THE EFFECT OF 5E LEARNING CYCLE APPROACH ON SIXTH GRADE STUDENTS' UNDERSTANDING OF CELL CONCEPT, ATTITUDE TOWARD SCIENCE AND SCIENTIFIC EPISTEMOLOGICAL BELIEFS

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ABSTRACT

THE EFFECT OF 5E LEARNING CYCLE APPROACH ON SIXTH GRADE STUDENTS' UNDERSTANDING OF CELL CONCEPT, ATTITUDE TOWARD SCIENCE AND SCIENTIFIC EPISTEMOLOGICAL BELIEFS

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The purpose of this study is to investigate the effectiveness of 5E learning cycle on sixth grade students' understanding of cell concepts, their attitude toward science and their scientific epistemological beliefs

In this study the data were collected using 'Epistemological Belief Questionnaire' developed by Conley, Pintrich, Vekiri and Harrison (2004), the 'Cell Concept Test' developed by researcher and 'Science Attitude Questionnaire' developed by Geban, Ertepınar, Yılmaz and Şahbaz (1994). The instruments were administered as pre-test & post-test to a total of 160 sixth grade students in four intact classes of the elementary school which located in Izmit district of Kocaeli. Two classes were randomly assigned as control and experimental groups. Experimental groups (n = 80) received 5E learning cycle instruction and control groups (n = 80) received traditional instruction.

The data were analyzed using multiple analysis of covariances (MANCOVA). While a statistically significant treatment difference with respect to collective dependent variables; understanding of cell concept and epistemological beliefs was found there was no significant difference on attitude toward science.

The results indicated that students in the experimental group who were engaged in learning cycle instruction demonstrated significantly better performance over the control group students who were engaged in traditional instruction in students' understanding of cell concepts and epistemological beliefs.

Keywords: 5E Learning Cycle, Constructivism, Scientific Epistemological Beliefs, Attitude, Cell

ÖZ

5 AŞAMALI (5E) ÖĞRENME EVRESİ YAKLAŞIMININ 6.SINIF ÖĞRENCİLERİNİN HÜCRE KAVRAMINI ANLAMALARINA, FEN BİLGİSİ DERSİNE OLAN TUTUMLARINA VE EPİSTEMOLOJİK İNANÇLARINA ETKİSİ

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Bu çalışmanın amacı; 5E öğrenme döngüsü modelinin 6. sınıf öğrencilerinin Fen Bilgisi dersinde hücre konusunu anlamalarına, Fen Bilgisi dersine olan tutumlarına ve epistemolojik inançlarının geliştirilmesine etkisini incelemektir.

Bu çalışmada veriler, "Hücre Kavram Testi", "Fen Bilgisi Tutum Ölçeği", "Epistemolojik Inanç Anketi"nin Türkçe versiyonlarının 2005-2006 sonbahar döneminde Kocaeli ili İzmit ilçesindeki bir okulun altıncı sınıf öğrencilerine uygulanması ile elde edilmiştir. Sınıflar kontrol grubu ve deney grubu olarak rastgele seçilmiştir. Deney grubundaki öğrenciler (n=80) dersi 5E öğrenme döngüsü modeli ile işlerken, kontol grubundaki öğrenciler (n=80) geleneksel öğretim yöntemi ile işlemişlerdir.

Elde edilen veriler, çok yönlü varyans analizi (MANCOVA), kullanılarak değerlendirilmiştir. Sonuçlar 5E öğrenme döngüsü modelinin 6. sınıf öğrencilerinin Fen Bilgisi dersinde hücre konusunu anlamalarına ve epistemolojik inaçlarının gelişimine etki gösterdiği ancak Fen Bilgisi dersine olan tutumalarına etki göstermediğini ortaya çıkarmıştır.

Anahtar Kelimeler: 5E Öğrenme Evresi, Yapılandırıcı Öğrenme Teorisi, Bilimsel Epistemolojik İnançlar, Fene Yönelik Tutum, Hücre

To My Parents

Gülsen and Gıyassettin KAYNAR

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF SYMBOLS

SYMBOLS

5E-LCBI	: 5E Learning Cycle Based Instruction
LCBI	: Learning Cycle Based Instruction
TI	: Traditional Instruction
CG	: Control Group
EG	: Experimental Group
PE	: Personal Epistemology
EB	: Epistemological Beliefs
CCT	: Cell Concept Test
SAS	: Science Attitude Scale
EBQ	: Epistemological Beliefs
DV	: Dependent Variable
IV	: Independent Variable
C	: Covariate
MANCOVA	: Multiple Analysis of Covariances
SPSS	: Statistical Package fort he Social Sciences Program
df	: Degrees of Freedom
N	: Sample Size
α	: Significance Level

CHAPTER I

INTRODUCTION

The goal of the present study was to investigate the effect of learning cycle approach on students' understanding of cell concepts, students' attitude toward science and students' scientific epistemological beliefs.

When looking from the broader point of view, learning cycle approach reflects the changes of all the types of the trends and customs of new era is expected that the changes also unbearable in the area of the education. Specifically, science education is under the enormous effect of the changes of technology and information era. The pointer of the compass shows the inquiry practices in science education that designed to develop students' scientific process skills and understanding of scientific concepts (Buddy, Watson, & Aubusson, 2003). The philosophy in inquiry practices come from learning theory which heavily depends on the Piagets' studies. Piaget states that suitable learning model should be developed according to the characteristic and level of the understanding of the developmental stages of child. The learning cycle is a teaching approach translates a model for cognitive development and, specifically, modeled after Piaget's theory of cognitive development (Barman & Allard, 1993). Besides the Piagetian theory, Ausubel's theory of meaningful learning and Vygotsky's social constructivist theory are the foundations of this approach.

Beside the effectiveness of learning cycle application in science teaching, the study was focused on the enhancement of epistemological beliefs of the elementary students. Epistemological beliefs can be explained as the beliefs about the nature of knowing and beliefs about the nature of knowledge

(Conley, Pintrich, Vekiri, & Harrison, 2004). This study had tried to analyze the source, certainty, development and justification dimensions of epistemological beliefs. Whether the learning cycle approach effective or not on the epistemological beliefs was the concern of the present study.

In the area of science education, the studies have been used the learning cycle approach for an important period of time. So, to see the effectiveness of the learning cycle approach on the epistemological beliefs, attitude toward science and understanding of cell concept was the aim of the present study. Learning cycle approach derived from the implementation of Piaget’s constructivist learning theory. The analyses of the theory give a clear understanding of the approach. The theory provides a body of knowledge concerning the intellectual development of students. Central to Piaget’s theory are the concepts of cognitive structure, cognitive functions, and cognitive content. The cognitive structure refers, in most general way, to the stages of development. Cognitive structures are identifiable patterns of physical or mental action that underlie specific acts of intelligence. There are four distinct patterns of intelligent action in Piaget’s theory: sensorimotor, preoperational, concrete operational, formal operational. The factors that maturation, social transmission, experiences and disequilibrium thought to be influenced by movement through stages. The phases of the learning cycle provides the formation of mental functioning (assimilation, accommodation, organization, disequilibrium) of the child. The exploration phase brings about assimilation among students, term introduction designed to promote students’ accommodation of the concept and the application promote students’ organization of the concept into their mental structures. Disequilibrium occurs throughout the phases. As students develop they acquire beliefs, values and attitudes that influence their learning and behavior (Bybee & Sund, 1982).

Furthermore, there were two essential contributions of his theory. First, he has pointed out that concept of learning and the creation of reasoning strategies were active processes for the learner. Teachers should insist on active mental involvement of students in their own learning. Also he has provided the explanations about child development and understanding. To provide learning experiences with students' active involvement but also guidance, teachers may use the learning cycle. Since the phases of learning cycle match the characteristics of child developmental stages which is mentioned in Piaget theory. Fundamentally, his theory tried to explain to the educators that the age and the environment of child identify the learning style and characteristics of them. As a teacher, the lesson organization style should meet with the requirements of child both mental and physical. The first formal use of learning cycle had been seen in an elementary science program called the Science Curriculum Improvement Study in the United States (Science Curriculum Improvement Study Handbook, 1974). Because of the matching characteristics of individual development stages and the requirements of him, the active involvement of the students is needed, so the learning cycle was chosen in this study. It is a learning approach that helps to clarify the relation of learning process and daily life experiences of students and provide the relevance of students' personal and social goals (Marek & Cavallo, 1997). There are three types of learning cycle in the literature-three phases, four phases (4E), five phases (5E) and seven phases (7E). Three phase learning cycle was extended to the five phases (5E) learning cycle and 5E was extended to seven phases (7E) learning cycle. The most common used type of learning cycle was three phase learning cycle including exploration, concept or term introduction and concept application. The first phase, the exploration phase allows learners assimilate the essence of the science concept. In this phase students gather appropriate data through experiences until reaching the disequilibrium state. The second phase, the concept or term introduction guides learners in the interpretation of their data and experiences resulting in reequilibration and the accommodation of the science concept. The third phase, the concept application provides learners with opportunities to relate the newly developed science concept to everyday applications and to other concepts through cognitive process that Piaget called organization (Marek, Laubach & Pedersan, 2003). In the present study, 5E learning cycle was chosen. Because it is the developed version of three phase learning cycle. And the effectiveness of different versions of learning cycle had been proven with many studies (Barman, 1993; Blank, 2000; Cavallo & Laubach, 2001; Colburn & Clough 1997; Lindgren & Bleicher, 2005; Marek & Cavallo; 1997; Marek & Methven, 1991; Odom & Kelly, 2001).

Wilder and Shuttleworth (2005) studied 5E learning cycle on the cell subject. The lesson had been conducted in a high school biology class. A traditional laboratory activity sequence was rearranged to structure inquiry and constructivist learning, so students were motivated to answer questions originating in the stages. The challenge activity in the elaboration stage provides additional motivation for students to apply their knowledge correctly. This 5E sequence automatically structures constructivist inquiry based learning.

In the present study, the effectiveness of the learning cycle approach on the student's attitude toward science had, also, been investigated. The study supported that having a constructivist view in the learning environment makes the views of the learner more positive toward the course (Braund & Reiss, 2006). Also, Gibson and Chase (2002) found that hands-on inquiry based pedagogical approach made science not only enjoyable but also interesting for students. Students stated that it is more engaging to them than sitting and listening to teachers. The present study expected that constructing a learning cycle science class or constructivist science learning environment create positive attitude toward science.

In addition, by saying students' scientific epistemological beliefs, it is mentioned that their beliefs about scientific knowledge and knowing science (Conley, Pintrich, Vekiri & Harrison, 2004). Why we need to develop to improve students' scientific knowledge and knowing science? Smith, Houghton, Maclin and Hennessey (2000) studied with sixth-grade students' epistemologies of science to develop in the light of constructivist pedagogy that puts the primary focus on helping students to understand, test and revise their ideas; stresses the function of the social community in the negotiation of meanings and the growth of knowledge and it gives to students increasing responsibility for directing important aspects of their own inquiry. Results of this study showed that students in the constructivist classroom were centrally aware that the development and modification of ideas about how the world works, and these ideas take work to develop and understand and collaboration is important in all aspects of the process. These findings support that there is a need to improve students' scientific knowledge and knowledge about science. Learning cycle strategy or approach have parallelism with the nature of science (Marek, Gerber, & Cavallo, 1999) The reason to choice learning cycle in classroom applications explained as due to the characteristic of the improvement of students' beliefs about scientific knowledge and knowing science.

The Significance of the Study

The purpose of this research was to investigate the effect of learning cycle approach on students' understanding of cell concepts, students' attitude toward science and students' scientific epistemological beliefs.

In science teaching, there is a change in direction from behaviorist approaches to constructivist, inquiry based approaches. Five E learning cycle is the approach that match with constructivist learning theory. Since science learning and teaching need to be explained by new theories, approaches and methods other than traditional ones which provide inefficient learning and understanding of science.

Nowadays, constructivist learning theory lies behind the new science technology curriculum in Turkey. The instructional methods that inquiry based science teaching and learning cycle that alive form of that philosophy in schools. And the constructivist learning theory tries to answer lots of questions related with the gaps of science teaching and learning. The significance of filling the gaps from the perceptions of the students' understanding and learning of science will going to bring us meaningful learning other than rote learning which is tried to be beared. For this reason some research studies have focused on the effectiveness of the learning cycle teaching model (Barman & Allard, 1993; Marek, Gerber & Cavallo, 1999; Huber & Moore, 2001; Lawson, 2001; Cavallo, Rozman, & Potter, 2004). Also, from epistemological beliefs point of view, Smith, Maclin, Houghton and Hennessey (2000) stated that creating sophisticated epistemologies may contribute to better learning of science content and greater mastery skills of argument. In this sense, creation of more sophisticated epistemologies and the effectiveness of learning cycle model in science content are complementary to each other. It may also contribute to the development of informed citizens who understand the importance of reasoned argument in evaluating competing knowledge claims and who understand that the existence of genuine controversies in science does not undermine the value of scientific process and knowledge. Furthermore, in the literature, there have been some studies that showed positive correlation between development of epistemological beliefs and hands-on, inquiry based instruction. For example, Solomon, Scott and Duveen (1996) showed that hands-on science instruction was related to epistemological awareness. In the study of Herrenkohl, Palinscar, Dewater and Kawasaki (1999) there was an analyses of the hands-on science classroom and inquiry based programs. Inquiry based programs tend to place more emphasis on argumentation and reflection that develop epistemological beliefs. This study had been investigating the effectiveness of the constructivist learning theory from the different perspective. Because, for the correct understanding any theory, there should be evaluation of multiple frames. So, it can be decided that it is beneficial for the usage or not. The present study provides an evaluation of the effectiveness of learning cycle.

As a conclusion, the research questions of the present study concerned the effectiveness of 5E learning cycle approach effect on students' scientific epistemological beliefs, attitude toward science and understanding of cell concept comparing with the traditional approaches. The subject of the present study was cell concept because it is the introduction subjects in the area of biological science. It is going to be used and integrated ever single part of biology concepts. So, it is important to see the answers of the questions when those different aspects taken into consideration for the improvement future science classes.

CHAPTER II

REVIEW OF THE LITERATURE

The Learning Cycle Approach is an inquiry-based teaching model derived from constructivist ideas of the nature of science. Therefore this chapter aims to present a brief review of related literature on the topics that are constructivist learning theory, Piaget's developmental theory, inquiry-based learning approach, learning cycle, attitude and epistemological beliefs of students.

2.1 Constructivist Learning Theory

Since the focus of the present study is to investigate the effectiveness of the learning cycle approach and it is known that the theory base of this approach is constructivist learning theory. It is necessary to give the information about constructivism and constructivist learning for lightning of the minds to provide a better understanding of constructivist learning theory. The two theorists - Piaget and Vygotsky- interpret the constructivism from different perspectives. Deepening of the related theories show that the born of learning cycle approach include a detailed process. Specifically, the described developmental stages of the Piaget's developmental theory which affect the formation of constructivist learning theory provide an understanding of child's thinking and understanding. With this knowledge, the teacher may facilitate learning of child by considering the characteristics of mental structures of that age which specifies availability and the needs of child.

According to Fosnot (1996) constructivism is basically a metaphor for learning, likening the acquisition of knowledge to a process of building or construction. In a similar way, Marek and Cavallo (1997) defined the constructivism that learners must actively formulate or construct understanding for them, based on their experiences. From these different definitions, it can be inferred that for the correct understanding of concepts by learners, the active involvement of learning experience while constructing the knowledge is the main need. Burton, Nino and Hollingsead (2004) explained the characteristics of constructivist classroom. In such a classroom, the learner plays an active role, physically, mentally, and socially. The teacher plays a supporting role through encouragement of students' active participation in the development of their own understanding. It is the teacher who helps the start of interest, connects to previous knowledge, and stimulates students' active and meaningful construction. The use of constructivism as an instructional approach allows all students to gain knowledge in a dynamic and productive manner. Students are placed in control of their learning. Because of the mentioned characteristics of constructivist classroom, Marek and Cavallo (1997) stated that learning cycle approach compatible with a constructivist outlook with a long history in science education.

A range of constructivist theories recognized, from information processing, interactive constructivism, and social constructivism to radical constructivism (Henriques, 1997). At the end of the seventies there was a move in science teaching away from an interest in general aspects linked with pupils' cognitive level towards specific aspects of their knowledge related to the content to be taught. At the same time, divisions were opening up which would lead to the different constructivist currents which we know today (Good, 1993; Matthews, 1994; Geelan, 1997). Among them cognitive constructivism and social constructivism are important for constructivist pedagogy.

As a theory of learning its central claim is that (human) knowledge is acquired through a process of active construction (Fox, 2001). There are two names that come to the minds related with the theories. One is Jean Piaget who was the cognitive constructivist of learning theory and the other is Lev Vygotsky who was the only name related with social constructivist theory. Deepening the understanding of Piaget's and Vygotsky's theories helps the learning and teaching applications of the mentioned theories.

Vygotsky (1978) distinguished between two developmental levels; the level of actual development is the level of development that the learner has already reached, and is the level at which the learner is capable of solving problems independently. The level of potential development (the "zone of proximal development") is the level of development that the learner is capable of reaching under the guidance of teachers or in collaboration with peers. The learner is capable of solving problems and understanding material at the potential development level that they are not capable of solving or understanding at their level of actual development. The level of potential development is the level at which learning takes place. It comprises cognitive structures that are still in the process of maturing, but which can only mature under the guidance of or in collaboration with others. Since the learning cycle was designed to be consistent with the nature of science and to promote collaborative learning and the construction of new ideas. There are implications to the teachers in the classroom called collaborative learning methods which require learners to develop teamwork skills and to see individual learning as essentially related to the success of group learning. The optimal size for group learning is four or five people. For instance, in group investigations, students may be split into groups that are then required to choose and research a topic from a limited area. They are then held responsible for researching the topic and presenting their findings to the class. More generally, collaborative learning should be seen as a process of peer interaction that is mediated and structured by the teacher. Discussion can be promoted by the presentation of specific concepts, problems or scenarios, and is guided by means of effectively directed questions, the introduction and clarification of concepts and information, and references to previously learned material.

Piaget's, Swiss psychologist and epistemologist, experiments with children had a great effect on science teaching in 1960s and 1970s. Piaget's theory was basically cognitive and was essentially a model of intelligence. Piaget (1969) has stated that the basic aim of his work had been "to explain the development of intelligence and to comprehend how from elementary forms of superior levels of intelligence and scientific thinking came about" (Bliss, 1995). The intelligence model of Piaget consists of four components: mental functioning, mental structures, content and developmental stages. Mental functioning: the way in which information processed by individual by means of adaptation and organization. Adaptation was the process of two combined process called assimilation and accommodation. With the assimilation process individuals dealt with an environmental event in terms of their current understanding of the world. And with the accommodation process described as individuals tend to change or adjust their that understanding in response to environmental demands. If there is a balance between these two processes that is needed by adaptation process so there must be equilibrium. And the organization as the name implies that the tendency of all species to order their processes into coherent systems, either physical or psychological (Ginsberg & Opper, 1979), mental structures: were the systems of transformation, content: the sum of knowledge possessed by an individual (Ginsberg & Opper, 1979) and developmental stages: sensori-motor, pre-operational, concrete operational, formal operational are the stages that described by Piaget. At sensory-motor stage, the child had learned that objects were permanent-just because an object disappeared from sight did not mean that it was no longer exist. Language began to develop and the child had learned how to attach sounds to the objects, symbols, experiences. The first signs began to emerge showing that intellect is developed and not spontaneous. At the preoperational stage, children of this stage are confined to making to step-by-step mental replicas of the environment and running off reality sequences in their heads. Preoperational child see, decide and report. Also, a preoperational child can think about signifiers and distinguish them from the objects, events, or situations they signify. Deferred imitation, symbolic play, drawing, mental image, verbal evocation are the characteristics of semiotic (symbolic) functions of this child. Also egocentrism, irreversibility, centering, state in a transformation, transductive reasoning, conservation reasoning are the most prominent traits of this child. At the concrete operational stage (the stage of empirical-inductive and intuitive thought), children use conservation reasoning since they can use the mental operations of thought reversal, de-centering, and seeing states in transformation, and they begin to use deductive and inductive reasoning as opposed to transductive reasoning. In addition to those mental operations, there are other operations in which these children can engage, such as seriating, classification, and correspondence. At the formal operational stage (the stage of hypothetic-deductive thought), the last stage, children has the propositional reasoning level. A proposition says the following: If the assumption or deduction (about such and such) is true, then it follows that such and such is also true; therefore this or that action is deducted or suggested. In other words, thought on this level in the Piaget model had a particular form (Marek & Cavallo, 1997). It is essential to state the movement throughout the stages. The processes of maturation, experience, social transmission and disequilibrium are factors that influence this event. Maturation is the process of growing or maturing. In relation to the increase of intelligence, what has to grow and mature is the nervous system. Experience divided into two: physical experience and logical-mathematical experience. These are influenced to the intellectual development. Social transmission means to pass along what your own society and most common seen as talking: oral language. Disequilibrium occurs when a person is presented with information or an event that does not fit into his mental structures. Confusion, cognitive dissonance and an attempt to fit the data are the processes that can be seen to overcome disequilibrium (Marek &

Cavallo, 1997). The implications of this theory to teaching and learning in terms of teacher role in class explained that the teacher should provide a rich environment for the spontaneous exploration of the child. A classroom that applied to the cognitive constructivist theory filled with interesting things to explore encourages students to become active constructors of their own knowledge (their own schemas) through experiences that encourage assimilation and accommodation. Direct experience, making errors, and looking for solutions are vital for the assimilation and accommodation of information. The theory of cognition upon which the learning cycle is based is a model of this intellectual development. Perry (1999) stated that because knowledge is actively constructed, learning is presented as a process of active discovery. The role of the instructor is not to drill knowledge into students through consistent repetition, or to experience them into learning through carefully employed rewards and punishments. Rather, the role of the teacher is to facilitate discovery by providing the necessary resources and by guiding learners as they attempt to assimilate new knowledge to old and to modify the old to accommodate the new. Teachers must thus take into account the knowledge that the learner currently possesses when deciding how to construct the curriculum and to present, sequence, and structure new material. Constructivist teaching methods aim to assist students in assimilating new information to existing knowledge, and enabling them to make the appropriate modifications to their existing intellectual framework to accommodate that information. Thus, while constructivism allow for the use of "skill and drill" exercises in the memorization of facts, formulae, and lists, they place greater importance on strategies that help students to actively assimilate and accommodate new material. For instance, asking students to explain new material in their own words can assist them in assimilating it by forcing them to re-express the new ideas in their existing vocabulary. Likewise, providing students with sets of questions to structure their reading makes it easier for them to relate it to previous material by highlighting certain parts and to accommodate the new material by providing a clear organizational structure. Because learning is largely self-motivated in the constructivist framework, and according to constructivism, this is the main aim of the learning experience.

Considering the main difference between Piaget and Vygotsky, Piaget saw the learning process of individual as intrapsychological (inside the child) process depending on developmental stages of child and believed that knowledge actively constructed by learners in response to interactions with environmental stimuli. However, Vygotsky saw the learning process of individual as both interpsychological (between people) and intrapsychological (inside the child) process depending on the cognitive development of language and culture of individual.

To sum up, in their theories, Piaget and Vygotsky tried to provide the matching characteristics of the nature of learner and learning and understanding styles of learners.

2.2 Inquiry-Based Learning Approach

In its nature, learning cycle approach heavily includes inquiry-based learning approach. Lindgren and Bleicher (2005) stated that learning cycle approach was an early inquiry oriented science teaching strategy. And, it is the form of classroom usage of constructivism. The nature of the theory brings the making of inquiry to deliver the needed knowledge. The process of inquiry is unique to its definition and has some steps for the attainment of it.

Marek and Cavallo (1997) stated that inquiry may be described as a search for information, a quest for knowledge, or an exploration of certain phenomena. Every description of inquiry includes the following: 1) active questioning and investigating, 2) acquiring new knowledge, 3) observing and manipulating (mentally or physically) objects, phenomena, and/or nature. Scientists and educators have written for many years about the need to involve children in our schools in scientific inquiry. The main reason for this is that children should have experiences with objects, phenomena, and/or nature that raise questions that begin a process of inquiry. The children must use their minds to explain their observations and experiences for themselves. In addition to this, inquiry is a process that all individuals naturally use in approaching new situations and solving problems in life. By engaging in inquiry, the children gain the experience with the mental activities that will improve their capacity to handle life situations and solve everyday problems. These mental activities include the use of the rational powers of the mind. The rational powers of the mind are recalling, comparing, inferring, generalizing, deducing, classifying, analyzing, imagining, synthesizing, and evaluating. Also, inquiry can be used by individuals not only in learning science but in thinking about matters of interest in everyday life (American Association for the Advancement of Science, 1990).

National Research Council (1996) in the United States defined the Standards for “full inquiry” that engaged in students as a learning process a) pose a productive question; b) design an investigation directed toward answering that question; c) carry-out the investigation, gathering the applicable data in the process; d) interpret and document their findings; e) publish or present their findings in an open forum.

The use of inquiry can be explained by defining the characteristics of science. It should be fit to the characteristics science and identifying them is necessary. In the study of Wenk (1999), two important characteristics of science were described. One is that there is uncertainty in scientific knowledge. Scientific ideas, theories, principles, and laws are explorations from observations. Since the observations are open to changes depending on time, location and individual. Also, they are subject to impression, error and doubt even if the observations were done most carefully and systematically (Feynman, 1998). The uncertainty characteristics of scientific knowledge are a limitation of the subject content, but it is not fatal drawback. Richard Feynman, a renowned physicist and philosopher of science, says that the doubt inherent in scientific knowledge is of value. He states:

> ...If we did not have a doubt or recognize ignorance, we would not get any new ideas. There would be nothing worth checking, because we would know what is true. So what we call scientific knowledge today is a body of statements of varying degrees of certainty. Some of them are most unsure; some of them are nearly sure; but none is absolutely certain... Doubt is not to be feared...it is to be welcomed as the possibility of a new potential for human beings (p. 27).

A second characteristic of science that becomes clear by engaging in inquiry is that the scientific method is a complex, nonlinear process. In doing science, a scientist goes through iterative cycles of observation, generation of hypothesis, testing evaluation of results, and the making of decision-judgments. By attempting to learn science by merely looking at the results of scientific inquiry and argumentation, one does not have the same opportunities to weigh evidence and consider alternatives-process that are at the core of science. In 1916, John Dewey wrote importance of the conflict in stimulating reflective thought. He said that they had reached the point of conflict in the matters of an experience. It is in this conflict and because of it that the matters, or significant (properties), stand out as matters. As long as the sun revolves about the earth without question, this ‘content’ is not in any way abstracted. Its distinction from the form or mode of experience as its matter is the work of reflection. The same conflict makes other experiences assume discriminated objectification; they, too, cease to be ways of living, and become distinct objects observation and consideration.

From these studies, it can be inferred that teaching science via inquiry, then, fits more closely with the nature of science itself in terms of the development of students' critical thinking, concept understanding, scientific reasoning abilities (Lawson, Abraham, & Renner, 1989)

2.3 Learning Cycle

In this part of the literature, the learning cycle approach tried to be defined from its birth to this time including the studies which related to the classroom applications of it both abroad and in Turkey, also pre-service teachers' experiences related with the learning cycle.

Piaget's developmental theory of cognition upon which the learning cycle is based is a model of intellectual development (Renner & Marek, 1988). Besides, Lavoie (1999) stated that learning cycle discussions satisfies the relation of one of Piaget's essential components of learning, 'social transmission' and extends Vygotksky's zone of proximal development. In the discussions of learning cycle, there was a name, need to be implied for explanation of the origin of this approach, called Robert Karplus who is the father of this model, explains that teaching of science requires more than content. Teaching requires a plan derived from both the discipline of science and the manner in which students learn. Karplus stated that the teaching procedure that was intended to satisfy those requirements called the learning cycle (Marek & Cavallo, 1997). In United States of America, National Science Education Standards had changed and announced the science education standards that concerning the characteristics of learning cycle, an inquiry-based instructional approach (National Research Council, 1996).

Explaining the development and types of learning cycle from its birth to adulthood days, in a chronological order, provide the clear understanding about it. The origins of the learning cycle can be traced back to 1959 when Robert Karplus who was a professor of physic at the University of Berkeley, began to teach science to elementary school children (Lawson, 2004). Afterthat, Atkin and Karplus (1962) developed a science teaching method they called guided discovery. At the beginning Atkin and Karplus described two phases, Invention and Discovery, in their method according to the way they believed scientist performed their work. Invention referred to the way scientists invented new terms or concepts to explain new phenomena they were studying, and discovery means that testing the invented concepts in new situations to confirm their usefulness. Karplus and Thier (1967), working on the Science Curriculum Improvement Studies (SCIS), added a third phase, *exploration*, to the teaching approach. They said that exploration must precede invention and discovery because young students could explore and experiment in order to allow more time for new concepts and insights to interact with their own initial conceptions. This was completely opposite to the traditional science teaching methods which Einstein simply briefing the procedure as The Inform-Verify-Practice (IVP) Procedure. The first use of the term learning cycle was met in the early 1970s in the academic world with the studies of Science Curriculum Improvement Studies and SCIS curriculum materials ruled as guidance for the teachers. In 1977, Karplus modified the names (Invention, Discovery and Exploration) of the phases of the teaching method to clarify their intentions for elementary teachers.

In the exploration phase of the learning cycle allows learners to assimilate the essence of science concept. In other words, the first steps toward developing concept understanding are to gather pertinent data through direct experiences and to do so until disequilibriated. The concept introduction phase is designed to guide learners in the interpretation of their data and experiences resulting reequilibration and the accommodation of the science concept. The concept application phase of the learning cycle provides learners with opportunities to relate the newly developed science concept to everyday applications and to other concepts through a cognitive process Piaget called organization (Lawson, 1995).

After the explanation of the phases of learning cycle, three different types of it were defined. Lawson (2001) stated that the three types of learning cycles in terms of their three different categories; descriptive, empirical-abductive and hypothetical-predictive. The difference comes from the degree to which students either gather data in a descriptive fashion, or initially set out to test alternative causal hypothesis. During descriptive learning cycles, students discover and describe an empirical pattern within a specific context (exploration). The teacher gives it a name (term introduction), and the pattern is then identified in additional context (concept application). This type of learning cycle is called descriptive because students describe what they observe without explaining their observations. Descriptive learning cycles answer the "What" question, but do not raise the causal "Why" question. During empirical-abductive learning cycles, students again discover and describe an empirical pattern (exploration), but they proceed further by generating possible causes (alternative causal hypothesis) for the pattern (term introduction). This requires the use of abduction (analogical reasoning). With the teacher's guidance, the students then sift through the data gathered during exploration to see if the hypothesis were consistent with those data and with other known phenomena (application). In other words, descriptive observations are made. But this type of learning cycle goes further to generate and initially test causal hypotheses, hence the name empirical-abductive. The third type of learning cycle, hypothetical-predictive, is initiated by raising a causal question, to which students then generate alternative causal hypothesis. Student time is devoted to designing tests of their hypotheses complete with explicitly stated predictions, and carrying out those tests (exploration). The analysis of observed results then allows for some terms to be introduced (term introduction). Finally the relevant concepts and reasoning patterns may be applied in other contexts (application).

Three phases type of learning cycle was developed to five phases type of learning cycle which called as 5E learning cycle. Bybee (1997) stated the successive steps of the 5E learning cycle as engagement, exploration, explanation, elaboration, and evaluation. Engagement step promotes interest and motivation. Its purpose is to capture children’s imagination. The implementation of this phase is successful if student appear puzzled and are actively motivated to inquire learning. In the exploration stage, teachers should give to students common, practical experiences, allowing them to build on their developing concepts and skills. These experiences can be used in subsequent steps to formally introduce scientific conceptions and language. Students are effectively exploring ideas including their ideas. In the explanation stage, teachers should give to students the opportunity to explain their findings to others. Students must give their explanations first with the teacher subsequently introducing relevant scientific explanations. These explanations need to be clearly linked to the engagement and exploration activities and student explanations. Essentially students are provided with a learning environment that encourages them to explain their ideas and understandings. In the elaboration stage, teachers should give to the students the opportunity to extend their knowledge of concepts to other contexts. Students have a tendency to associate concepts with specific situations, and are often unable to identify relationships in different circumstances. This phase is vital in developing more general views of phenomena, as children identify similarities in different contexts. Students apply their new understandings to different contexts in a problem solving environment. In last phase, evaluation, students’ understanding may be assessed more formally. Students are also encouraged to question their own conceptions (Boddy, Watson, & Aubusson , 2003)

Also, there was a study related with 7Es which was the developed version of 5Es. In Eisenkraft (2003) study, the proposed Seven Es model expanded the engage element into two components; elicit and engage. The two stages of elaborate and evaluate were developed to the three components; elaborate, evaluate and extend. These changes were not suggested to add complexity but rather to ensure instructors that do not skip out the important elements for learning from the lessons while under the incorrect assumptions they were meeting the requirements of learning cycle.

There were studies related with the application of learning cycle to the science course. These studies were analyzed the effectiveness of learning cycle applications.

Abraham and Renner (1986) and Renner, Abraham and Birnie (1985; 1988) conducted large scale studies with high school chemistry and physics students investigated the roles which played by each phase of the learning cycle by systematically eliminating a phase and by varying the phase sequences. From these studies five conclusions were drawn; all three phases are necessary for the concept learning, students prefer learning cycles with all three phases, students dislike learning cycles with long and/or complex application phases, the combination of exploration and term introduction phases is more effective than term introduction alone, the application phase may substitute for term introduction if the application includes the use of the term(s) used to refer concept(s).

Barman (1992) described the evaluation of a technique that introduces elementary science methods students to the learning cycle and provides them with a mechanism for using this strategy with current elementary science textbooks. In this study, the learning cycle consist of three distinct phases: a) exploration, b) concept introduction, and c) concept application. Before the learning cycle introduction, elementary science methods students are involved in a variety of hands-on science activities that gave an opportunity to practice and evaluate their questioning techniques, and information regarding current learning theories and how they apply to teaching science. After the students had experienced several learning cycle lessons, they were asked to analyze a chapter of an elementary science textbook to determine whether its lessons follow the learning cycle format. Afterthat, to determine whether the students would apply the learning cycle to their future teaching experiences, follow-up telephone interviews were conducted. For pre-service teachers to successfully use the learning cycle, the evaluation results suggest that they need several opportunities to work through elementary science lessons that follow this approach and that they need practice in developing, using, and evaluating learning cycle lessons.

Guzetti, Taylor, Glass and Gamas (1993) conducted a meta-analysis of 47 learning cycle based studies and found effectiveness in favor of the learning cycle students. Benford (2001) found that the extent of college student’s reasoning improvements was significantly related to the instructors’ skills at engaging students in the learning cycle based inquiries.

Another study conducted by Lawson (2001) for the application of the three phase learning cycle method of teaching in the context of biology instruction investigated the reason for the usage of learning cycle. According to Lawson (2001) learning new concepts is not a purely abstractive process, and concept learning depends in part on one’s ability to generate and test ideas and rejected those that lead to contradictions. So, concept learning can be characterized as ‘constructive’, a new conceptual knowledge depends on the part upon skill in generating and testing ideas. Secondly, this study implied the using of reasoning to construct concept; if instruction is more open-ended, then considerable opportunity exists for students to use and improve their reasoning skills while exploring nature and using If/then/therefore reasoning to test their ideas and those of others. Thirdly, the essential elements of instruction were identified for the improvement of both declarative and procedural knowledge. There should be some elements in the learning cycle. The first one, questions should be raised, or problems posed that require students to generate predictions based on prior beliefs (concepts and conceptual systems) and/or prior procedures. The second one, those predictions or procedures then lead to results that are ambiguous and/or contradicted. This forces students to argue and to reflect on the prior beliefs and/or procedures. The third one, alternative beliefs and/or more effective procedures can be suggested. The fourth one and the last, alternative beliefs and/or the more effective procedures should now be utilized to generate new predications and new data that allow either the change of old beliefs and/or the construction of new beliefs (concepts).

Cavallo, McNeely, and Marek (2003) examined ninth-grade students' explanations of chemical reactions using two forms of open-ended essay questions during a three phase learning cycle instruction. Sixty ninth-grade physical science students from four different classes involved in the study. Two classes were evaluated using open-ended questions without key terms and the other two classes were evaluated using the same open-ended test questions with key terms. Three tests were administered to students giving as much as time as needed. In the study area, all teachers used learning cycle teaching procedure and associated curriculum in grades K through 12, and they were prepared to teach the learning cycle. In addition, all teachers in the elementary schools used most updated version of the Science Curriculum Improvement Study (SCIS-3, 1992) and all teachers in the secondary schools used the learning cycle curriculum titled, Investigations in Natural Science (1986, 1997). So, the expected thing is that all students in this area are used to study learning cycle courses and evaluations. Results showed that more misunderstandings were elicited by the use of key terms as compared to the non-use of key terms, significant positive shifts in students' understanding over the learning cycle, and lastly differences in gender were observed. Females showed equal or greater understanding compared to males.

Lee (2003) studied plant nutrition by using three phase learning cycle (exploration, concept development and application). In this investigation, students' understanding of plant nutrition was studied by using guided inquiry learning cycle. It can be adapted across several grade levels from middle school life science to introductory college classes. The materials can be found even in minimally equipped biology classrooms and laboratories. The importance of the reason of studying plant nutrition comes from its direct relationship with the study of human nutrition and historically of less interest to adolescents and young adults in secondary and post-secondary biology classes. In this plant nutrition learning cycle lesson, the first phase of a learning cycle allowed students to mentally explore ideas through brainstorming to identify what they currently know and ask questions. During exploration the experiment was designed and data were collected, summarized, and initially analyzed. At this point ideas shared with peers leading to concept development that the phase required teacher facilitation. After concepts were formed, necessary biological terminology was provided and the students were set to use their new ideas in the application phase. This phase of the learning cycle best promotes learning if it was both relevant and meaningful to the students' lives. At the end of concept development, formative assessment made and at the end of the lesson, summative assessment made by teacher. Students can construct concept map of plant nutrients and their effects on plants. Also, students involved in the collaborative work as a pair, small group or even through the entire class. The lesson gave better understanding of the plant nutrition concepts and provides direct relations to daily life experiences about plants.

Also Cavallo (2005) studied learning cycle on the subject of plants and asked the questions to frame her research. Some of them were that children notice seeds and plants everyday, but do they really understand what seeds are and how they are related to plants?, have they ever observed what inside a seed when it grows?, what do plants need to grow, and what do they need to stay healthy? Three related learning cycles were conducted that they were exploring seeds, germinating seeds and monitoring plant growth, and devising plant experiments. Third-grade students answered mentioned questions above about plant growth and discover that new seeds were made from the plants they grow. The measurement of the student learning can be made throughout each phase (exploration, concept invention and concept application) of the learning cycle by reviewing and evaluating the data and notes written in students' seed book for understanding and accuracy, including concept understanding, data collection and measurement techniques, mathematical representation of data, and skill in areas of language arts. Presentations, teamwork performances and group contributions were the evaluation types of students. Beside those, students may rewrite and publish their seeds books at the end of the unit. With these studies, students were constructed a strong foundation for learning more complex topics about plants as they progress to higher grades and they had new awareness and understanding of seeds and plant life that exist in the world around them. The learning cycle was provided a better understanding about plant concepts.

Lauer (2003) studied the subject ecology by using three phase learning cycle (exploration, term introduction, concept application). The reason for the choice of ecology as a subject is its richness in terms and technical jargon that seems difficult to students. Most introductory ecology textbooks include glossary of terms but simply listing definitions usually fails to conceptualize the true meaning of a term. In this study, games and simulations were used to help students to learn the related terms such as organism designation, organism type, the concept of fitness, population densities. Classroom games help the lightening of students in two different ways. The one is to promote the understanding and comprehension of particular terms and the other is to break up the monotony and drudgery of a long lecture, as both students and instructors respond positively to multiple teaching strategies. There were three examples in the article related with learning cycle preparation: physiological ecology, population ecology, ecosystem ecology. In the exploration phase, students explored new scientific objectives, concepts and ideas. This initiation was followed by the term introduction phase, where were organized and analyzed, and terms used to describe/define the science were introduced. The last phase was the concept application phase, where students were deepen their understanding of the subject by extending it into a new context. In these three phases, games/simulation was used to achieve the defined objectives. The methods that used in these examples were not formally evaluated in class, but anecdotal assessment using test scores and student responses had been positive. Also, students remember these games and simulations, and learn without perceived effort. This is inspiring from the point of view of instructor.

McCarty (2005) developed the learning cycle lesson for Newton's first law of motion. Learning cycle of this lesson successively include elicitation phase, exploration phase, invention phase, application phase, and finally extensions. This learning cycle helped to abandon student's misconception and then form and remember the concepts that introduced. Students showed keen interest to engage in all the activities and eager to continue their investigations.

Odom and Kelly (2000) performed a different research that they tried to analyze the effectiveness of concept mapping, expository instruction, concept mapping/learning cycle and the learning cycle in promoting understanding of diffusion and osmosis in high school biology. Researchers believed that a combined lesson with concept mapping and learning cycle in osmosis and diffusion content will provide a more complete framework for knowing than concept mapping, learning cycle, or expository instruction alone. Logical Reasoning Test (LRT) (Popejoy & Burney, 1990) and Diffusion and Osmosis Diagnostic Test (Odom & Settlage, 1994) were administered to a total of 108 secondary students (grades 10-11) that enrolled in four different sections of college preparatory biology. The first treatment integrated concept mapping and expository teaching and the second treatment integrated learning cycle and concept mapping/learning cycle. In this study the used learning cycle has three phases; exploration, concept introduction, and application. The results seem to suggest that both the concept mapping/learning cycle and concept mapping strategies enhance some aspects of learning of diffusion and osmosis concepts more effectively than expository teaching. However, the two treatments (concept mapping and concept mapping/learning cycle) were not significantly different than the learning cycle treatment. Each methodology has its strengths and has contributed significantly to improving science achievement, the promotion of the learner, and the promotion of the facilitative role of the teacher. As a result, it can be said that it is very important that teachers' use of a single methodology, either learning cycle or concept mapping alone without the other, provides the learner with only a partial framework of knowing.

Boddy, Watson, and Aubusson, (2003) was focused on the relationship between teaching and learning addressing the gap between a constructivist learning theory and its practice in class. The study was conducted with ten students who provided two main sources of data that are interviews and video footage of the lessons. The Making and Marketing Products unit of work was developed, based on 5E learning cycle approach, and taught to a year 3 class. The Making and Marketing Products unit was taught as part of the class's normal curriculum. The teaching/learning sequence for the unit of work followed the 5E learning cycle approach. Teacher's field notes were used as supporting anecdotal data. The findings fall into three category. The first was the phenomenographical analysis of the interviews and model, promoted learning. The second is an analysis of both the interviews and videotapes to determine how effective the 5E learning cycle approach was in promoting learning, if this was shown to be the case. The third section compares the interview and videotape findings to establish the validity of the overall findings. From the evaluations of these findings, this study showed that the unit of work, based on the 5E learning cycle approach, can be used successfully to implement a constructivist view of teaching in the primary school classroom. Students found funny and interesting and were motivated to learn while others said they were interested and motivated because they were learning. Also, the unit of work, based on the 5E learning cycle approach, promoted higher-order thinking because each student demonstrated a greater percentage of higher-order thinking than lower-order thinking. However, it can be inferred that such an approach is the best way to implement a constructivist (socio-, neo-Piagetian) view of teaching and learning but that it has been demonstrated to be a successful referent for a novice teacher.

Wilder and Shuttleworth (2005) focused on the important question that explained science teachers condition while planning their lesson with inquiry: how do I balance helping my students learn all the content they are required to know while providing them opportunities for inquiry? Five Es learning cycle approach is an effective and realistic way to explore the answer of the research question. This learning cycle lesson prepared for the cell subject and applied to ninth grade high school Biology I students. The lesson addressed the National Science Education Standards in the United States (NRC, 1996) in two areas: teaching and content. By using the cell learning cycle lesson, students were more engaged and motivated than traditional cell lesson and also showed eagerness to answer questions that faced with in all stages. This Five Es sequence automatically structures constructivist, inquiry-based learning while addressing content required by high school students.

Although most of the learning cycle studies were specifically related with science, there was a study related with learning cycle application in social science classroom. Bevevino, Dengel, and Adams (1999) conducted their study in the social lesson class. The issue of conflict, specifically in the context of World War I; the problems and conditions leading to war, alternatives to armed conflict which was planned by students by using three phase learning cycle (exploration, discussion and presentation of new content, application and expansion). In the explanation phase, students address a problem, make hypothesis and predict solutions. In the phase of discussion and presentation of new content, student and the teacher discuss the results of phase 1; the teacher introduces new concepts through a mini lecture. In the last phase, students use knowledge gained from phases 1 and 2 to address a new problem. The learning cycle ends with the whole class coming to a consensus as to the best solutions offered. As a conclusion, inquiry lessons that encourage students to develop their own frames of thought are complicated and time consuming to plan but extremely effective in the classroom. Also, learning becomes a more personally interesting and deeply internalized experience.

There were some studies that used the learning cycle as a model of teaching in the pre-service science teachers education to make their job easy in classroom applications. Settlagh (1999) studied with pre-service elementary school teachers to deepen their understanding about the learning cycle so they can enlarge their teaching repertoire. For this study, researcher investigated the answers of the following questions: Does a pre-service teacher's disposition toward science as a subject area contribute to an ability to comprehend learning cycle? Does a pre-service teacher's perceived effectiveness as a future science teacher predict how well he or she will grasp the nuances of the learning cycle? Does the pre-service teacher's confidence in their potential to affect the children's learning relate to their capacity to understand this instructional approach? The results showed that the relationship between the attitudes toward science and self efficacy were worth noting. There were two important studies conducted by Enochs, Scharmann, and Riggs, (1995) and Woolfolk, Rosof, and Hoy, (1990). Enochs et al., found that pre-service teachers with more child centered, activity-based orientations toward science teaching have greater confidence in their future science teaching effectiveness and the second study conducted by Woolfolk et al., (1990) stated that practicing teachers with higher efficacy have a more humanistic orientation toward behavior management and are more supportive of independent problem solving by students. It can be inferred that the pre-service teachers who gained mentioned characteristics (child centered, activity based orientations, etc.,) showed more tendency to apply learning cycle in classroom since those characteristics matched with nature of learning cycle applications.

Another study conducted by Lindgren and Bleicher (2005) examined the difficulties and factors that led to understanding the learning cycle strategy. The Learning Cycle Test (Odom & Settlage, 1996) was administered to 83 pre-service elementary teachers to observe the change in students understanding of the learning cycle. For this test, Marek, Laubach, and Pedersan (2003) state that the Learning Cycle test proved to be a useful tool for measuring some aspects of our pre-service teachers' understandings and misunderstandings of the learning cycle" (p.156) An example item can be given from the test as follows: "Which teaching behavior is appropriate during the first phase of the learning cycle?". Beside this test, there were additional studies conducted during the semester, and students were periodically asked to self-rate their confidence to learn science and to teach science on a scale of 1-5, with 5 being the high end of the scale. Results showed that there was a significant increase in participants' understanding of the learning cycle. However, this increase was not even across the four student categories. In this study students were separated into four categories successful, enthusiastic, disinterested, fearfulness. The four categories of students responded differently to their experiences learning about the learning cycle, and some of the themes were associated with different categories of students. The first one was changing mindset related to pre-service teachers' acceptance of the learning cycle, was the notion of "changing mindset". It became associated with the successful and enthusiast groups. The second theme was "we do not want to teach as we were taught". Disinterested science learners had disliked school science and found science boring. They seemed eager for a different method that was unlike what they had found so uninspiring, at best. The third theme was "multiple exposure and practical experience". One modeling of the learning cycle was insufficient, no matter how compelling the learning cycle plan. The learning cycle did not make perfect sense to many students in their early exposure to it even successful students. The theme was "exploration key to engagement". In the learning cycle there is opportunity to explore, discover, investigate, and act like a scientist during the exploration phase. Many of the successful and enthusiast students initially found this way of teaching confusing, primarily because one investigates a concept before one learns what the concept might be. However, in general, modeling and engaging elementary pre-service teachers in learning science concepts through at least three learning cycles was necessary to assist them developing a deeper understanding of the strategy and its connections to inquiry.

In Turkey, there were some studies related with the effectiveness of the learning cycle. For example, Ates (2005) focused on teaching direct currents (DC) circuits to university students, and gender differences. Three phase of learning cycle used in this study including exploration, term introduction, and concept application. Four Physics classes participated in the study, randomly assigned into one of the two treatment groups as experimental and control. While the experimental group taken the course using the learning cycle and the control group with traditional method. Determining and Interpreting Resistive

Electric Circuits Concept Test (DIRECT) was used to evaluate students' understanding of a variety of resistive DC circuit concepts. Results indicated that the learning cycle treatment group significantly outperformed the traditional treatment group in understanding key aspects and concepts about DC circuits. During the learning cycle, students learned through their own actions and reactions by being involved in hands-on activities. And the result related with gender showed that females performing physic lesson as well as males under the learning cycle based instructional approach. Usage of experiments and hands-on activities may lead to more equivalent performance to male and females that learning cycle application promote better learning and also gender equity in physics classes.

Balcı (2005) investigated eight grade students' misconceptions about photosynthesis and respiration in plants by using 5E learning cycle based instruction and conceptual change text based instruction to improve students' understanding of photosynthesis and respiration in plants. The results of the study showed that 5E-LCBI and conceptual change text based instruction caused a significantly better acquisition of scientific conceptions related to photosynthesis and respiration in plants than traditional instruction. Furthermore, reasoning abilities of students had significant contribution on the understanding of those studied subjects in the 5E-LCBI and conceptual change text classes.

Atay (2006) investigated the relationship among eight grade school students' cognitive variables (prior knowledge, learning approaches, reasoning abilities) and motivational variables (self-efficacy, locus of control and attitude toward science) in relation to students' achievement in genetics in learning cycle classrooms and in traditional classrooms. The results of the study revealed that learning cycle instruction improved students' achievement in genetics compared to traditional instruction.

All these studies have met in a common denominator that the effectiveness of the learning cycle lessons. Beside its effectiveness, it helps the increasing students' motivation and active participation of them. The planning part takes time when comparing traditional expository lesson.

2.4 Attitude toward Science

The present study also concerned with the effectiveness of learning cycle approach on students' attitude toward science in comparison with a traditional instruction.

A large and diverse body of research has accumulated over the last three decades concerning the importance of various attitudes towards science and the relationship between these attitudes and understanding of science or science achievement. Papanastasiou and Zembylas (2002) defined the attitude as the favorable or unfavorable response to things, places, people, events or ideas. Therefore, attitude toward science can be described as favorable or unfavorable response to science. Osborne, Simon, and Collins (2003) stated a range of components in the measures of attitudes to science includes;

- the perception of science teacher;
- anxiety toward science;
- the value of science;
- self-esteem at science;
- motivation towards science;
- enjoyment of science;
- attitudes of peers and friends toward science;
- attitudes of parents towards science;
- the nature of the classroom environment;

- achievement in science;
- fear of failure in course.

The present study searches for the effective method of teaching for the improvement and implementation of the instructional method for future science classroom. If the science education seems meaningful to the students meaning that they can achieve meaningful learning, it is expected that they develop positive attitude toward science. Or, they will choose to make science in their future life other than leaving from it. Many of the research suggest that there are lots of reasons for the leaving of science. The important variables on attitudes toward science include achievement motivation, science self-concept, science anxiety and science activities (Haladyna & Shaughenessey, 1982; Talton & Simpson, 1986). The researchers show that there was a positive correlation between student's self perceptions and learning outcomes which affected attitude toward science either positively or negatively (Kremer & Walber, 1981; Simpson & Troost, 1982). Another important variable on attitude toward science is teacher influences. Since teacher play primary role in the students' learning process. Some researchers have emphasized the relative influences of teacher as well as learning environment on student attitudes toward science (Haladyna & Shaughnnesy, 1982; Wright & Haunshell, 1981). Teacher quality variables such as the academic preparation of the teacher in the specific field of science, science teaching practices (Ebenezer & Zoller, 1993), hands-on activities, cooperative learning, and student involvement in learning influence student attitudes (Druva & Anderson, 1983; Haladyna, Olsen, & Shaughnnesy, 1982 ; Myers & Fout, 1992). Research has consistently showed that individual interest in science is very important for learning science (Hoffman & Haussler, 1968). Also, unless students are able to see the utility of science in their daily lives, they will become disinterested in science. So the issue is that the instructional method makes familiar the science concepts with the daily life experiences. Papanastasiou and Zembylas (2002) investigated the locality of relationship between attitude toward science, self beliefs and science achievement for senior high school students and found differential effects in the relationship between science related attitude and achievement.

2.5 Epistemological Beliefs

The present study concerned about the effects of 5E learning cycle approach on students' scientific epistemological beliefs. So, in the last part of the literature the epistemological beliefs have been reviewed. Firstly, earliest beginnings of epistemological beliefs and research on students' personal epistemology that examines the nature of development and change in how students think about knowledge and knowing reviewed. Afterthat, the studies that provided combined investigations about students' epistemological beliefs, the learning cycle and inquiry based teaching approaches to see the effect of Piaget's developmental theory on whether there is a development of students' understanding about the topics that taught in class and development of students' epistemological beliefs or not was the focus.

The development of epistemological beliefs is necessary to provide the awareness of nature of knowledge or knowing. Because having constructivist-oriented scientific epistemological views could be an important pre-requisite for implementing so called constructivist based teaching strategies (Tsai, 1999) and backing to the Jean Piaget who was an epistemologist regarded empirical studies of infants, children, and adolescents as an essential source of information about the nature of knowledge emphasized the development of it. According to his developmental theory of knowledge or named as genetic epistemology (Piaget, 1976), there were some essentials of knowledge such as:

- knowledge has a biological function, and arises out of action,
- knowledge is basically "operative", it is about change and transformation,
- knowledge consist of cognitive structures, development proceeds by the assimilation of the environment to these structures, and the accommodation of these structures to the environment. Movement to the higher levels of development depends on reflecting abstraction meaning that coming to know properties of one's own actions, or coming to know the ways in which they are coordinated.

Explaining the characteristics of knowledge, the next step is to provide the studies about one’s beliefs and nature of knowledge named as personal epistemology. Empirical evidence demonstrating the role of epistemological beliefs in learning can be traced back to the pioneering work of Piaget (1950) and Perry (1970). The study of personal epistemology began with the Willam Perry, Jr. (1968) hypothesized nine developmental positions that served as the path from being dualistic thinker in early college years to being a committed relativistic thinker at the end of the four year college experience. Perry (1970) worked from psychological perspective and studied with college students and their changing ideas of the source and certainty of knowledge, and implications of those changes on their learning strategies. This study was highly influential and initiated a line of research that set about developing Piagetian stage theories of epistemological development. After Perry’s work (1968; 1970) some researchers had started to study the conception of epistemology. Kitchener and King (1981) developed the epistemological conception of reflective judgment meaning that an individual judges the quality of knowledge is based on the source and certainty of knowledge. The researchers had studied with the college students and adults who progressed through seven developmental stages of reflective judgment that range from unquestioning acceptance of knowledge to tentative acceptance of knowledge after critical thinking. Schoenfeld (1983) studied the mathematical epistemological beliefs of high school students found that the students believe mathematicians born with the ability to do mathematics. Dweck and Legget (1988) studied with the middle school students beliefs about intelligence. Some of the students believe that intelligence is fixed and that the ability to learn is determined at birth and those students displayed helpless behavior in the face of difficult academic task. Other students believe intelligence is incremental that the ability to learn can improve over time and experience and those students persisted in effort also varied their study strategies when faced with a difficult task. As expected, incremental intelligence believers outperformed fixed ability believers. Belenky, Clinchy, Goldberger and Tarule (1986) refined Perry's research by focusing on women's ways of knowing, particularly women's assumptions about knowledge, reality and authority and developed a model of epistemological beliefs based on women's perspective. They proposed that epistemological beliefs need to take into consideration other than those of certainty and source of knowledge.

Schommer (1990) proposed a relation between epistemological beliefs and numerous aspects of learning implying that it was more than justification of argument and comprehension monitoring. She stated that the dimensions of epistemological beliefs varied in content and elaboration from researcher to researcher, all of these characterizations represented personal epistemology as uni-dimensional that conceiving them may fail to capture the complexity of personal epistemology and may mask the multiple links between personal epistemology and different aspects of learning. For this reason epistemological beliefs should reconceived as a system of more or less independent beliefs meaning that there is more than one belief to consider and individuals may be sophisticated in some beliefs while not necessarily sophisticated in other beliefs. With this conceptualization, epistemological beliefs can be studied individually or in various combinations. Again, Schommer (1994) stated that researches on personal epistemology interested in what individuals believe about the source, certainty, and, organization of knowledge, as well as the control and the speed of learning. Epistemological beliefs have been found to relate to reading comprehension, learning in complex and ill-structured domains, as well as learners' active participation and persistence in learning. Furthermore, epistemological beliefs play a subtle, yet critical role in learning. For this reason, the development of deep understanding of nature of these beliefs is important. Furthermore, Schommer-Aikins (2004) attempted to predict the interrelationship between beliefs about knowledge and beliefs about learning proposing a model. Furthermore, this model considers how epistemological beliefs influence other systems such as classroom performance and self-regulated learning.

Hofer and Pintrich (1997) defined personal epistemology which refers to beliefs that individuals hold about knowledge; what knowledge is and how knowledge is justified. Such epistemological premises are a component of the cognitive process of thinking and reasoning. Currently there are a number of theoretical models of personal epistemology that comprise common structural dimensions. While varying across models, four structural dimensions relating to the nature of knowledge and the process of knowing can be considered the core of individuals' beliefs. How one conceptualizes knowledge, and how this change over time, underline most epistemological models.

In the study of Hofer (2002) drew the frame of the personal epistemology by asking some questions such as how will you evaluate and assess the veracity of what you read and hear?, whose authority will you accept and why?, what evidence will you decide is acceptable justification for particular recommended choices of action?, how certain are you that what you read is true or supportable or believed?, how will you reconcile your own experience with those of experts?, when do you decide that you know enough and that you understanding is adequate? The answers of these questions define one's personal theory of knowledge in other words personal epistemology. And it is need to be modeled to clarify the understanding of it. So with the help of an integrated model about personal epistemology, it would a) establish common ground among seemingly disparate conceptions to paradigmatic approach, b) aid in defining the construct, c) explain development not describe it, d) provide a mechanism of change, e) examine complex relationships such as the relationship between domain generality and specificity, f) situate us within cognitive development, g) value and incorporate affect, h) give direction to researchers such as in the promotion of theory testing, and i) inform and guide educational pursuits such as day-to-day classroom practices. Also, Hofer (2004) gave a short description of personal epistemology as a cognitive developmental process or as a system of beliefs or a multidimensional set of interrelated beliefs about knowledge and knowing. In her study, she stated that the models include reference to dimensions in two main areas: the nature of knowledge (what one believes knowledge is) and the nature or process of knowing (how one comes to know). Within nature of knowledge are the dimensions certainty of knowledge and simplicity of knowledge, and within the area of nature of knowing are the dimensions source of knowledge and justification for knowing. They can be described as follows;

- Certainty of knowledge: The degree to which one views knowledge as certain is an aspect of personal epistemology across multiple schemes.

- Simplicity of knowledge: At lower levels knowledge is viewed as discrete, knowable facts, and at higher levels, individuals see knowledge as relative, contingent, and contextual.

- Source of knowledge: An aspect of nature of knowing, this dimension refers to the locus of knowledge, perceived as originating the self and residing in external authority (from whom it may be transmitted) or, on the other extreme, as actively constructed by individuals in interaction with the environment and others.

- Justification for knowing: This dimension involves how individuals justify what they know and how they evaluate their own knowledge and that of others.

The model proposed by Hofer (2004), reconceptualizes personal epistemology as a metacognitive process or 'epistemic metacognition', which has important ties to everyday learning and motivation. The interrelationship had been viewed between cognition, motivation, and learning to be very context sensitive, difficult to separate, and therefore difficult to generalize. Also, current research on the role of knowledge in learning and instruction reflected that a second generation of research that adds to the existing body of research by establishing the crucial role of prior knowledge in learning

Sandowal (2005) defined the term epistemology that is used quite differently by philosophers and psychologists. It is the branch of philosophy concerned with the study of knowledge. Philosophers of science have been concerned with outlining an epistemology of science-the logical and philosophical grounds upon which scientific claims are advanced and justified. This move, itself, presupposes that scientific knowledge and the process of its construction are potentially different from other forms of knowledge and knowing. It is important to understand that from philosophical perspective, scientific epistemology is a description of the nature of scientific knowledge, including the sources of such knowledge, its truth value, scientifically appropriate warrants, and so forth. Psychologists take this notion of epistemology and internalize it, defining personal epistemology as the set of beliefs that individuals hold about the nature of knowledge and its production. According to Sandoval, one's beliefs about knowledge are likely to influence how one approaches to learning, but they are definitely not the same. A flaw in psychological studies of personal epistemology has been to infer that expressed beliefs about how to best learn reflect epistemological beliefs, as opposed to other beliefs or motives (e.g., how to most easily succeed in school)

Bendixen and Rule (2004) investigated the answers of questions related with personal epistemology that they are very complex in nature; How does personal epistemology function within other external and internal systems? and, of course, this work is very useful for the educators. The construct of personal epistemology involves the nature of knowledge and knowing including the certainty of knowledge, the simplicity of knowledge, the source of knowledge, and the justification for knowing. Also, personal epistemology consisted of better grained cognitive resources. Another question is that how will what we know about personal epistemology inform the every day practice of teachers? Cognitive equilibration and cognitive disequilibrium are a driving force for the development of personal epistemology. A general consensus seems to exist that personal epistemologies developed in some constructivist manner. It can be inferred that constructivist learning theory and its application in the classroom supported development of personal epistemology. In the study of Schraw (2001), there is an explanation between epistemological understanding and the development of it that there is neither a unified model of epistemological understanding to guide research, nor a single model that clearly articulates the relationship between personal epistemology and how epistemological beliefs change and develop.

Schreiber and Shinn (2003) explored the possible association between epistemological beliefs and the learning process of community college students. This study has two principles. The first one is that epistemological beliefs do not operate independently; instead, they interact with other knowledge structures. The second one is that this study is an extension of research in both areas. If epistemological beliefs are associated with learning and impact how we learn information, then they should also be associated with learning processes. One would expect to see students who believe that learning should be simple (knowledge is best characterized by isolated facts) would score high on Agentic Processing. For this reason, the authors predicted that relationships among Schommer's four factors, Fixed Ability, Simple Knowledge, Quick Learning and Certain Knowledge and Schmeck's Deep Processing, Elaborative Processing and Agentic Processing observed. In this study, 115 high school graduates were asked to complete The Schommer Epistemological Questionnaire (Schommer, 1998) and The Inventory of Learning Process-Revised (Schemeck & Geisler-Brenstein, 1995). In the analysis part, firstly, the correlation examined between the Schommer's four epistemological beliefs and Schmeck's learning processes. Then, they also developed a path model to examine the relationships among beliefs and processes. This study showed that there is a relationship between epistemological beliefs and learning processes, but it also needs more examination and a much more collection of data. There was an interesting result that the more a student tends to believe that the ability can improve, the more the student processes information in a serial fashion.

To provide a clear understanding of the present study, it is important to look the development of epistemological beliefs from the science education point of view. Hammrich (1998) stated that science education should help students develop an adequate understanding about the nature of science or acquire appropriate epistemological views of science. According to the results of different studies educators have highlighted that epistemological beliefs affect the degree to which individuals are involved in and in control of their learning and their persistence in difficult situations. They could be viewed as an important factor influencing higher order process that guides learning, conceptual change and cognitive operations (Tsai, 1999).

Smith, Maclin, Houghton and Hennessey (2000) assessed the impact of elementary science experiences on students' epistemological views. For this purpose, two demographically similar groups of 6th-grade students were individually interviewed using the Nature of Science Interview (Carey, Evans, Honda, Jay, & Unger, 1989). In the study of Smith et al., (2000), groups had experienced sustained elementary science instructions; one was constructivist perspective and the other was traditional perspective. The results showed that students in the more traditional science classroom had developed a knowledge unproblematic epistemology of the type previously reported by Carey et al. (1989). In the other class that students in the constructivist classroom had developed an epistemological stance toward science that focused on the central role of the ideas in the knowledge acquisition process and on the kinds of mental, social and experimental work involved in understanding, developing, testing, and revising these ideas. From this study it can be concluded that elementary schoolchildren are more ready to formulate sophisticated epistemological views than many have thoughts

The reasons for the need of the development of sophisticated understanding of how knowledge is justified in science can be explained in a way that more sophisticated epistemologies can contribute to better learning of science content (Hammer, 1994; Schommer, 1993; Songer & Linn, 1991) and the greater mastery skills of argument (Honda, 1996; Kuhn, 1991; Sodian&Schrempp, 1997) Beside these, more sophisticated epistemologies may also contribute to the development of informed citizens who understand the importance of reasoned argument in evaluating competing knowledge claims and who understand that the existence of genuine controversies in science does not undermine the value of scientific process and knowledge (Schwab, 1962)

Smith et al. (2000) asked important questions that would elementary schoolchildren be able to make restructuring their epistemological concepts and making fundamental conceptual changes if they were given extensive experiences in pursuing firsthand inquiry in science and negotiating the meaning of their findings among a community of learners? If they were able to make conceptual changes, what would their epistemology of science be like? Would they be able to develop a sophisticated, constructivist epistemology in which they appreciate that scientific knowledge is constructed through a process of conjecture, argument, and test? According to developmental frameworks (King & Kitchener, 1994) which assumes the existence of biologically based general developmental constraints on students' thinking and reasoning elementary schoolchildren are "concrete" thinkers (Chandler, 1987; Inhelder & Piaget, 1958). Although they are capable of engaging in experimentation and learning from the observed results, they are incapable reasoning hypothetically, understanding a theory as a conjecture involving unseen entities, examining the consistency of theoretical propositions, or driving testable implications from such hypothetical conjectures. Children initial absolutist epistemologies are thus seen as the limitations of concrete operational thought. Movement away from a fact-based and absolutist epistemology is an inherently late development, depending on the achievement of formal operational thought, and often requiring intellectual challenging experiences provided by college and graduate school. With the advent of formal operations, students become capable of more complex forms of perspective taking and reasoning. They are able to reflect on sets of beliefs of self and other, to identify these sets of beliefs as perspectives, and to consider how these perspectives influence one's interpretation of experience. These new abilities undermine students' belief in absolute truth. They lead to first radical relativism, an epistemology in which all controversies are seen as reflecting legitimate differences in perspective, each supported by pieces of evidence, but with no means of resolving those differences. A more sophisticated constructivist view follows in which individuals are seen as “active constructors of meaning, able to make judgments and commitments in a relativistic context” (Hofer & Pintrich, 1997, p.121)

Schommer-Aikins and Hutter (2002) investigated the relationship between individuals’ beliefs about the nature of knowledge and nature of learning (epistemological beliefs) and their thinking about everyday controversial issues. The sample of the study was totally a hundred and seventy four adults (chemical engineers, clerks, homemakers, factory workers, pharmacists, and teachers) whose age was ranging from 17 to 71 years old. They had completed epistemological belief questionnaire and some open ended questions in a discussion environment. The results showed that the more the participants believed in complex and tentative knowledge, the more likely they were to take on multiple perspectives.

Valanides and Angeli (2005) was investigated the effects of teaching critical-thinking principles on university students’ epistemological beliefs, whether these effects had any relation to the teaching approaches, and whether there was any significant interaction between teaching approach and students’ epistemological beliefs. One hundred and eight undergraduates were randomly assigned to the three different 65-minutes instructional interventions, named as General, Infusion and Immersion approaches. These three approaches had some common properties that a) analyze the problem, b) generate solutions, c) develop the reasoning for each solution, d) decide which is the best solution, e) use criteria to evaluate your solutions. The results showed that students exhibited a statistically significant improved post-performance in their epistemological beliefs. And the epistemological beliefs had changed over time.

It has been known that early research studies on students' personal epistemology and examined the nature of development and change in how students think about knowledge and knowing, especially in college students. However, Conley, Pintrich, Vekiri, and Harrison (2004) studied with fifth grade students to investigate how these beliefs can facilitate or constrain student understanding, reasoning, thinking, learning and achievement. In addition to this, this study examined changes over time in young elementary school children's epistemological beliefs in science and how it was affected by gender, ethnicity, socio-economic status (SES). Participants were 187 fifth grade students in 12 elementary schools studied with hand-on science instruction. The sample was ethnically diverse (46% Latino, 27% Anglo, 27 % African American). Data were collected in the spring of the school year as students studying the unit on chemical properties. Epistemological beliefs were measured with self-report questionnaires (Elder, 2002) administered in class at the start (Time 1) and after the completion (Time 2) of a nine-week hands-on science unit investigating chemical properties of substances. Information about gender, ethnicity, SES, and achievement (mean percentile ranks of the standardized reading and math scores were averaged to create a single achievement score) was collected from school records. The results indicated that young children's epistemological beliefs about science change over time, but students did not show significant improvement on the justification and development dimensions. Specifically, students became more sophisticated in their beliefs about the source of knowledge and the certainty of knowledge over the course of instruction. These results parallel with the findings of Solomon, Scott, and Duveen (1996) that showed that hands-on science instruction was related to epistemological awareness. In addition to these findings, previous studies suggested that elementary school children in constructivist classrooms develop more sophisticated epistemological stances than do those in traditional classrooms (Smith et al., 2000). Conley et al. (2004) also found no evidence for the main effects of gender or for moderating effects of gender on development over time (no gender by time interactions). In terms of ethnicity and socioeconomic status (SES), results showed no reliable differences in epistemological thinking by ethnicity as well as no moderating effect of ethnicity in change over time in epistemological beliefs. However, there were strong SES differences in how students think about knowledge and knowing. The meaning of this is the lower SES students did have less sophisticated beliefs. With respect to students' achievement, it was found that higher achieving students express more sophisticated beliefs. However, achievement level did not interact with time, so achievement level did not moderate the general change over time in epistemological beliefs.

Focusing the relation between teaching and learning strategies and development of personal epistemological beliefs or students' scientific epistemological beliefs brings us to the importance of the usage of these strategies. The studies show that suitable preparations to the related grades and well planned strategies fostered the improvement of these beliefs.

The literature review gives evidences that construction of knowledge by learner with the facilitation of instructor is necessary to provide a meaningful learning of the subjects. And there is a constructivist learning theory modeled by learning cycle instruction provides effectiveness on the development of students' understanding of concepts, epistemological beliefs and creation of positive attitude toward science. The present study has been focused on the effectiveness of learning cycle implementation on the students' understanding on cell concept, their attitude toward science and their epistemological beliefs in comparison with the traditional methods.

CHAPTER III

PROBLEMS AND HYPOTHESES

This chapter presents the main problem, sub-problems which is related with the stated main problem, and the hypothesis of the study which was tested in chapter 5.

3.1 Main Problem

The main problems of the study was:

1. What are the effects of methods of teaching (5E-LCBI versus TI) on sixth grade students’ understanding of cell concepts, attitude toward science and scientific epistemological beliefs when their pre-understanding, pre-attitude, pre-epistemological beliefs test scores are controlled?

3.2 Sub-problems

1. What are sixth grade students’ understanding of cell concept after the treatment?
2. What are sixth grade students’ epistemological beliefs after the treatment?
3. What are the attitudes of the sixth grade students toward science after the treatment?

3.3 Hypotheses

The sub-problems stated above are tested statistically by the following hypothesis:

H_0 1: There is no statistically mean difference between the effects of 5E-LCBI and TI on students understanding of cell unit, students' attitude toward science, and students' scienctific epistemological beliefs when pre-test scores of these tests are controlled as covariates?

CHAPTER IV

METHOD

In this part of the thesis, the method that followed during the research study is explained. Specifically, the present chapter is provided the about the research design, population and sampling, description of variables, measuring instruments, data collection, and, finally, statistical techniques that were used in the analysis of data.

4.1 Research Design

In this research study, experimental design, specifically quasi-experimental design, was adopted. Quasi-experimental designs do not include the use of random assignment subjects of experimental and control groups on certain variables (Fraenkel & Wallen, 1996). The research design of the study is displayed in Table 4.1.

Table 4. 1 Research Design of the Study

Groups	**Before Treatment**	**Treatment**	**After Treatment**
EG	CCT, SAS, EBQ	5E-LCBI	CCT, SAS, EBQ
CG	CCT, SAS, EBQ	TI	CCT, SAS, EBQ

This research study had two experimental groups and two control groups. In this table, EGs represents the Experimental Groups received 5E learning cycle instruction. CG represents the Control Group received traditional instruction. CCT was the Cell Concept Test, SAS was the Science Attitude Scale and EBQ was Epistemological Belief Questionnaire. The treatments of the study were 5E-LCBI representing the 5E Learning Cycle Based Instruction and TI representing the traditional instruction.

In this study, CCT, SAS and EBQ were administered to both students of experimental and control groups before the treatment to determine their existing knowledge about cell concepts, to determine their attitude toward science and to understand their scientific epistemological beliefs, respectively. After the 5E-LCBI treatment, CCT, SAS and EBQ were administered to both experimental and control groups to determine the effect of 5E learning cycle based instruction on students' concept achievement, attitude toward science and scientific epistemological beliefs, respectively.

4.2 Subjects of the Study

Target population and accessible population need to be defined to describe the characteristics of the subjects of the study. This study was an experimental research in Izmit, Kocaeli, Turkey. According to The City of Kocaeli Ministry of Education (Kocaeli MEB, 2005-2006 Academic Year), there were 120 public elementary schools in Izmit. Based on these records, the target population of the present study was all sixth grade public elementary students in Izmit, Kocaeli. Among all those public elementary schools, one of them was selected as an accessible population to this research study. This study was carried out during the fall semester of 2005-2006 academic year. There were 6 sixth grade classes in this school, four of them were randomly selected for the study. Among the four classes, the instructional methods of 5E-LCBI and TI were randomly assigned to the EGs and CGs. There were eighty students in control groups and eighty students in experimental groups (see Table 4.2). As seen in the table, there were totally 76 female students and 84 male students with a mean age of 12. The socio-economic background of the students was similar, majority of them coming from lower to middle class families.

Table 4.2 Information for the Gender Distribution of the Sample

Gender	Control Groups	Experimental Groups
Female	39	37
Male	41	43
Total	80	80

This study was conducted over a 3 weeks period. A total of 160 students were involved in the study. The classroom instruction for both groups was given by the same science teacher. Two of the classes were assigned as the experimental group and the other two as the control group. The control groups received the traditional instruction which included lecture/ discussion methods to teach concepts. Teaching strategies relied on teacher explanation and textbooks. In the control groups, the teacher had made his usual preparation. In order to facilitate the proper use of 5E-LCBI in the experimental groups, the teacher involved in the study was given two 45 minutes training sessions prior to beginning the study. Meetings with the teacher were held during the study to ensure that he was conducting the treatments in both groups appropriately. The teacher was contacted several times a week to enable the researchers to answer any questions or to address problems and to review the treatment procedures. Both control and experimental groups used the science laboratory as needed.

4.3 Variables

In this research study, variables were divided into two categories as dependent and independent variables. The independent variable is presumed to affect dependent variable. In this research study, there were three dependent variables and one independent variable. The characteristics of all variables shown in table 4.3

Table 4.3 Dependent (DV) and Independent Variables (IV) of the Study

Type of Variable	**Name**	**Type of Value**	**Type of Scale**
DV	POSCCT	Continuous	Interval
DV	POSSAS	Continuous	Interval
DV	POSEBQ	Continuous	Interval
IV	MOT	Discrete	Nominal

4.3.1 Dependent Variables

The dependent variables (DV's) were Student's Cell Concept Test Posttest Scores (POSCCT), Student's Science Attitude Posttest Scores (POSSAS), and Student's Scientific Epistemological Beliefs Posttest Scores (POSEBQ). These variables were continuous and measured on interval scales.

4.3.2 Independent Variable

Method of Science Teaching (MOT) was the independent variable (IV) of this study. It was discrete variable and measured on nominal scale.

4.3.3 Covariates

Pre-test scores of Cell Concept Test, Science Attitude Scale, and Epistemological Belief Questionnaire were used as covariates of the study.

4.4 Data Collection Instruments

There were three measurement instruments in this study. Cell Concept Test (CCT) was used to measure student's understanding in the unit of cell. Science Attitude Scale (SAS) was used to measure student's attitude toward science. Finally, Epistemological Belief Questionnaire (EBQ) was used to measure student's epistemological beliefs about their scientific knowledge.

4.4.1 Cell Concept Test (CCT)

CCT (Appendix A) was used to measure student's understanding of cell concepts before and after the treatment. This test was developed by researcher by the examining the related literature and by taking the national science curriculum taking into consideration. The test assessed mainly students' understanding of basic concepts in cell, organelles, and types of the materials transport in the cell. It consisted of 15 multiple-choice questions. Each question included an open ended part which asked students to write the reason behind their choices. The test items covered the knowledge, comprehension, analysis, and synthesis levels on Bloom's taxonomy of educational objectives in the cognitive domain (Appendix B). The face validity and clarity of each item in the test were determined by a panel of four science teachers and three science educators. The science teachers also analyzed the relation of the test items to the instructional objectives. They confirmed that the content validity of the instrument was appropriate for the participants and determined that the CCT was valid with respect to the measured constructs. The pilot study of CCT had performed in a public elementary school which is located in the center of Izmit. The reliability coefficients of Kuder-Richardson 20 (KR20) was found to be .67 for pre-test and .70 for post-test.

4.4.2 Science Attitude Scale (SAS)

SAS (Appendix C) was a 15-item, 5 point Likert type scale developed by Geban, Ertepınar, Yılmaz, Altın and Şahbaz (1994) to determine students' attitudes toward science as a school subject. The choices of each item were strongly agree, agree, undecided, disagree, and strongly disagree. The reliability coefficient computed by Cronbach alpha estimates of internal consistency of this scale was found to be .83 for pre-test and .90 for post-test. SAS were administered to control and experimental groups as pre- and post-test.

4.4.3 Epistemological Belief Questionnaire (EBQ)

A 26-item Epistemological Belief Questionnaire (Appendix D) was developed by Conley, Pintrich, Vekiri and Harrison (2004) was used to measure students' scientific epistemological beliefs through four dimensions: Source, Certainty, Development and Justification. Source was concerned with beliefs about knowledge residing in external authorities, for example: "Everybody has to believe what scientists say". Certainty referred to belief to the right answer, for example: "All questions in science have one right answer". Development concerned with changing subjects, for example: "Ideas in science sometimes change". Justification was concerned with the role of experiments and how individuals justify knowledge, for example: "A good way to know if something is true is to do an experiment". Items were rated on a 5 point scale ranging from strongly agree, agree, undecided, disagree, to strongly disagree. EBQ was translated to the Turkish by the researcher under the valuable advises of thesis advisors. The translated form of the questionnaire was revised and translated again by an English teacher who was from Foreign Language

Education department and has ten years experiences in English teaching. After that, the Turkish teacher had checked the language of the translated version of the questionnaire.

The reliability coefficient computed by Cronbach alpha estimates of internal consistency was found to be .72 for pre-test and .83 for post-test. It was applied to both control and experimental groups as pre- and post-tests.

4.5 Teaching and Learning Materials

In this research study, experimental research was performed and there were two control and experimental groups.

This study was conducted over a three weeks period during the 2005-2006 fall semester. Four classes including 160 students were involved in the study. These four classes were instructed by the same science teacher. The instructional methods were randomly assigned to the classes. Instructions in all the classes were observed by the researcher to see the implementation of the treatment. Students in all groups were exposed to same content for the same duration. Duration of the lessons was three 40-minutes periods for a week. The topic related to the cell and organelles content was covered as a part of the regular curriculum. At the beginning of the study CCT, SAS, EBQ were administered to both control and experimental groups to determine their understanding about cell concept, attitude toward science and scientific epistemological beliefs, respectively.

Students in the control groups received traditional instruction. At the beginning of the instruction, the teacher explained the concepts related with cell. Then, students read the topic from their textbooks in the classroom. Afterthat, the teacher pursued the textbook to conduct experiments related with the cell concepts. The students did not actively participate in the experiments, they only observed their teacher while he was conducting the experiments. At the end of the experiments(observation of onion cell, observation of epithelial cell), students answered the questions of the teacher.

Students in the experimental groups received 5E learning cycle based instruction for the cell concept. At the beginning of the instruction, the teacher was trained for the application of 5E learning cycle. In the preparation step the teacher formed the groups to maximize student interaction. Each group structure was similar to the others so homogeneity of groups (eight groups including five people in each group) characteristics provided to prevent the inequality among the groups. The phases of learning cycle related with cell concepts covers two different subjects, one was cell and organelles and the other was transportation of materials in cell. The phases of the cell and organelles 5E learning cycle was explained as follows (Appendix E). The cycle of instruction begin with the *"Engagement"* part to provide engagement to the related subject. The teacher started learning cycle instruction making two analogies: Computers and automobiles have lots of parts. Then, the teacher successively asked several questions related with these analogies: Do you know the parts of computers and automobiles?.. The discussion environment was provided within each group to discuss the answers of questions. Then, the teacher explained the parts of them. Students were asked "Like these hi-tech instruments, do the observable living things and unobservable living things have the parts which made up the living organisms?" During the discussion, the teacher did not make any interruption to the groups, however he made careful observations. After the discussion, the teacher introduced an activity named as "Flubber". Then, the teacher explained the activity describing the materials which was going to create "Flubber". It would resemble a model of something. The students expected to guess what was it actually. During the activity, the teacher answered the questions coming from the students without using the related terminology (i.e cell, cell structure, cell organelles). Beside, the teacher asked questions to the students related with the activity so they realize that they were performing this activity since it had a close relation with the subject. The phase of the engagement were performed in the laboratory since the physical environment of the laboratory was suitable for group discussion and activity session. In the phase of *exploration,* the teacher asked to the students if they had ever used the microscope or not. And almost all students had no experience till this time. Before the experiment, the teacher showed and explained all the parts of microscope. Also he explained the preparation of slide of the microscope. Then, he gave chance to all students to observe their slides under the microscope. After this experience, students were expected to prepare plant and animal cells slides for the microscopes. Then they observed their preparation under the microscope and recorded their observations and answered the questions on the laboratory worksheet. In the *explanation phase*, as the students discussed the results of the experiment conducted in the exploration phase, the teacher used this information to introduce the concept of the cell such as structure and organelles of the cell. Some of the terminology (i.e. cell, cell structure, cell organelles) that used by the students had written to the board by the teacher. At the end of this phase, another activity named as “Identity Card Preparation Activity” was performed. The teacher wanted from the groups to prepare identity card of each part (i.e. nucleus) of the cell to the colored papers. And the students also were expected to draw a figure of each part of the cell as possible as they can.

In the *elaboration* phase, different questions were asked to the students to deepen their understanding about cell. Moreover, two different activities were performed by the students. The first one was “ID Card” which was performed to define the characteristics of each cell organell so the students were expected to exchange those "ID Cards" and check each others preparation and the second one was "Decide, The Type of Cell" which was included lots of questions related with cell types and the students were expected to decide the type of cell like prokaryote or eukaryote. Groups performed these activities in the laboratory and shared the results of them. The most important side of learning cycle was that it provides *evaluation* in every phase of the cycle. Actually, this phase was summing up of activities and experiments. In this phase, students were expected to prepare a concept map of cell organelles and cell types.

Following the cell and its parts subject, the teacher started to the second learning cycle related with material transport in the cell.

At the end of the treatment, CCT, SAS and EBQ were given to all students as post-tests to determine the effect of the treatment.

4.6 Procedure

Before the treatment, researcher deeply investigated and examined the theoretical framework of the study. Constructivist learning theory, learning cycle, inquiry based science approach, Piaget and developmental theory of learning, epistemology, personal epistemology, scientific epistemological beliefs were determined as keywords list. METU Online Library, METU Library, Ulakbim (TUBITAK), Bilkent Library are the sources of theory base study. Educational Resources Information Center (ERIC), International Dissertations Abstracts, Ebscohost, Science Direct, Springer databases, Internet (Google and Google Scholar), thesis and other studies done in Turkey were investigated by the researcher. All the articles and thesis were carefully read.

After the scanning procedure of the literature, the instruments of the study and lesson plans including activities and experiments were prepared.

Experimental research, specifically quasi experimental design, was performed in this study as a research type. Experimental research usage is very common widely in use since its unique research characteristics. The characteristics of that specific to this type of research methodology that it is the only type of research directly attempts to influence a particular variable, and when properly applied, it is the best type for testing hypotheses about cause-and-effect relationships (Fraenkel & Wallen, 1996). Researcher looks at the effect(s) of at least one dependent variable on one or more independent variables. In this study, effect of 5E-LCBI (traditional vs. 5E-LCBI) on students' scientific epistemological beliefs, understanding of cell concepts and attitude toward science was investigated.

Planning and preparation steps pursued the training session of science teacher who was responsible for the application of the research study . The science teacher has 26 years of experiences in science teaching. In the training session, the science teacher was trained by researcher. The aim of the study, its theory, its significance for science education were explained to the teacher and the questions that asked by science teacher were answered so the meaningfulness of the study provided to the science teacher by researcher. The lesson plan was explained to the teacher including the steps of 5E learning cycle; Engagement, Exploration, Explanation, Elaboration and Evaluation. Measuring instruments of the study (EBQ, CCT, SAS) were explained to the teacher and these instruments were applied to both control and experimental groups as a pretest, before the treatment and posttest, after the treatment. The research study was conducted over three weeks period. While control groups were receiving traditional method of teaching, experimental groups were instructed by 5E learning cycle instruction. In the control group, teacher did the instruction in his way especially in teacher-centered mood using the only textbook (MEB Publications). Science laboratory was used two times in control group. In experimental group, over three week period, science laboratory was used to perform 5E learning cycle instruction that mainly student centered. There is one computer in the laboratory that short simulations related cell concepts were shown to the students who were EGs.

4.7 Analysis of Data

The data obtained from the study were analyzed in two parts, descriptive statistics and inferential statistics by using SPSS.

4.7.1 Descriptive Statistics

The mean, standard deviation, skewness, kurtosis of the variables were presented.

4.7.2 Inferential Statistics

The main aim of the study to find the effect of method of teaching on students' epistemological beliefs on achievement and attitude toward science. Thus, as a statistical technique, Multiple Analysis of Covariance (MANCOVA) was used to analyze the data to test the hypothesis of the study. Since MANCOVA allows researcher to control for the effects of continuous independent variables that is covariate. Covariates are variables which have effects on the dependent variables, but their effects are not of interest. In experimental design, covariates are usually the variables not controlled by the experimenter, but still having an effect on the dependent variables. In this research study, pre-test scores of CCT, SAS, EBQ were covariates. To perform inferential statistical analyses, α was set to 0.05 (probability of making Type I error).

4. 8 Assumptions and Limitations

There were assumptions and limitations mentioned by the researcher that are given below.

4.8.1 Assumptions

1. The application of treatments was under standard conditions.

2. The administration of CCT, SAS, EBQ were under standard conditions.

3. The participant students of the study responded to the items of the instrument sincerely.

4. The science teacher properly pursued our instructions.

5. Students both in control and experimental groups did not interact and shared questions of the CCT, SAS, and EBQ before and during the administration of the study.

6. Students in experimental groups also did not interact and shared what had been done in lessons.

4.8.2 Limitations

1. Generalizations of this study are limited because the participants of this quasi experimental study were not selected randomly.

2. A qualitative study might be conducted to make clear statements with respect to the results of the quantitative analysis.

3. A quantitative study is limited to sixth grade students at four intact classes of public school.

4. In the present study, analyses were conducted by using total mean score of EBQ which was indicating that dimensions were not taken into consideration.

CHAPTER V

RESULTS AND CONCLUSIONS

This chapter provides information about the results of the research study. The results of the study are investigated in three sections. The first section presents the descriptive statistics associated with the data collected from the administration of the pre- and post-test. The second section presents the inferential statistics data which is yielded from testing three null hypotheses outlined in Chapter 3. The third section explains the findings of the study.

5.1 Descriptive Statistics

Statistical analyses were performed at 0.05 significance level ($\alpha = .05$) using Statistical Package for Social Sciences (SPSS). Descriptive statistics related to the scores which were measured by the students' science achievement (CCT scores, table 5.1), attitude toward science (SAS scores, table 5.2) and scientific epistemological beliefs (EBQ scores, table 5.3) for both control and experimental groups. Descriptive statistics also provides some information concerning the distribution of scores on continuous variables (skewness and kurtosis)

Table 5.1 Descriptive Statistics for the Cell Concept Test Scores

	Control Group (CG)		Experimental Group (EG)	
	Pretest	Posttest	Pretest	Posttest
Cell Concept Test (CCT) Scores				
Mean	6.21	8.72	8.37	11.27
Standard Deviation	3.79	2.80	3.46	2.61
Skewness	0.52	0.24	-0.16	-1.12
Kurtosis	-0.70	-0.75	-1.04	0.89
Range	14	11	12	11
Minimum	1	3	2	3
Maximum	15	14	14	14

Descriptive statistics related to the CCT were calculated for both control and experimental groups before and after the treatment. In CCT, there were fifteen multiple-choice questions. Each correct answer was given the 1 point. A total score in test was 15 points. Concerning the CG scores (Table 5.1), while the pretest mean scores was 6.21, posttest mean scores was 8.72. For EG scores, the mean value of pretest scores was 8.37 and the mean value of posttest scores was 11.27. This result meant that the 5E-LCBI made more difference in terms students' understanding on cell unit.

Table 5.2 Descriptive Statistics for the Science Attitude Questionnaire Scores

	Control Group (CG)		Experimental Group (EG)	
	Pretest	Posttest	Pretest	Posttest
Science Attitude Scale (SAS) Scores				
Mean	58.83	62.78	59.48	57.75
Standard Deviation	8.83	6.33	7.50	8.44
Skewness	-0.47	0.32	0.058	0.19
Kurtosis	0.21	-0.069	-0.045	0.23
Range	41.00	29.00	36.00	38.00
Minimum	34.00	46.00	39.00	37.00
Maximum	75.00	75.00	75.00	75.00

Since the present study concerned with on the effect of TI and 5ELCBI the students' attitude toward science, the descriptive statistics of SAS were investigated. Descriptive statistics related to the SAS were calculated for both control and experimental groups regarding pre- and post- applications. The mean values for the CG were 58.83 and 62.78 for the pre- and posttest results, respectively. The mean values for the EG were 59.48 for pre-test and 57.75 for post-test. Although the related mean values were very close to each other, students in CG developed more positive attitude toward science than students in EG.

Table 5.3 Descriptive Statistics for the Epistemological Belief Questionnaire Scores

	Control Group (CG)		Experimental Group (EG)	
	Pretest	Posttest	Pretest	Posttest
Epistemological Belief Questionnaire Scores (EBQ)				
Mean (total)	87.34	88.55	88.94	102.54
Standard Deviation	9.68	10.25	12.51	9.11
Skewness	-0.126	-0.021	-0.665	-0.035
Kurtosis	-0.328	-0.768	1.089	-0.077
Range	39.00	41.00	68.00	45.00
Minimum	66.00	66.00	47.00	78.00
Maximum	105.00	107.00	115.00	123.00

Since the present study concerned with the students' scientific epistemological beliefs under the effect of TI and 5ELCBI, the descriptive statistics of EBQ were investigated.

Descriptive statistics related to the EBQ were calculated for both control and experimental groups regarding pre- and post- applications. For the pre- and posttest results of CG scores, the mean values were 87.34 and 88.55. The EG scores of the mean values were 88.94 for pre-test and 102.54 for post-test. The results showed that 5E-LCBI made an increase on the improvement of students' scientific epistemological beliefs. Both groups had a beliefs about nature of knowledge or knowing.

5.2 Inferential Statistics

This section deals with the clarifications of multiple analysis of covariance (MANCOVA) assumptions, and analysis of hypothesis.

5.2.1 Assumptions of MANCOVA

MANCOVA has five assumptions: Normality, equality of variances, homogeneity of variance-covariance matrices, homogeneity of regression slope and independency of scores on the dependent variables.

For normality assumption, Regression analysis has been made to obtain Mahalanobis distance. This analysis will pick up on any cases that have a strange pattern of scores across three dependent variables. In this case, the Mahalanobis distance was equal to 10.909 and the corresponding critical value is 16.27. Since the value of 10.909 less than 16.27, it assumed that there were no substantial multivariate outliers.

Equality of variances assumption determined by The Levene's Test. The Levene's Test gave the information about the assumption of equality of variance for that variable. From the Table 5.2.2, the Sig. values showed that they were not larger the value of .05 so the assumption was not violated. They were .978, .154, and .130 respectively for each dependent variable values.

Table 5.2.1 Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Tests				
POSCCT	.065	3	149	.978
POSSAQ	1.779	3	149	.154
POSEBQ	1.911	3	149	.130

The correction of the assumption of homogeneity of the variance-covariance matrices provided by analysis of Box's M statistic. The Sig. value of Box's M statistic larger than .001 (Sig.= .362) then the assumption of was not violated. The results of Box's M statistic displayed in Table 5.2.2

Table 5.2.2 Box's Test of Equality of Covariances Matrices

Box's M	F	df1	df2	Sig.
20.242	1.083	18	77053.103	.362

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across the groups.

For the homogeneity of regression slope assumption, syntax of analysis was designed. And from this analysis, the F value obtained. The sig of F value was .713 and this was greater than .05, so this assumption also was not violated.

For independency of scores on the dependent variables assumption, the participants were randomly sampled, and the score on a variable for any one participant was independent from the scores on this variable for all other participants.

In addition to assumption check procedure, the correlations among covariates also were checked. The pearson correlation between the pre-test results of cell concept test and epistemological belief questionnaire was -.047, pre-test result of cell concept test and attitude toward science was .145, pre-test result of epistemological belief questionnaire and attitude toward science was -.036.

5.2.2 Analysis of Null Hypotheses

5.2.2.1 Null Hypotheses 1:

There is no statistically mean difference between the effects of 5E-LCBI and TI on students' understanding of cell unit, students' attitude toward science, and students' scientific epistemological beliefs when pre-test scores of CCT, SAS and EBQ were controlled as covariates.

Multiple analyses of covariances (MANCOVA) was conducted to determine the effect of method of teaching on students' understanding of cell unit, students' attitude toward science, and students' scientific epistemological beliefs when pre-test scores of these tests were controlled as covariates. The result revealed that there was a statistically significant effect of the method of teaching on students' understanding of cell unit ($F(1,146) = 21.121$, $p = .000$), students' attitude toward science ($F(1,146) = 21.543$, $p = .000$), and students' scientific epistemological beliefs ($F(1,146) = 78.141$, $p = .000$) when pre-test scores of these tests were controlled. Also, the values for $F = 38.847$, Wilks' Lambda=.553 and $p = 0.000$ in the multivariate tests for the group. In other words, this null hypothesis was rejected.

At the end of the study session, 5E-LCBI made significant mean difference students' understanding of cell unit, students' attitude toward science, and students' scientific epistemological beliefs.

The statistical result of the SPSS calculated eta squared as 0.12, 0.12, and 0.34, respectively for the POSCCT, POSSAS, POSEBQ scores. These eta-square values represented that 12%, 12%, 34% of the variance in students' understanding of cell unit, students' attitude toward science, and students' scientific epistemological beliefs scores was explained by the method of teaching. The effect size values matched the large effect size indicating that practical significance of the study is high.

Table 5.2.3 Test of Between-Subjects Effects for Method of Teaching (MOT)

Source	DV	Type III Sum of Squares	df	Mean Squares	F	Sig.	Eta Sq.	Ob. Power
Group	POSTATTI	1151.121	1	1151.121	21.543	.000	.129	.996
	POSTEPIS	7284.274	1	7284.274	78.141	.000	.349	1.000
	CELLPOS	123.654	1	123.654	21.121	.000	.126	.995

5.3 Conclusions

The results of this study can be summarized as follows.

- The method of teaching, 5E-LCBI had made a statistically significant effect on students' understanding of cell concept. 5E-LCBI was effective on the understanding of cell concept.

- 5E-LCBI showed no effect on the development of attitude toward science. In the study period, the treatment showed no effectiveness on the improvement of attitude toward science. However, TI showed effect on the development of attitude toward science.

- 5E-LCBI had made a statistically significant effect on students' epistemological beliefs. 5E-LCBI was effective on the improvement of students' scientific epistemological beliefs.

CHAPTER VI

DISCUSSION, IMPLICATIONS and RECOMMENDATIONS

This chapter presents the summary of the research study, conclusions and discussions of the results, and finally announces the implications of the study and recommendations for further studies.

6.1 Discussion

The purpose of this study was to investigate the effects of 5E-LCBI and TI on 6^{th} grade students' understanding of cell concepts, students' attitude toward science and students' scientific epistemological beliefs.

The results of the study showed that 5E-LCBI had a positive effect on students' understanding of cell concept and students' scientific epistemological beliefs.

Regarding the results of the study that 5E-LCBI treatment was effective over TI when we considered the students' understanding of cell concept. TI included direct teaching supported by textbook. However, 5E-LCBI provided different alternatives to students to understand concepts. Students became active other than listening and note taking. Being active involver may cause to think and interpret what they are doing. Having a responsibility of making activities or experiments may cause to arise of need to plan and organize something. An inquiry process during the 5E-LCBI treatment may cause to investigate different things related with that concepts and this directly cause to learn new things other class subjects. To meet with new things such as planning an activity, making an inquiry of a given concept, organizing and performing an experiment may cause to increase of an interest related with the concepts. The positive effect of 5E-LCBI on students' understanding was supported by previous studies in the literature. For example, Barman and Allard (1993) stated that learning cycle strategy have wide spread applicability a variety of grade levels, including college students and positive gains in student achievement were observed over the traditional lecture/laboratory format. In a similar study, Wilke and Grangner (1987) found that the learning cycle increased students' retention rate of biological concepts. Abraham (1988) reported that students exposed to the learning cycle outperformed taught subjects when compared with traditional classrooms.

Kyle, Bonsteter, Sedotti, and Dvarskas (1989) and Shymansky, Hedges, Woodworth (1990) had found similar findings about the effectiveness of an activity-oriented approach to science in comparision with a non-activity format. It had been found that an activity approach science instruction promoted science achievement, process skill development, problem solving skills, and attitude toward science. Also, the study of Boddy, Watson, and Aubusson (2003) found that 5E learning cycle approach can be used successfully to implement a constructivist view of teaching in the primary school classroom. In this study, students found the unit of work fun and interesting and were motivated to learn while others said they were interested and motivated because they were learning. 5E learning cycle, also, promotes higher-order thinking because each student demonstrated a greater percentage of higher-order thinking than lower-order thinking.

Furthermore, some of the results of recent studies with elementary students emphasized the effectiveness of 5E learning cycles in different science subjects such as plant nutrition (Lee, 2003), development of plants (Cavallo, 2005), ecology (Lauer, 2003). The present study showed the effectiveness of 5E learning cycle on the subject of cell concepts.

The present study also showed that elementary students have epistemological beliefs about science of their knowledge. The present study showed that 5E-LCBI provides a broader point of view with the related subjects. Since the responsibility of students increase with the activities (engagement, exploration, explanation, elaboration), experiments (exploration) and projects (evaluation), they became aware of what they were learning. Furthermore, students performed the activities and experiments by themselves. In addition to this they discussed the results of them with their groups and with the whole class. This means that they had reached the knowledge by themselves. This performance may lead to the construction of knowledge. The positive effect of 5E-LCBI on students' epistemological beliefs was supported by previous similar studies in the literature. In a study of Smith, Maclin, Houghton and Hennessey (2000) showed similar results with the present study. They used constructivist pedagogy that a pedagogy in which students actively develop, test and revise their ideas about how things work through collaborative firsthand inquiry with their peers and all those studies guided by a knowledgeable teacher. Students in the constructivist classroom were centrally aware that science involved the development and modification of ideas about how the world works, that these ideas take work to develop and understand, that experiments are useful both as a means of clarifying and testing ideas, and that collaboration is important in all aspects of the process. In another study, Elder (1999) was investigated relations between elementary students' epistemological beliefs and their learning of science. The study examined the links between students' beliefs about science knowledge and their learning as demonstrated by performance-based assessment. The results indicated that students' beliefs were modestly related to their learning in science and point to the importance of considering different types of learning. Also, epistemological beliefs were found to be integrally linked learning process skills only when those skills were embedded in a context of learning rich conceptual knowledge. The study of Baxter, Elder and Glasser (1996) supported the results of the present study. The study found that elementary aged students' conceptual science knowledge supports their abilities to perform a problem solving task including successfully planning, monitoring and developing a strategic approach and this was linked to their understanding of other realms of learning (i e. epistemology).

Also, Smith, Houghton, Maclin and Hennessey (1997) found that a very traditional instruction environment that students solely learn from a text and concerned with learning (memorizing) facts may not result in students having differing beliefs about the nature of school science and about the nature of real science. They would be unable to build conceptions about different from what they experience. However, in a truly inquiry classroom, students may come to have sophisticated epistemological ideas since they learn in an instructional environment that how scientists do science and actually practice authentic ways in the classroom.

Furthermore, Conley, Pintrich, Vekiri and Harrison (2004) studied the change in young children's epistemological beliefs over the course of instruction in hands-on science classrooms. It has been known that this type of instruction is very different from textbook driven traditional instruction where students read a text and discuss the ideas or fill out worksheets and take tests on the material presented in the book or by the teacher. It would lead to less reliance on authorities such as the teacher or textbooks and also doubts about the certainty of knowledge, given the high potential for different students to generate different results from their hands-on experiments. Although the changes in epistemological beliefs were not large, students became more sophisticated in their beliefs about the source of knowledge and certainty of knowledge over the course of instruction.

In another study, Solomon, Scott and Duveen (1996) also found similar results. Their study showed that hands-on science instruction was related to epistemological awareness. However, King and Kitchener (1994) believed that elementary school children are ‘concrete’ thinkers that they are incapable of reasoning hypothetically, understanding a theory as a conjecture involving unseen entities, examining the consistency of theoretical propositions, or deriving testable implications from such hypothetical conjectures. In addition to this, the development of formal operational thought that is the shift in thinking occurs later during the college years. Apart from the characteristic of the learner or nature learner, there is some thing that instructor characteristic or nature should be considered. Related with this issue, Schommer-Aikins and Easter (2006) performed a study related with ways of knowing and epistemological beliefs concluding that college instructors should aware that ways of knowing are linked to epistemological beliefs, and this supports the academic performance, then instructors may willing to give some class time to the epistemic notions. Because epistemological beliefs can be developed by having consciously consider the consequences of speeding through assignments as opposed to taking time for reflection, attempting to integrate the information as opposed to memorizing the facts in isolation, and holding on to ideas as if they will never change as opposed to anticipating that what we know today may serve as a just one step to newer ideas in the future.

Attitude toward science is the other concern of the present study. The development of positive attitudes toward science is one of the basic goal of science instruction. Since the development of positive attitude toward science affects the chose of science courses in the future. If students think that they can easily do science, they feel confidence about performing it and they will choose to study in science in the future. In the present study, students’ attitude toward science was not affected by 5ELCBI but it was positively affected by TI. Considering the fact that 5E-LCBI treatment had taken over a three week period, this period of time may not enough to change or increase their attitude toward whole science course. Another point is that attitude may change subject to subject. There were some studies that support the improvement of students' attitude toward science by the use of learning cycle (Fleener & Marek, 1992; Brown, 1996). The work of Osborne and Collins (2000) would suggest that, for many, the contemporary curriculum may suffer from obverse problem with too much emphasis on undemanding activities such as recall, copying, and lack of intellectual challenge. The mentioned reasons may block the creation of positive attitude toward science. Also, Hoffman and Haussler (1998) stated that individual interest in science is very important for learning science. If students are unable to see the utility of science in their daily lives, they will become disinterested in science. For this reason, the joint effects of attitude toward science and attitudes utility of science on science learning in schools should be studied in the future.

In summary, the present study found that 5E learning cycle approach has effectiveness over traditional instruction on students' understanding of cell concepts and their epistemological beliefs. However, 5E learning cycle approach made no difference on the improvement of attitude toward science. Also, learning cycle approach and traditional instruction have no interaction with the gender.

6.2 Implications

1. Since learning cycle implementation in science lesson improve understanding of the content and scientific epistemological beliefs of students, it can be advisable to teachers to provide the meaningful learning of the contents.

2. Elementary science curriculum should be reorganized including learning cycle applications.

3. For proper implementation of learning cycle approach, pre-service teachers and in-service teachers should be periodically trained about constructivist learning theory, Piagets' developmental theory, inquiry based science approach and learning cycle approach.

4. To facilitate teachers' job, sample lessons plans of the learning cycle about different topics should be prepared and integrated into the curriculum.

5. Teachers should design the lessons to develop scientific epistemological beliefs of students.

6. Curriculum developers and teacher educators should be trained about learning cycle and its applications and they should periodically go to observe the science classes and give feedback to the teachers.

6.3 Recommendations for Further Research

According to the findings of this study, the researcher recommends that;

The study can be replicated in different school types with larger sample size to increase the generalizability.

The study can be carried out by using 7E learning cycle approach.

After the some period of time, a retention test can be given to look what students remember about what they learned and whether the learning cycle approach made a permanent learning about mentioned subjects.

The study can be carried out using different research methodologies combining qualitative and quantitative types.

The study can be carried out using not only learning cycle but also other constructivist teaching strategies.

The study can be carried out using longitudinal methodology to see the effect and development level of the learning cycle approach on students' understanding of specific science concepts, scientific epistemological beliefs and attitude toward science.

The study can be carried out for different grade levels and different subjects of science.

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APPENDICES

APPENDIX A

CELL CONCEPT TEST (CCT)

(HÜCRE HAVRAM TESTİ)

Sevgili Öğrenciler,

Aşağıda hücre konuları ile ilgili, 15 adet çoktan seçmeli soru bulunmaktadır. Her sorunun bir doğru yanıtı vardır, doğru olan yanıtı daire içine alınız.

1. Aşağıdaki organellerden hangisi yalnızca hayvan hücresinde bulunur?

a) Mitokondri
b) Sentrozom
c) Golgi aygıtı
d) Ribozom

2. Hücre zarı ile ilgili olarak aşağıdakilerden hangisi söylenemez?

a) Hücrenin çevresiyle alış verişini yapmasını sağlar.
b) Hayvan hücresinde bulunmaz.
c) Çok ince yapılıdır.
d) Seçici geçirgendir.

3. Hücredeki ribozom sayısı normalinden daha fazla ise, bu hücre için nasıl bir çıkarım yapılabilir?

a) Bir hayvan hücresidir.
b) Hücredeki protein sentezi hızlıdır.
c) Hücrenin metabolizma hızı yavaşlamıştır.
d) Hücrede, yaşamsal etkinlikler normal sevrinde devam etmektedir.

4.

I. İçinde bir ya da bir kaç çekirdekçik bulunur.
II. Sitoplazma içinde dağılmış durumdadır.
III. Hücrenin yönetim merkezidir.

Yukarıdakilerden hangisi ya da hangileri hücrede yönetimden sorumlu temel yapı ile ilgili özelliklerdendir?

a) I
b) II
c) I, III
d) I, II, III

5. Sitoplazmasında fazla miktarda mitokondri bulunan bir hücrenin birbirinden farklı yaşamsal faaliyetleri ile ilgili olarak aşağıdakilerden hangisini söylemek doğru olmaz?

a) Protein sentezi hızlıdır.
b) Hücre içi sindirim yapmaktadır.
c) Hücre su almaktadır.
d) Bölünmeye hazırlanmaktadır.

6. Ağzımızda salgılanan tükürük, hem ağız kuruluğunu önler hem de besinleri ıslatarak sindirime yardımcı olur.

Buna göre tükürüğün oluşumunu sağlayan hücreler topluluğunda hangi organele rastlanması gerekir?

a) Ribozom
b) Endoplazmik Retikulum
c) Lizozom
d) Golgi aygıtı

7. ‘Hareket enerjisi’ ile ‘makine’ arasında bir ilişki vardır. ‘Vücut enerjisi’ ile aşağıdakilerden hangisi arasında buna benzer bir ilişki kurulabilir?

a) Hücre
b) Güneş
c) Besin
d) Organ

8. Aşağıdaki organel çiftlerinden hangisi hem bitki hem hayvan hücresinde bulunur?

a) Mitokondri-sentrozom
b) Endoplasmik retikulum-plastid
c) Golgi aygıtı-mitokondri
d) Hücre zarı-hücre çeperi

9. Aşağıda verilen hücre içi yaşamsal faaliyetlerden hangisi bir parçalanma olayıdır?

a) Proteinlerin oluşması
b) Enerji açığa çıkması
c) Yağların oluşumu
d) Selüloz yapının meydana gelmesi

10. Aşağıdaki organellerden hangisinin karşısına onunla ilgili bir görev yazılmamıştır?

a) Endoplazmik retikulum-Madde iletimi

b) Lizozom-Protein sentezi

c) Mitokondri-Enerji üretimi

d) Golgi aygıtı-Salgı paketleme

11. Bitki hücresinde, hücreyi koruyan ikinci bir yapının olması hücreye nasıl bir kolaylık sağlar?

a) Hücre içi madde alışverişini kolaylaştırır.

b) Hücrenin daha uzun ömürlü olmasını sağlar.

c) Hücrenin besin üretim hızına yardımcı olur.

d) Hücre daha kısa sürede sayıca artış gösterir.

12. Canlılarda, besinlerin sindirilmesi, soluk alıp verme, soyun devamı gibi faaliyetler yaşamsal faaliyetlerdir ve ilgili organlar tarafından gerçekleştirilir.

Hücre içinde yaşamsal faaliyetlerin gerçekleştiği bölüm aşağıdakilerden hangisidir?

a) Çekirdek

b) Sitoplazma

c) Hücre zarı

d) Kromatin

13. Hücre içinde bilinmeyen bir olay nedeniyle, hücrenin bütün lizozomları patlarsa aşağıdakilerden hangisi söylenebilir?

a) Hücrede enerji üretimi artar.

b) Hücre kendini sindirir.

c) Protein sentezi yavaşlar.

d) Solunum yavaşlar.

14. Hücre zarından bazı maddelerin geçmesi, bazı maddelerin ise geçmemesi aşağıdakilerden hangisi ile açıklanabilir?

a) Hücre zarının seçici geçirgen oluşuyla

b) Hücre zarının yapısındaki maddelerle

c) Hücre zarında protein, yağ ve iyon oluşuyla

d) Hücre içinde sitoplazma ve çekirdek oluşuyla

15. Bir canlının kalıtsal bilgileri nerede ve ne şekilde depolanır?

a) Hücre-sitoplazma

b) Çekirdek-kromozom

c) Sitoplazma-RNA

d) Hücre-çekirdek

APPENDIX B

TABLE OF CCT SPECIFICATION

Obj.Level→ Questions No. ↓	Knowledge	Comprehension	Analysis	Synthesis	Evaluation
1		X			
2		X			
3			X		
4		X			
5			X		
6				X	
7			X		
8		X			
9		X			
10		X			
11			X		
12		X			
13			X		
14		X			
15	X				

APPENDIX C

SCIENCE ATTITUDE SCALE

(FEN BİLGİSİ DERSİ TUTUM ÖLÇEĞİ)

Bu ölçek, Fen Bilgisi dersine ilişkin tutum cümleleri ve her cümlenin karşısında sizin düşüncenizi ölçen beş seçenek içermektedir. Lütfen her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

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1. Hiç Katılmıyorum 2. Katılmıyorum 3. Kararsızım 4. Katılıyorum
5. Tamamen katılılıyorum

1) Fen Bilgisi çok sevdiğim bir alandır.
2) Fen Bilgisi ile ilgili kitapları okumaktan hoşlanırım.
3) Fen Bilgisinin günlük yaşantıda çok önemli yeri yoktur.
4) Fen Bilgisi ile ilgili ders problemlerini çözmekten hoşlanırım.
5) Fen Bilgisi konuları ile ilgili daha çok şey öğrenmek isterim.
6) Fen Bilgisi dersine girerken sıkıntı duyarım.
7) Fen Bilgisi derslerine zevkle girerim.
8) Fen Bilgisi dersine ayrılan ders saatinin daha fazla olmasını isterim.
9) Fen Bilgisi dersine çalışırken canım sıkılır.
10) Fen Bilgisi konularını ilgilendiren günlük olaylar hakkında daha fazla bilgi edinmek isterim.
11) Düşünce sistemimizi geliştirmede Fen Bilgisi öğrenimi önemlidir.

12) Fen Bilgisi çevremizdeki doğal olayların daha iyi anlaşılmasında önemlidir.
13) Dersler içinde Fen Bilgisi dersi sevimsiz gelir.
14) Fen Bilgisi konuları ile ilgili tartışmalara katılmak bana cazip gelmez.
15) Çalışma zamanımın önemli bir kısmını Fen Bilgisi dersine ayırmak isterim.

APPENDIX D

EPISTEMOLOGICAL BELIEF QUESTONNAIRE(EBQ)

Sevgili öğrenciler,

Aşağıda verilen anket sizlerin bilim hakkındaki düşüncelerinizi almak amacıyla hazırlanmıştır. Anketi yanıtlarken, verilen ifadelere ne derece katıldığınızı ya da katılmadığınızı ilgili kutucuğun içini karalayarak belirtiniz. Eğer kararınızı değiştirirseniz, vermek isteğiniz yanıta çarpı işareti koyarak bir sonraki soruya geçiniz.

Yardımlarınız için çok teşekkürler☺

1. **İsim&Sınıf :__________**

2. **Cinsiyet: ❑ Kız ❑ Erkek**

3- **Genel Not Ortalamanız: __________**

4. **Fen Bilgisi Dersinin Geçen Dönemdeki Karne Notu : __________**

5. **Annenizin mesleği _____________________**

6. **Annenizin Eğitim Durumu**

❑ Hiç okula gitmemiş ❑ İlkokul ❑ Ortaokul

❑Lise ❑Üniversite ❑Yüksek lisans (Yüksek Lisans/ Doktora)

❑Okuma yazma bilmiyor

7. **Babanızın mesleği____________________**

8. **Babanızın Eğitim Durumu:**

❑ **Hiç okula gitmemiş** ❑ **İlkokul** ❑ **Ortaokul**

❑**Lise** ❑**Üniversite** ❑**Yüksek lisans (Yüksek Lisans/Doktora)**

❑**Okuma yazma bilmiyor**

1. Kesinlikle katılmıyorum 2. Katılmıyorum 3. Kararsızım

4. Katılılıyorum 5. Kesinlikle katılmıyorum

1) İnsanlar, bilim insanlarının söylediklerine inanmak zorundadır.
2) Bilimde, bilimsel kitapların söylediklerine inanmak zorundasınız.
3) Fen Bilgisi dersinde, öğretmenin her söylediği şey doğrudur.
4) Bilimsel kitaplarda okuduğunuz her şeyin, doğru olduğuna emin olabilirsiniz.
5) Sadece bilim insanları kesin olarak, bilimde neyin doğru olduğunu bilirler.
6) Bilimde, bütün soruların tek bir doğru yanıtı vardır.
7) Bilimle uğraşmanın en önemli kısmı, doğru yanıta ulaşmaktır.
8) Bilim insanları bilim hakkında hemen hemen her şeyi bilir, onun için; bilinecek daha fazla bir şey kalmamıştır.
9) Bilimsel bilgi her zaman doğrudur.
10) Bilim insanı bir deneyden sonuç aldğı zaman, o deneyin başka bir yanıtı yoktur.
11) Bilim insanları bilimde neyin doğru olduğu konusunda her zaman hemfikirdirler.
12) Günümüzdeki, bilimsel bilgiler; bilim adamlarının daha önce düşündüklerinden farklıdır.
13) Bilimsel kitaplardaki düşünceler bazen değişir.

14) Bilim insanlarının bile yanıtlayamadığı bazı sorular vardır.
15) Bilimsel bilgiler bazen değişir.
16) Yeni buluşlar, bilim adamlarının doğru olarak düşündüğü şeyleri değişir.
17) Bilim insanları, bilimde neyin doğru olduğu ile ilgili bilgilerini bazen değiştirirler.
18) Bilimsel deneylerdeki fikirler, meraklı olmaktan ve neyin nasıl çalıştığı hakkında düşünmekten gelir.
19) Bilimde, bilim insanın düşüncelerini test edebilmesi için birden fazla yol olabilir.
20) Neyin nasıl çalıştığı hakkında yeni fikirler bulmak için deneyler yapmak, bilimin önemli bir kısmıdır.
21) Bulduklarınızdan emin olmak için, deneyleri birden fazla denemek faydalıdır.
22) Bilimdeki doğru çıkarımlar, sadece bilim insanlarından değil herhangi birinden de gelebilir.
23) Deney yapmak, bir şeyin doğru olduğunu bilmenin bir yoludur.
24) Doğru çıkarımlar, bir çok farklı deneyden çıkan sonuçlara dayanır.
25) Bilimsel bilginin ana kaynağı, sizin konu ile ilgili sorularınız ve yaptığnız deneysel çalışmalar olabilir.
26) Bir deneye başlamadan önce, bir fikrinizin olması iyidir.

APPENDIX E

5E LEARNING CYCLE –I

5E ÖĞRENME MODELİNE DAYALI HÜCRE ve ORGANELLERİ DERSİ

TEŞVİK ETMEK:

Günlük yaşamda kullanımı yaygın olan, bilgisayarlar ve otomobiller ile ilgili sorular sorulur. Örneğin, Hiç bilgisayar ya da otomobil tamir edilirken gördünüz mü? Bilgisayarın kasasını ya da monitörünü meydana getiren parçalar nelerdir? Otomobili meydana getiren parçalar nelerdir? (Bir tartışma ortamı oluşması sağlanır.) Peki, bu araçlarda olduğu gibi acaba gözle görülebilen ve görülemeyen canlıları da meydana getiren yapılar var mıdır? Yoksa, canlı tek bir parçadan mı ibarettir?

Öğrencilerden 'flubber' etkinliği için gerekli malzeme listesi, yapılacak etkinlik açıklanarak kendilerine verilir.

ETKİNLİK-1

Flubber :

- Küçük beyaz ya da şeffaf balon
- Balonun içine doldurabileceğiniz bir miktar akışkan (jöle olabilir)
- Organelleri temsil edecek farklı parçalar (renkli boncuklar, düğmeler, kurdelalar...)

Açıklama: Küçük şeffaf ya da beyaz balon içine bir miktar jöle konur, daha sonra düğme, boncuk, kurdela gibi farklı renkteki ve farklı boydaki cisimler jölenin içine yerleştrilir. Öğrencilerin balonun içine jöle koymaları esnasında onlara gerekli yardım ve yönlendirme sağlanır.

Öğrenciler 4'lü gruplar haline getirilerek, kendilerinden istenen materyaller ile 'flubber' yapmaları istenir. Etkinliğin yapım sürecinde öğrencilerden gelebilecek sorular 'hücre ve organel' sözcükleri kullanmadan yanıtlanabilir. Ya da öğretmen etkinlik yapım sürecini öğrencilerin zihninde 'Ne yapıyoruz?', 'Yaptığımız şey acaba neyi anlamamızı sağlayacak?' gibi yönlendirici düşüncelere itebilecek belirli soruları sorabilir.

Etkinliğimizde;

- Sizce balon neyi temsil ediyor?
- Sizce boncuk, düğme, kurdela v.b şeyler neyi temsil ediyor?
- Sonuçta elde ettiğimiz model acaba bize ne hakında bilgi verecek?

gibi sorular ile öğrencilerin bu etkinliği bir amaç için yapıyor oldukları ve acaba sonuçta nasıl bir şey elde edeceklerini düşünmeleri sağlanır. Öğrencilerden gelecek yanıtlar doğru da olsa yanlış da olsa yorum yapılmaz.

KEŞFETMEK:

Öğrencilere daha önce mikroskop kullanıp kullanmadıkları ve preparat hazırlayıp hazırlamadıkları sorulur. Gelebilecek yanıtlar doğrultusunda mikroskop ve işlevi konuşulur.

Mikroskop ile ilgili önbilgi bir kaç cümle ile verilir. Öğretmen öğrencilerle birlikte, 'ağız içi epitel ve soğan zarı preparatı ' hazırlar. Mikroskop kullanımı sonrasında, öğrencilerden gerekli alan temizliğini yapmaları önemle hatırlatılır. Öğrencilerden hazırladıkları preparatları dikkatlice incelemeleri ve gördükleri şekli olduğu gibi çizmeleri istenir. Sonrasında etkinlik kağıdı öğrencilere dağıtılır ve yirmi dakikalık süre içerisinde tamamlamaları istenir.

ETKİNLİK -2

Bitki ve Hayvan Hüclerinin Benzerlikleri ve Farklılıkları Var mıdır?

Gözlemleriniz doğrultusunda aşağıdaki sorulara yanıt veriniz.

1- Ağız içi epitel ve soğan zarı peraratında görüklerinizi çiziniz.
2- Her iki hücre tipininin şeklini açıklayınız.
3- Aynı büyüklükteler mi?
4- Görünüşleri birbirine ne kadar benziyor ya da ne kadar farklı?
5- İki farklı hücre içinde ne tür yapılar gözlemlediniz?
6- İki hücre arasındaki benzerlik ve farklılıkları bir tablo çizerek açıklayınız.

AÇIKLAMA:

Öğrencilerin verdikleri yanıtların tartışma ortamı içinde paylaşımından sonra, ‘hücre’ sözcüğü tahtaya yazılır. Bu yapının en basit ve sade tanımlaması verilir. Hücre: Bitki ve hayvanların en küçük yapıtaşıdır ya da hücre en küçük canlılık birimidir. Öğrencilerden hücre ve organellerini açıklayan *‘Hücre Kitapçığı’* hazırlamaları istenir (grup halinde veya ayrı ayrı). Daha sonra, hücre ile ilgili bilgileri öğrencilere sorular (Canlılığın yapısını oluşturan en küçük birim nedir?, Bu birimin yapısını nasıl açıklarsınız?, Bu birim içerisinde yer alan yapılar neler olabilir?, Bu birimin yerine getirdiği görevleri neler olabilir?...) sorularak açıklanır.

HÜCRENİN YAPISI

Canlıların en küçük temel yapı birimine hücre denir.

Hücreler ökaryot ve prokaryot olmak üzere iki kısımda incelenir.

Prokaryot hücre:

Kalıtım maddesi (DNA) etrafında çekirdek zarı bulunmayan ve ribozom hariç diğer hücre organellerine sahip olmayan ilkel, basit yapılı hücre tipidir. DNA sitoplazma içinde serbest bir biçimde hareket etmektedir. Bakteri ve mavi - yeşil alg örnek verilebilir.

Ökaryot hücre:

Kalıtım maddesi (DNA) etrafında çekirdek zarı bulunan ve hücre organellerine sahip olan gelişmiş hücre tipidir. Bitki, hayvan, mantar hücreleri örnek verilebilir. Ökaryot bir hücre üç ana kısımda incelenir. Bunlar dıştan içe doğru; hücre zarı, sitoplazma ve çekirdektir

Hücre zarı, Sitoplazma, Çekirdek:

1. Hücre Zarı: İki protein tabakası arasında, iki yağ tabakasından oluşmuştur. Proteinlerin bir kısmına karbonhidratlar bağlıdır. Bitkisel ve hayvansal tüm hücrelerde bulunan zar; canlı, seçici-geçirgen, saydam ve ince özelliktedir. Zar, hücreyi korur, şekillendirir, madde alış verişini kontrol eder. Hücre zarının birçok önemli fonksiyonu vardır; Hücreyi dış ortamdan ayırır, korur, ve seçici geçirgendir; yani zararlı maddeleri hücre içine alamaz, faydalı maddeleri de dışarıya geçirmez. Hücre zarının bunu nasıl başardığını anlamak için küçük delikli bir süzgeci düşünelim. Süzgeçle bir salkım üzüm yıkadığımızda su, deliklerden geçer ama delikler üzümlerin geçmesine izin vermeyeceğinden üzümler süzgecin içinde kalır. Sadece belirli maddelerin geçmesine izin veren bir yapıya **seçici geçirgen** denir. Seçici geçirgen olan hücre zarı su, oksijen, karbondioksit ve diğer küçük molekülleri geçirir. Zardaki bir katman lipit moleküleri içerir. Bu moleküller, katman içinde hareket edebilmektedir. Lipit molekülleri hareket ederken aralarında küçük boşluklar oluşur. Su ve diğer küçük moleküller bu boşluklardan hücreye girip çıkabilir.

Hücre zarı protein moleküllerini de içerir. Proteinler hücre zarı içinde yüzer ve maddelerin hücre içerisine giriş çıkışına yardımcı olur.

Araştıralım!!

Hücre içindeki yapıları belirli bir zarla çevrili olup olmamalarına göre araştırıralım.

2. Sitoplazma: Hücre zarı ile çekirdek arasını dolduran, canlı, renksiz, yarısaydam, suda çözünmeyen bir sıvıdır. Yapısında su ve çeşitli maddeler bulundurur, akışkandır. Organeller Sitoplazma içinde yer alır ve bu yapılar hücrenin hayati faaliyetleri için gereklidir. Bu sıvıda protein, yağ, karbonhidrat ve vitaminler vardır.

Hücre Organelleri:

Mitokondri:

Hücrenin enerji üretim merkezleridir. Solunum olayını gerçekleşmesine olanak verir. Sayıları hücrelere göre değişebilir. Matrix, krista iç yapıyı oluşturur. Ayrıca içerisinde ribozom organeli ve kalıtım maddesi bulundurur. (DNA)

Araştıralım!! (Ev ödevi olarak verilecek)

Doğduğumuz zaman hem annemize hem de babamıza ait bir çok özellik bizimle birlikte gelir. Peki, sahip olduğumuz mitokondrileri annemize borçlu olduğumuzu biliyor muydunuz? Neden böyle olduğunu araştıralım.

Ribozom:

Görevi protein sentezini gerçekleştirmektir. RNA molekülü içerir.

Endoplazmik Retikulum:

Madde taşınmasında görevlidir. Hücre çekirdeği ve hücre zarı ile bağlantılıdır. Üzerinde ribozom bulunduranlara granüllü E.R. denir. Sitoplazma içindeki alanın büyük bir bölümünü kapsar. Ribozomlar tarafından yapılan bazı proteinler, endoplazmik retikulum tarafından hücre zarına taşınır, oradan da diğer hücrelere gönderilir. Diğer proteinler ise endoplazmik retikulum tarafından, daha fazla işlem görmek üzere, golgi cisimcikleri olarak adlandırılan organellere götürülür.

Golgi Cisimciği:

Hücre için gerekli salgıları salgılamakla görevlidir.

Araştıralım!!

Golgi sözcüğünün ne anlama geldiğini araştıralım. Acaba Golgi cisimciğine neden Golgi demişler, hiç merak ettiniz mi?

Lizozom:

Sindirim enzimleri taşır. Hücreye alman besinlerin sindirilmesinde görevlidir. Bitkisel hücrelerde bulunmaz.

Sentrozom (Sentriol):

Sentriol denen, birbirine dik iki silindirik çubuksu yapıdadır. Görevleri, hücrenin bölünmesine yardımcı olarak çoğalmayı kolaylaştırmaktır.Hücre bölünmesi sırasında iğ ipliklerinin oluşturulmasında görevlidir. Bitkisel hücrelerde bulunmaz.

Koful (Vakuol):

Tek hücrelilerde, sindirim ve boşaltım görevi yapar. Genç, bitki ve hayvan hücrelerinde küçüktür. Bitki yaşlandıkça koful da büyür. Genelikle su ve besin depolar.

Plastidler:

Bitki hücrelerinde bulunur, üç çeşittir.

I. Kloroplast: Yeşil renk pigmenti bulundurur. Fotosentezle görevlidir. Yapraklarda, otsu gövdede bulunur.

II. Kromoplast: Turuncu, sarı, kırmızı renk pigmenti bulundurur. Çeşitli vitaminleri kapsar, meyveye renk verir. Havuç, domates v.b...

III. Lökoplast: Renksiz plastidlerdir. Genellikle nişasta depo eder. Köklerde, tohumda bulunur.

Hücre Çeperi: Hücre zarı üzerinde selüloz birikmesi ile oluşur. Bitki hücresine sertlik ve desteklik verir. Bitki hücrelerinde bulunur.

3. Çekirdek : Hücresel olayların yönetilmesinde ve karakterlerin sonraki nesillere aktarılmasında görevlidir. Birden fazla çekirdeği olan hücreler olduğu gibi çekirdeği olmayan hücreler de vardır. Örneğin; bakterilerde ve mavi – yeşil alglerde hücre çekirdeği yoktur. Çekirdeksiz hücreler bölünemez.

Çekirdek dört ana bölümden oluşur.

I. Çekirdek Zarı: Çift katlı olup, hücre zarının sahip olduğu tüm özelliklere sahiptir. Hücre bölüneceği zaman eriyerek kaybolur.

II. Çekirdek Plazması: Hücre sitoplazmasına benzer yapıdadır. İçerisinde organik bileşikler ve nükleik asit bulundurur.

III. Çekirdekçik: Çekirdek içerisinde bulunan koyu renkli taneciktir. Birden çok olabilir. Hücre bölünmesi esnasında kaybolur.

IV. Kromatin iplik: Çekirdek sitoplazması içerisinde, ağ şeklindeki yapılardır. Hücre bölünmesi esnasında kısalıp kalınlaşarak kromozom adını alır.

Kromozom sayısı, türlere göre değişkenlik gösterir. Örneğin insanda 46, soğanda 16 kromozom bulunur.

Nükleik Asitler

DNA (Deoksiribonükleik asit) ve RNA (Ribonükleik asit) olmak üzere iki çeşittir.

DNA nükleotid dizilerinden yapılmış büyük moleküllerdir. Nükleotidler bir organik baz bir de-oksiriboz şekeri ve birde fosfat (fosforik asit) grubundan oluşur.

Kromozomlar üzerinde bulunan ve karakterlerin nesiller boyu aktarılmasını sağlayan yapılara gen denir.

Her özellik için iki gen bulunur. Dişi ve erkekten gelen genler.

Her özellik şifresiz en az üç organik baz tarafından temsil edilirler.

ETKİNLİK-3

TANITICI KART HAZIRLAMA ETKİNLİĞİ

Öğenciler buldukları bitki ve hayvan hücresi resimlerini ve organel resimlerini hazırladıkları aynı boyda ve dikdörtgen biçimindeki kartonlara yapıştırırlar. Kartonların arkasına da hücre çeşidi ya da organel ile ilgili bilgiyi yazarlar. Kartları hazırlarken bitki hücresi ve ona ait organelleri yeşil kartona, hayvan hücresi ve ona ait organelleri sarı kartona, iki hücre çeşidinde ortak olan organelleri ise turuncu kartona yapıştırırlar.

GENİŞLETME:

Mikroskopta hazırlanan ağız içi ve soğan zarı preparatlarının başka hangi canlılardan yani nelerden hazırlanabileceği sorulur. Yazı tahtası bitki ve hayvan bölümü olarak ikiye ayrılır. Öğrencilerden gelen yanıtlar değerlendirilip, tahtadaki ilgili bölüme yazılır. Bitkiler ve hayvanlar dışında başka canlıların olup olmadığı sorulur. Canlıların hücre yapılarına ve onların doğada yapabildikleri görevlere göre sınıflandırılabileceği açıklanır.

ETKİNLİK-4

Kimlik Kartı

Öğrencilerden sınıflandırmada tanıdıkları herhangi bir canlıyı seçmeleri ve onun için kimlik kartı hazırlamaları istenir.

ETKİNLİK-5

O Ne Tür Bir Hücre?

Aşağıda hücre çeşitlerine (prokaryot ya da ökaryot hücre) ait bazı özellikler verilmiştir. Verilen özelliğin yanındaki çizgiye , Ökaryot (Ö), Prokaryot (P) veya Her ikisi de (H) sözcüklerinin baş harflerini yazınız.

_ Metabolizmaya sahiptir.

_ Sınırları belirli bir çekirdeği vardır.

_ Büyür.

_ Ürer.

_ Besinleri içine alır.

_ Sınırları belirli bir çekirdeği yoktur.

_ Artık ürünleri hücre dışına atabilir.

_ Hücre içi su miktarını dengede tutar.

_ Golgi cisimciğine sahiptir.

_ Hücre zarından difüzyon ile madde geçişi olabilir.

_ Bakteriler bu grupta incelenir.

DEĞERLENDİRME:

Sınıf içinde yapılacak çalışmada, konu ile ilgili kavram haritası yapımı ile öğrencilerin konuyu özetlemeleri sağlanır. Kavram haritası yapımı sırasında; hücre, bitki hayvan, hücre duvarı, hücre zarı, çekirdek, kloroplast sözcüklerinin kullanılması istenir.

Sınıf çalışmaları sonrası için öğrencilerden, bitki ve hayvan hücresi posteri hazırlamaları istenir. Öğrencilerin 2' li gruplar halinde yapacağı bu çalışmada, öğrencilerden büyük boy beyaz karton üzerine bitki ve hayvan hücresi posteri hazırlamaları istenir. Öğrencilerin hayal güçlerini sınırlamamak için, çalışmalarını kısıtlayıcı herhangi bir yönerge verilmemelidir. Ayrıca, tüm organelleri içine alan bir hücre modeli yapımı da proje ödevi olarak veriir. Hücre modeli yapımı sırasında, öğrencilerin maliyeti uygun olması açısından geri dönüşüm malzemeleri (köpük, sünger, plastik poşet vs.)kullanmaları konusunda yönlendirme yapılır.

APPENDIX F

SAMPLE ACTIVITIES

Etkinlik: Hücre Kitapçığı

Öğrencilerden, hücre ve içinde bulunan yapılarla ilgili olarak, araştırma yapmaları ve bu araştırmaları sonucu elde ettikleri bilgilerden bir kitapçık hazırlamaları istenir. Kitapçığa, kapak ve içindekiler bölümlerini eklemeleri ve hücre ile ilgili bulabildikleri resimleri de koymaları istenir.

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Etkinlik: Kimlik Kartı

Öğrencilerden, hücre organellerini tanıtıcı ve açıklayıcı, resimli tanıtıcı kartlar hazırlamaları istenir. Hazırladıkları tüm kartların, boyutlarının aynı olmasına dikkat etmeleri gerektiği belirtilir.

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