten sonra x-ray ışınları icat edilmeden önce bu tip tedavilerin veya tanıların nasıl yapılabildiği konuşulmuştur. Bunun üzerine öğrencilere x-ray ışınlarının mucidi Wilhelm Chonrad Rontgen'in hayatı ile ilgili yazı dağıtılmış ve sınıfta okunarak tartışılmıştır. Bu hikaye üzerinde öğretmen deneylerin bilimsel bilginin doğrulanmasındaki yeri ve bilimin değişken doğasına vurgu yapmıştır. Sonrasında bir insan yavrusu ile yetişkin bir insanın kemikleri aynı mıdır sorusu sınıfta kısaca tartışılmış, öğrencilere farklı yaşlardaki insanların el röntgenleri gösterilerek öğrencilerin yaş ilerledikçe kemiklerin de büyüdüğü sonucuna varmaları beklenmiştir. Bu aşamada öğrencilere kemiklerin canlı mı yoksa cansız mı olduğu tekrar sorulmuş, alınan cevaplar üzerine mikroskopta kemik hücreleri inceletilerek kemiklerin canlı olduğu çıkarımı sağlanmıştır.

E3: Arastırma-kesif yapma (Explore)

Öğrencilere beşer kişilik gruplara ayrılmış ve ilk aşamada her gruba çeşitli tavuk kemikleri içeren ağzı kapalı torbalar verilmiştir. Gruplardan torbada bulunan kemikleri inceleyerek çalışma kağıdındaki soruları grup içinde tartışarak yanıtlamaları istenmiştir. Bu aşama öğrencilerin kemikleri sınıflandırmalarını amaçlamaktadır. Bu sayede kemik çeşitleri açıklanacaktır. İkinci aşamada ise iki farklı boy bacak kemiği içeren poşetler dağıtılarak cevaplamaya devam etmeleri istenmiştir. Bu aşamada ise öğrencilerden kemiklerin büyüdüğünü ayrıca daha büyük canlıların daha büyük kemiklere sahip olduğunu fark etmeleri beklenir. Daha sonra insan kemikleri hakkında deneyimlerini arttırmak amacıyla öğrencilere puzzle şeklinde bölünmüş bir insan iskeleti kemikleri dağıtılmıştır. Öğrenciler kemikleri birleştirdikten sonra insan kemiklerini sınıflandırmaları için bir boyama aktivitesi yapılmış daha sonra da iskelet modelinde kemikler incelenmiştir. Üçüncü aşamada da öncelikle kemiğin içinde ne olduğunu tahmin etmeleri istenmiştir. Daha sonra dağıtılan tavuk bacak kemiklerinin içini incelemeleri istenmiş, bunun için öğrencilere eldiven ve kemiği kırabilecekleri kıracaklar dağıtılmıştır. Öğrenciler çalışma kağıtlarındaki soruları cevaplamayı ve gözlemlerini not almayı tamamladıklarında çalışma bu soruların tüm sınıf ile tartışılacağı bir sonraki aşamaya geçilmiştir.

E4 : Kavram Aktarımı (Explain)

Bir önceki aşamada yapılan incelemelerden elde edilen deneyimler ve çalışma kâğıdında cevaplanan sorular sınıfça tartışılır. Öğretmen öğrencilerin açıklamalarını dinledikten sonra gereken yerlerde bilimsel açıklamaları öğrencilere sunar.Örneğin öğrecilerin yaptıkları kemik sınıflandırmaları dinlendikten sonra öğretmen kemiklerin bilimsel olarak kabul gören haliyle kısa, uzun ve yassı kemik olarak sınıflandırıldığını açıklamıştır.

Öğrencilere kemiğin yapısında ne olduğu ve üzerinde bulunan kısımlarının görevleri sorulmuştur. Kemiğin neden sert olduğu, yapısındaki hangi maddenin bu sertliği sağladığı, dış kısmının ve iç kısmının nasıl farklı olduğu, iç kısmının neden dışı gibi sıkı değil de daha boş olduğu, iç kısmında bulunan iliğin görevinin ne olduğu gibi sorular yöneltilmiştir.

Bunun üzerine kemiğin sertliğinin sebebi sınıfta tartışılmış ve öğrencilere bir deney düzeneği kurdurulmuştur. Kemiğin sertliğin sebebini açıklayabilmek için öğrencilere sirkede bekletilmiş bir kemik ile normal bir kemiği karşılaştırarak incelemeleri istenmiştir. Bu etkinlikten önce sirkenin kalsiyuma zarar verdiği bilgisi öğrencilere verilmiş ve deney öğrencilere tasarlatılmıştır. Deney sonrası öğrencilerden kemiğin neden zarar gördüğü ve kemiğin sertliğinin neden gittiği hakkında yorum yapmaları istenmiş ve alınan cevaplar üzerinden bilimsel açıklamalar sunulmuştur.

E5: Kavram Uygulaması (Elaborate)

Öğrencilerden grup olarak iskelet sistemi ile ilgili öğrendiklerini içeren bir poster hazırlamaları istenmiştir. Posterde kemikler ve iskelet sistemi ile ilgili merak edilen, ilginç bilgilerin yer alabileceği belirtilmiş ve tasarım öğrencilere bırakılmıştır. Daha sonra öğretmen tahtaya "Neler öğrendik?" başlığını yazmış ve öğrencilerden öğrendikleri kavramları ve bilgileri sıralamalarını isteyerek bunları tahtada özetlemiştir.

E6: Degerlendirme (Evaluate)

Hazırlanan posterler değerlendirilmiştir.

Öğrencilerden derste öğrendikleri kavramları kullanarak kavram çarkı hazırlamaları istenmiş bu amaçla boş kavram çarkları öğrencilere dağıtılmıştır. Öğrencilerin hazırladıkları kavram çarkları öğretmen tarafından incelenmiş ve öğrencilere geri bildirimlerde bulunulmuştur. Öğrencilerin kavram öğreniminin değerlendirmesi ise kavram testi uygulaması ile gerçekleştirilecektir.

E7: Kavramların İlişkilendirilmesi-Genişletilmesi (Extend)

Bu aşamada öğrencilerin bir sonraki derste işleyecekleri kaslarımız ve eklemler konularına bağlantı kurabilmeleri için aşağıdaki araştırma soruları yöneltilmiştir.

- Kemiklerimizi nasıl hareket ettiriyoruz?
- Kemiklerimiz birbirine nasıl bağlanıyor?
- Parmaklarımızı boynumuzdan fazla hareket ettirebilmemizin nedeni nedir?

Verilerin Analizi

Öğrencilerin kavram testleri ve Bilimsel Süreç Becerileri Testi ile toplanan verileri karışık faktörlü varyans analizi (Mixed-ANOVA) kullanılarak incelenmiştir. Ayrıca öğrencilerin Öğrenmede Güdüsel Stratejiler Anketi ve Epistemolojik İnançlar Anketi'ne verdikleri cevaplar karışık faktörlü çok değişkenli varyans analizi (Mixed MANOVA) ile incelenmiştir. Yapılan analizlerin sonuçlarının araştırma sorularını cevaplamada yetersiz kalmasından dolayı analizlerin kodu (Syntax) genişletilmiş ve böylece her bir veri için grup içi ve gruplar arası karşılaştırmaların ayrı ayrı yapılması sağlanmıştır. Bağımsız karşılaştırmalarda artma olasılığı yüksek olan Tip 1 hatayı azaltmak amacıyla Bonferroni Analizi uygulanmıştır. Ayrıca her analizden önce gerekli sayıltılar test edilmiş ve herhangi bir uyumsuzluk gözlenmemiştir.

Bulgular

Bu bölümde bulgular her araştırma sorusu için ayrı bölümler halinde açıklanacaktır.

1. Araştırma Sorusu: 6. sınıf öğrencilerinin insan vücudunda sistemler konusuna yönelik ön bilgileri, öz-düzenleme becerileri, öğrenme stratejileri, bilimsel epistemolojik bilgileri ve bilimsel süreç becerileri ne düzeydedir?

Yapılan analizlerde öğrencilerin uygulama öncesi hareket ve destek, dolaşım ve solunum sistemleri hakkında var olan kavramsal bilgilerinin ortalama değerlerinin her iki grupta da alınabilecek en yüksek değer (10) ile karşılaştırıldığında son derece düşük olduğu gözlenmiştir (bkz. Tablo 1.5). Bu durum öğrencilerde kavram yanılgılarının var olduğuna işaret edebilir. Yapılan çalışmalar öğrencilerin ilgili konularda kavram yanılgılarına ve eksik bilgilere sahip olduğunu desteklemektedir (Caravita & Falchetti, 2005; Arnaudin & Mintzes, 1985; Sungur ve diğ., 2001; Alparslan ve diğ., 2003).

Table 1.5 Ön test Ortalama Değerleri

	Deney Grubu	Karşılaştırma Grubu
Destek ve Hareket Sistemi Kavram Testi	2.94	2.54
Dolaşım Sistemi Kavram Testi	1.85	1.54
Solunum Sistemi Kavram Testi	2.00	1.17

Ayrıca Öğrenmede Güdüsel Stratejiler Anketi'nin ön test uygulamasından elde edilen veriler öğrencilerin motivasyon alt boyutundaki her bir değişkende (içsel hedef yönelimi, dışsal hedef yönelimi, konu değeri, öğrenme inançlarını kontrol etme, öz-yeterlik ve sınav kaygısı) ortalama değerin üzerinde bir skor elde ettiğini göstermiştir. Bu durum öğrenme stratejileri alt boyutundaki değişkenler (tekrarlama, ayrıntılandırma, örgütleme, kritik düşünme, biliş-üstü öz düzenleme, zaman ve çalışma çevresinin düzenlenmesi, çabanın düzenlenmesi, arkadaştan öğrenme ve yardım arama) için de aynıdır. Bu bulgu öğrencilerin Fen ve Teknoloji dersine karşı motivasyonel inançlarının ve öğrenme stratejileri kullanımlarının yüksek olduğunu göstermektedir. Öğrencilerin bilimsel epistemolojik inançları ön test verilerine göre incelendiğinde, öğrencilerin her boyutta ortalama değerin üzerinde bir skor elde ettiği görülmüştür. Bu durumda bilginin kaynağı ve bilginin kesinliği boyutlarında öğrencilerin naif inançlara sahip olduğu, ancak bilginin gelişmesi ve bilginin doğrulanması boyutlarında sofistike inançlar barındırdıkları ortaya çıkmıştır. Bilimsel süreç becerileri testinin ön test sonuçları incelendiğinde ise öğrencilerin ortalama değerin altında sonuçlar alması bu becerilerin öğrencilerde düşük olduğunu göstermektedir.

2. Araştırma Sorusu: 7E öğrenme döngüsü ve geleneksel öğretim yönteminin altıncı sınıf öğrencilerinin insan vücudunda sistemler (destek ve hareket, dolaşım ve solunum sistemleri) konusundaki kavramsal anlamalarına etkisi ne düzeydedir?

Destek ve Hareket Sistemi Kavram Testi ile elde edilen verilerin analizi sonucunda zaman ve uygulama değişkenleri arasında anlamlı bir etkileşim olduğu gözlenmiştir (Wilk's λ= 0.94, F(2, 154)= 4.91, p= 0.01 , η^2=.60). Bu durumda bu iki bağımsız değişkenin bağımlı değişken üzerindeki etkilerini ayrı ayrı inceleyebilmek için analiz kodu genişletilmiştir. Bu analizde ayrıca artması muhtemel tip 1 hatayı düşürmek amacıyla kod içerisinde Bonferronni düzeltmesi uygulanmıştır. Analiz sonucunda ön test verilerinde grupların ortalama değerlerinin birbirilerine çok yakın olduğu ve gruplar arasında anlamlı bir fark olmadığı bulunmuştur ($p > .05$). Ancak son test verilerinde istatistiksel olarak anlamlı bir fark elde edilmiştir ve ortalamalar karşılaştırıldığında bu farkın deney grubu lehine olduğu gözlenmiştir ($p < .05$). Öte yandan izleme testinde gruplar arasında anlamlı bir fark bulunmamıştır ($p > .05$). Öğrencilerin kavramsal anlamalarının zaman içinde değişimi gözlendiğinde ise deney grubu için her üç ölçüm arasında da anlamlı farklar olduğu ortaya çıkmıştır. Ölçümlerdeki ortalama değerler karşılatırıldığında ise öğrencilerin puanlarının ön teste nazaran son testte arttığı ancak bu değerin izleme testinde az miktarda düştüğü ortaya çıkmıştır. Karşılaştırma grubunda ise bulunan tek anlamlı fark ön test ile izleme testi ölçümleri arasındadır.

Dolaşım Sistemi Kavram Testi ile elde edilen verilerin analiz zaman ve uygulama değişkenleri arasında anlamlı bir etkileşim olmadığını göstermiştir (Wilk's λ= 0.98, F(2, 146)= 1,67, p> 0.05). Öte yandan zaman değişkenin öğrecilerin kavramsal anlamaları üzerinde anlamlı bir etkisi olduğu ortaya çıkmıştır (Wilk's λ= 0.77, F(2, 146)= 21.77, p< 0.05, η^2= .23). Ek olarak uygulama değişkenin de anlamlı etkisi gözlenmiştir(F(1, 147)= 5.64, p= 0.02, η^2= .04). Bir önceki veri analiziyle uyumlu olarak bu değişkenlerin etkisi detaylı olarak incelenmiştir. Bulgular, gruplar arasında dolaşım sistemi kavramlarını anlamaları açısından ön test ve son test ortalamalarında anlamlı bir fark olmadığını, ancak izleme testi sonuçlarında gruplar arasında anlamlı bir fark olduğunu ortaya koymuştur. Uygulamanın tamamlanmasından bir ay sonra toplanan veride elde edilen bu fark deney grubunun lehinedir. Zaman içerisindeki değişimler incelendiğinde ise deney grubunda da karşılaştırma gurubunda da ön testler ve son test değerleri arasında anlamlı bir fark bulunmuştur. Ayrıca ön testler ile izleme testleri değerleri arasında da anlamlı bir fark olduğu ortaya çıkmıştır. Ancak son testler ile izleme testleri arasında anlamlı bir fark gözlenmemiştir.

Solunum Sistemi Kavram Testi verilerinin analiz sonuçlarında zaman ve uygulama değişkenleri arasında anlamlı bir etkileşim bulunmuştur (Wilk's $\lambda = 0.92$, $F(2, 156) = 6.39$, $p < 0.05$, $\eta^2 = 0.08$). Her bir değişkenin etkisi detaylı olarak incelendiğinde gruplar arası farkın ön test değerlerinde anlamlı olmadığı, son test değerlerinde ise istatistiksel olarak anlamlı oldu, ve bu farkın deney grubu lehine olduğu ortaya çıkmıştır. Ayrıca zaman içindeki değişimlerin analizi, deney grubunda yer alan öğrencilerin ön test ile son test puanları arasında ve ön test ile izleme testi puanları arasında anlamlı bir fark olduğunu göstermiştir. Öte yandan karşılaştırma grubunda tek anlamlı fark ön test değerleri ile izleme testi değerleri arasında elde edilmiştir.

Genel olarak üç analizde de uygulama öncesi gruplar arasında kavramsal anlama açısından bir fark gözlenmezken uygulama sonrasında ve bir ay sonra yapılan karşılaştırmalarda, kavram testlerinde 7E öğrenme döngüsü ile öğrenim gören öğrencilerin geleneksel yöntemle öğrenim gören öğrencilerden daha başarılı ortaya çıkmıştır. Bu bulgu, 7E öğrenme döngüsü metodunun öğrencilerin kavramsal anlamalarını ve bu kavramların kalıcılığını arttırmada geleneksel öğretim yöntemine göre daha önemli bir etkiye sahip olduğunu göstermektedir.

3. 7E öğrenme döngüsü ve geleneksel öğretim yönteminin altıncı sınıf öğrencilerinin motivasyonlarına (içsel hedef yönelimi, dışsal hedef yönelimi, konu değeri, öğrenme inançlarını kontrol etme, öz-yeterlik ve sınav kaygısı) etkisi ne düzeydedir?

Deney ve karşılaştırma grubundaki öğrencilerin Fen ve Teknoloji dersine karşı motivasyonel inançları açısından bir fark olup olmadığını tespit etmek amacıyla karışık MANOVA analizi yapılmıştır. Sonuçlar uygulamanın bağımlı değişkenlerin üzerinde bütünleşik olarak anlamlı bir etkisi olduğunu ortaya koymuştur (Wilk's λ= 0.92, $F(6, 159)$= 2.40, $p<$ 0.05. η^2= .08). Ayrıca zaman değişkeninin de değişkenler üzerindeki etkisi istatistiksel olarak anlamlıdır (Wilk's λ= 0.79, $F(6, 159)$= 6.92, $p<$ 0.05. η^2= .21). Uygulama ve zaman değişkenlerinin etkileşimlerinin ise değişkenler üzerinde anlamlı bir etkisi olmadığı bulunmuştur (Wilk's λ= 0.93, $F(6, 159)$= 1.86, $p>$ 0.05). Her bir motivasyonel değişkeni bağımsız olarak incelemek ve uygulama ve zaman değişkenlerinin öğrencilerin motivasyonel inançlarına etkisine ayrı ayrı bakabilmek için analizin kodu bir önceki analizler gibi geliştirilmiştir. Sonuçta ön test değerlerinden elde edilen ortalama değerler karşılaştırıldığında hiç bir değişken için anlamlı bir fark gözlenmemiştir. Öte yandan öğrencilerin son test ortalamaları kaşılaştırıldığında gruplar arasında içsel hedef yönelimi, dışsal hedef yönelimi, konu değeri ve öz-yeterlik alt boyutları açısından anlamlı farklar elde edilmiştir. Gruplar arası bu farkların tamamı deney grubu lehinedir. Deney ve karşılaştırma grubunun ön test ve son test ortalamaları karşılaştırıldığında ise karşılaştırma gurubunun tüm alt boyutlarda anlamlı bir değişim gösterdiği, deney grubunun ise hiç bir alt boyutta anamlı değişim göstermediği ortaya çıkmıştır. Ancak ortalamardaki değişimler incelendiğinde sınav kaygısı boyutu hariç tüm alt boyutlarda grup değerlerinde bir düşüş olduğu ve bu düşüşün karşılaştırma grubunda önemli ölçüde olduğunu gözlenmiştir. Bu bulgu öğrencilerin motivasyonel inançlarının düşme eğilimi gösterdiğini, ancak 7E öğrenme döngüsü modelinin öğrencilerdeki bu düşüşe dengeleyici bir etkide bulunduğunu göstermiştir.

4. 7E öğrenme döngüsü ve geleneksel öğretim yönteminin altıncı sınıf öğrencilerinin öğrenme stratejilerine (tekrarlama, ayrıntılandırma, örgütleme, kritik düşünme, biliş-üstü öz düzenleme, zaman ve çalışma çevresinin düzenlenmesi, çabanın düzenlenmesi, arkadaştan öğrenme ve yardım arama) etkisi ne düzeydedir?

Karışık MANOVA analizi sonuçları zaman değişkeninin öğrencilerin öğrenme stratejileri kullanımında anlamlı bir etkisi olduğunu göstermiştir (Wilk's λ= 0.72, $F(9, 156)$= 6.70, p< .05, η^2 =.28). Gruplar arası farka dayalı olarak ise uygulama değişkeninin anlamlı bir etkisi bulunmamıştır (Wilk's λ= 0.95, $F(9, 156)$= 0.94, p> 0.05). Analiz uygulama ve zaman etkileşiminin de anlamlı bir etkisi olmadığını göstermiştir (Wilk's λ= 0.92, $F(9, 156)$= 1.43, p> .05). Analizin kodu genişletilerek grup içi ve gruplar arası karşılaştırmalar her alt boyut için detaylandırılmıştır. Bu ayrıntılı analiz sonucunda gruplar arasında ön test ortalamaları açısından anlamlı bir fark olmadığı bulunmuştur. Son test ortalamaları karşılaştırıldığında ise deney ve kontrol grubu arasında ayrıntılandırma, kritik düşünme, biliş-üstü öz düzenleme, zaman ve çalışma çevresinin düzenlenmesi ve çabanın düzenlenmesi değişkenlerinde istatistiksel olarak anlamlı bir fark elde edilmiştir. Ayrıca deney grubunun son test ortalamalarının karşılaştırma grubuna göre her alt boyutta daha yüksek olduğu gözlenmiştir. Sonuçlar herbir alt boyutta ön test ile son test arasında gerçekleşen değişimler açısından incelendiğinde, deney grubunda ayrıntılandırma ve arkadaştan öğrenme boyutlarında anlamlı bir değişimin olduğu ve bu değişimin ortalamanın artışı şeklinde olduğu bulunmuştur. Öte yandan karşılaştırma grubundaki değişimlerin, örgütleme, biliş-üstü öz düzenleme, zaman ve çalışma çevresinin düzenlenmesi, çabanın düzenlenmesi, arkadaştan öğrenme alt boyutlarında anlamlı olduğu ancak ortalamaların bu boyutlardan sadece örgütleme ve arkadaştan öğrenme boyutlarında artış gösterdiği, diğer boyutlarda ise azalma şeklinde olduğu gözlenmiştir. Bu durum 7E öğrenme döngüsü modelinin, öğrencilerin öğrenme stratejileri üzerinde geleneksel yöntemlere göre daha etkili olduğuna ve bu stratejileri geliştirdiğine işaret etmektedir.

5. 7E öğrenme döngüsü ve geleneksel öğretim yönteminin altıncı sınıf öğrencilerinin bilimsel epistemolojik inançlarına (bilginin kaynağı, bilginin kesinliği, bilginin gelişmesi ve bilginin doğrulanması) etkisi ne düzeydedir?

Öğrencilerin bilimsel epistemolojik inançları karmaşık MANOVA analizi ile incelenmiş ve bulgular zaman bağımsız değişkeninin bağımlı değişkenler üzerinde anlamlı bir etkisi olduğunu (Wilk's λ= 0.75, $F(4, 159)$= 13.53, p< 0.05. η^2 = .25), uygulama bağımsız değişkenin ise anlamlı bir etkisi olmadığını göstermiştirmiş (Wilk's λ= 0.96, $F(4, 159)= 1.75$, $p> 0.05$). Ayrıca zaman ve uygulama değişkenlerinin etkileşimlerinin bağımlı değişkenler üzerinde anlamlı etkisi bulunmamıştır (Wilk's λ= 0.99, F(4, 159)= 0.21, p> 0.05). Önceki analizlere benzer şekilde bağımsız değişkenler ve altboyutlar bazında detaylandırılan analiz sonucunda gruplar arasında ön test ortalamaları açısından anlamlı bir fark olmadığı tespit edilmiştir. Son test ortalamalarının karşılaştırılması ise gruplar arası farkın sadece bilginin kaynağı alt boyutunda anlamlı olduğunu ve deney gurubunun karşılaştırma grubuna göre daha sofistike inançlar sergilediğini göstermiştir. Ortalamaların zaman içindeki değişimleri incelendiğinde deney ve karşılaştırma gruplarının her ikisinde de bilginin gelişimi ve bilginin doğrulanması alt boyutlarında anlamlı bir değişim gözlenmiş ancak bu değişimin daha az sofistike inançlara sahip olma yönünde olduğu gözlenmiştir. Bu bulgular 7E öğrenme döngüsü ile sunulan öğrenme ortamının, öğrencilerin bilginin kaynağına yönelik inançlarına olumlu bir etki yaptığını ortaya koymaktadır. Öte yandan her iki öğretim yönetminin de diğer alt boyutlara dikkat çekici bir etkisi gözlenmemiştir.

6. 7E öğrenme döngüsü ve geleneksel öğretim yönteminin altıncı sınıf öğrencilerinin bilimsel süreç becerilerine (değişkenleri belirleme, değişkenleri tanımlama, hipotez kurma,deney tasarlama ve verileri yorumlama ve grafik çizme) etkisi ne düzeydedir?

Deney ve karşılaştırma gruplarındaki öğrencilerin bilimsel süreç becerileri karmaşık ANOVA yoluyla incelenmiş, bulgular zaman ve uygulama değişkenlerinin anlamlı bir etkisi olmadığını göstermiştir. Ayrıca zaman ve uygulama değişkenlerinin etkileşiminin de bağımlı değişken üzerinde anlamlı bir etkisi olmadığı ortaya çıkmıştır. Analizin kodu genişletilerek yapılan karşılaştırmalar ve öğrencilerin uygulama öncesi ve sonrası elde ettikleri değerlerin ortalamaları da hem gruplar arasında hem de zaman içinde anlamlı bir değişim olmadığını ortaya koymuştur. Ancak her iki grup öğrencileri de ortalama değerlerini uygulamadan sonra öncesine göre az miktarda artırmış, ayrıca deney grubu öğrencileri uygulama öncesinde ve sonrasında karşılaştırma gurubu öğrencilerine göre daha yüksek değerler elde etmiştir. Bu bulgular her iki öğretim yönteminin de öğrencilerin bilimsel süreç becerilerine dikkat eçkici bir etkisi olmadığına işaret etmektedir.

Doğurgalar

Bu çalışmada 7E öğrenme döngüsü ile geleneksel öğretim yöntemi öğrencilerin kavramsal anlamaları, öz düzenleme becerileri, bilimsel epistemolojik inançları ve bilimsel süreç becerileri açısından karşılaştırılmıştır. Bulgular 7E öğrenme döngüsü modelinin öğrencilerin kavramsal anlamaları ile kavramları akılda tutmalarında ve ayrıca öz düzenleme becerilerini geliştirmede etkin olduğunu ortaya koymuştur. Bu nedenle Fen ve Teknoloji dersi öğretmenlerine insan vücudunda sistemler konusunda 7E öğrenme döngüsü modeli ile öğretim yapılması tavsiye edilmektedir. Bu konu soyut düşünme gerektiren ve karmaşık sistemler içeren bir konudur ve yapılandırmacı öğretim yöntemleri ile bu konudaki akvramların bilimsel öğrenimi desteklenebilir. 7E öğrenme döngüsü modelinin etkinliği ve uygulanışı öğretmenlere hizmet içi eğitimler ile açıklanmalı, bu model dahilinde hazırlanmış materyaller ve planlarla modelin uygulanması desteklenmelidir. Bu alanda çalışan akademisyenler ile öğretmenler arasındaki etkileşimin arttırlıması da modelin uygulşanması ve planların geliştirilmesinde etkin olacaktır. Ayrıca eğitim fakültelerinde öğrenim gören öğretmen adaylarının, aldıkları metod derslerinde 7E öğrenme döngüsü modelini tanımasına ve uygulamasına fırsat sağlanmalıdır. Son olarak öğrencilerin bilimsel epistemolojik inançlarını ve bilimsel süreç becerilerini geliştirmek amacıyla uygulanan öğretim yöntemlerinde tartışma ve argümantasyon içeren etkinliklere yer verilmeli ayrıca öğrencilerin bir çok deney düzeneği kurarak ve test ederek bu becerileri defalarca uygulayabilecekleri bir ortam sağlanmalıdır.

APPENDIX U

CURRICULUM VITAE

PERSONAL DETAILS

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Address: Orta Doğu Teknik Üniversitesi, TSK Modelleme ve Simülasyon Merkezi, Üniversiteler Mah. Dumlupınar Blv. No:1, P.K. 06800, Çankaya Ankara/TURKEY

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EDUCATION

- **PhD:** 2007 – 2014 Elementary Education, Middle East Technical University, Ankara

  GPA: *3.79/4*

- **MS:** 2004 – 2007 Elementary Science Education, Middle East Technical University, Ankara

  GPA: *3.93/4*

  Thesis Title: The Effect of Problem-Based Learning on the Elementary School Students' Achievement in Genetics

- **BS:** 1999 – 2003 Elementary Science Education, Gazi University, Ankara

  GPA: *3.14/4*

WORK EXPERIENCE

- **December 2004 - August 2014:** Research Assistant, Department of Elementary Education, METU, Ankara, TURKEY,
- **2011 – 2012: Visitor Scholar:** Graduate School of Education & Information Studies, University of California Los Angeles (UCLA), Los Angeles, CA, USA.
- **2003-2004:** Elementary Science Teacher, Orhangazi, Orhan Ocal Giray Elementary School, Bursa, TURKEY

AWARDS & SCHOLARSHIP

- **2008**, **The Thesis of the Year Award,** Best Theses at Post-graduate, METU.
- **2007,** TUBITAK (NSF of Turkey), UBYT International Scientific Publication in Social Sciences **Award**.
- **2007,** TUBITAK (NSF of Turkey), UBYT International Scientific Publication in Social Sciences **Award** (Second time).
- **2007-Present**, TUBITAK (NSF of Turkey) 2211 National PhD Scholarship Program, Turkey, http://www.tubitak.gov.tr/home.do?ot=1&sid=523&pid=453.
- **2011,** YÖK, International Research Scholarship for Phd Students, Turkey
- **2014,** ODTU Geliştirme Vakfı (METU enhancement foundation), International Scientific Publication in Social Sciences **Award.**
- **2014, Conference Scholarship Award,** European Educational Research Association, ECER-2014-Porto, PORTEKİZ

RESEARCH INTEREST

Constructivist Learning Approaches, Learning Cycle, Problem-Based Learning, Elementary Science Education, Conceptual Change, Student Self-Regulation, Student Scientific Epistemological Beliefs

FOREIGN LANGUAGE

English

NATIONAL AND INTERNATIONAL PUBLICATIONS/ PRESENTATIONS

- **Araz, G.,** & Sungur, S. (2007) Effectiveness of Problem Based Learning on Academic Performance in Genetics. *Biochemistry and Molecular Biology Education*, *35*(6). 448-451.
- **Araz, G.,** & Sungur, S. (2007) The Interplay between Cognitive and Motivational Variables in a Problem-based Learning Environment. *Learning and Individual Differences*, *17*, 291-297.
- Kingir, S., Tas, Y., **Gok, G**., & Sungur Vural, S. (2013). Relationships among constructivist learning environment perceptions, motivational beliefs, selfregulation and science achievement. *Research in Science & Technological Education*, *31*(3), 205-226.

- **Araz, G.,** & Sungur, S. (2006). The Effects of Problem-Based Learning on the Elementary School Students' Understanding of Genetics. In M.-S. Giannakaki, G. T. Papanikos, Y. Pozios, & J. K. Richards (Eds.), Research on Education (pp. 187-193). Athens, Greece.
- **Araz, G.,** & Sungur, S. (2007). Implementation of the PBL in the Unit of Genetics. American Educational Research Association, Chicago, USA, April 9-13.
- **Araz Gok, G**., Tas, Y., Kingir, S., & Tuncer Teksoz, G. (2009, August-September). Preserves Science Teachers' Understanding of Greenhouse Effect. Paper presented at the annual meeting of European Science Education Research Association, Istanbul, Turkey.
- **Gök, G**., Sungur, S., & Tekkaya, C. (2012, April). Development of a Conceptual Inventory on Human Skeletal System. Poster presented at the annual meeting of the Western Psychological Association, San Francisco, CA.
- **GöK, G**., Öztekin, C., & Sungur Vural, S. (2013). The Effect of 7E Learning Cycle Instruction on Elementary Science Students' Motivation and Learning Strategy Use. Paper presented at the annual meeting of European Educational Research Association (ECER), Istanbul, Turkey, September 10-13.
- **GöK, G**., Sungur Vural, S. & Öztekin, C. (2014). The Effect of 7E-Learning Cycle Instruction on Middle School Students' Conceptual Understanding of Respiratory System. Paper presented at the annual meeting of European Educational Research Association (EERA-ECER), Porto, Portugal, September 1-2.
- Tas., Y., Kingir, S., **Gok, G.,** Tuncer Teksoz, G. (2008, August). The Ideas of Preservice Science and Technology Teachers Related with Climate Change. Paper presented at the annual meeting of VIII. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, Bolu, Turkey.
- Gok, A. & **Gok, G**. (2008, February). Usibility Comparison of Three Navigation Designs in Hypermedia Environments. Paper presented at the annual meeting of Akademik Bilisim, Canakkale, Turkey.

TEACHING EXPERIENCE

- Quantitative Data Analysis in Education.
- Laboratory Applications in Science I.
- Laboratory Applications in Science II.
- Educational Inquiry
- Measurement and Assessment
- Probability and Statistics
- Methods of Teaching Science
- Practice Teaching in Elementary Education
- School Experience

ACTIVITIES & COMMUNITY SERVICE

- **Jury** at METU Elementary School Science fair. Judge for selecting best science projects prepared by elementary students (2007).
- University orientation volunteer for the new coming students (2005-2006).
- Recycle project at the METU campus (2007).

APPENDIX V

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ■

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : Gök
Adı : Gülsüm
Bölümü : İlköğretim

TEZİN ADI: 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

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora ■

Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. ☐

Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. ☐

Tezimden bir (1) yıl süreyle fotokopi alınamaz. ■

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: