

## EFFECTIVENESS OF 5E LEARNING CYCLE INSTRUCTION ON STUDENTS' ACHIEVEMENT IN CELL CONCEPT AND SCIENTIFIC EPISTEMOLOGICAL BELIEFS\*

### 5E ÖĞRENME MODELİNİN ÖĞRENCİLERİN HÜCRE KONUSUNDAKİ BAŞARI VE BİLİMSEL EPİSTEMOLOJİK İNANÇLARINA OLAN ETKİSİ

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**ÖZET:** Bu çalışmanın amacı 5E öğrenme modelinin 6.sınıf öğrencilerinin hücre konusundaki başarı ve bilimsel epistemolojik inançları üzerine etkisini araştırmaktır. Epistemolojik İnanç ölçeği ve Hücre Kavram testi dört ayrı sınıfta okuyan toplam 153 altıncı sınıf öğrencisine ön-test ve son-test olarak uygulanmıştır. Uygulamada iki sınıf deney ve kontrol grubu olarak seçilmiştir. Deney grubundaki öğrenciler dersi 5E öğrenme modeli ile işlerken, kontrol grubundaki öğrenciler dersi geleneksel öğretim yöntemi ile işlemişlerdir. Veriler çökyönlü varyans analizi kullanılarak analiz edilmiştir. Sonuçlar her iki grup arasında deney grubu lehine anlamlı bir fark olduğunu ortaya koymuştur. Ayrıca, 5E öğrenme modeli ile öğrenim gören deney grubu öğrencilerinin hücre konusundaki başarılarının ve bilimsel epistemolojik inançlarının, kontrol grubu öğrencilerine göre anlamlı derecede yüksek olduğu bulunmuştur.

**Anahtar sözcükler:** hücre, 5E öğrenme modeli, bilimsel epistemolojik inançlar

**ABSTRACT:** This study investigated the effectiveness of 5E learning cycle on 6<sup>th</sup>-grade students' achievement of cell concepts, and their scientific epistemological beliefs. Epistemological Belief Questionnaire and the Cell Concept Test were administered as pre-test and post-test to a total of 153 sixth grade students in four intact classes of an elementary school. Two classes were randomly assigned as control and experimental groups. Experimental groups received 5E learning cycle instruction and control groups received traditional instruction. The data were analyzed using multivariate analysis of covariance. Results showed that treatment had a significant effect on the collective dependent variables. Univariate ANOVAs indicated a statistically significant mean difference between experimental and control groups regarding cell concepts achievement and epistemological beliefs in the favor of experimental groups.

**Keywords:** cell, 5E learning cycle, scientific epistemological beliefs.

## 1. INTRODUCTION

In an attempt to promote meaningful learning in science, a substantial body of research has accumulated in the last few decades has examined the effectiveness of different teaching strategies on students' understanding of variety of science concepts. One of the teaching strategies based on constructivist epistemology with a long history in science education is the learning cycle. It is a hands-on, minds-on teaching strategy derived from Piaget's mental functioning model that makes students aware of their own reasoning by helping students reflect on their activities (Scharmann, 1991). The learning cycle allows students to become active participants in the process of science as they construct understanding of scientific concepts. In addition, it provides opportunities for student interaction and dialogue through systematic instruction, learning experiences and activities in each of well-known phases (Barman, 1989).

Originating in an elementary science program called Science Curriculum Improvement Study (SCIS) by Robert Karplus learning cycle generally consists of three distinct phases: (1) exploration, (2) concept introduction, and (3) concept application (Renner & Marek, 1990). As long as the learning cycle has been used and researched for nearly four decades, science educators have extended the three phases into five, known as the 5E learning cycle: Engagement, Exploration, Explanation, Extension, and Evaluation (Trowbridge, Bybee, & Powell, 2000) and into 7, known as 7E learning cycle (Eisenkraft, 2003). The 7E learning cycle expands the Engagement phase into Engagement and Elicit

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and Elaborate and Evaluate phases into Elaborate, Evaluate and Extend. In general, every learning cycle has at its core the same inductive instructional sequence. Briefly, the learning cycle begins with the active engagement of students in investigating the natural phenomena. During exploration, students engage in hands-on activities as the basis for developing a specific concept and related vocabulary. In this phase, teacher acts as a facilitator, providing materials and directions, guiding the physical process of the activities. After the exploration, the teacher promotes a discussion period in which students share their observations with classmates. This is the time in which the teacher connects student experiences to the target science concept including the identification of scientific vocabulary. Once the concept has been labeled, students engage in additional activities in which they apply newly gained knowledge to unfamiliar areas (Settlagh, 2000).

Since 1960s, learning cycle been used effectively to teach of variety of science concepts, such as diffusion and osmosis (Odom & Kelly, 2001), plant nutrition (Lee, 2003), photosynthesis and respiration in plants (Balci, Cakiroglu & Tekkaya, 2006), mitosis (Lawson, 1991), ecology (Lauer, 2003) and cell (Wilder & Shuttleworth, 2004). For example, Barman, Barman and Miller (1996) investigated fifth grade students' understanding about sound concept and compared three-phased learning cycle instruction with textbook/demonstration method of instruction. Results indicated that students who were taught with learning cycle approach improved their understanding significantly better than the students who received textbook/demonstration instruction. In a similar vein, Odom and Kelly (2001) explored the effectiveness of concept mapping, the learning cycle, expository instruction, and a combination of concept mapping/learning cycle in promoting conceptual understanding of diffusion and osmosis. They found that the concept mapping/learning cycle and concept mapping treatment groups significantly outperformed compared to the expository treatment group in conceptual understanding of diffusion and osmosis. Studying with ninth and tenth grade students, Renner (1986) compared the effectiveness of the learning cycle and expository instruction in promoting gains in content achievement and intellectual development. The found that learners at the concrete level taught by the learning cycle method made significantly greater gains on concrete concepts, and moved more often from one developmental level to another when compared to students in the expository group. Similar findings were also reported by Purser and Renner (1983) and Schneider and Renner (1980). In a separate study, by adding a prediction/discussion phase at the begining of a three-phase learning cycle including exploration, term introduction and concept application Lavoie (1999) found that prediction/discussion-based learning cycle instruction when compared with traditional learning cycle produced significant gains for process skills, logical thinking and conceptual understanding in biology.

The present study also concerned about the effects of 5E learning cycle instruction on students' scientific epistemological beliefs. Epistemological beliefs involve learner' theories about knowing, nature of knowledge, and knowledge acquisition (Hofer & Pintrich 1997; Schommer, 1990). Some studies have attempted to examine effect of instruction on students' epistemological beliefs (Conley, Pintrich, Vekiri, & Harrison, 2004; Elder, 1999; Valanides & Angeli, 2005; Smith, Maclin, Houghton & Hennessey, 2000; Solomon, Scott, & Duveen 1996; Songer & Linn, 1991; Qian & Alverman, 1995). For example, in one of the earlier studies, Elder (1999) focused on the fifth grade students' epistemological beliefs on a science instruction which based on inquiry model of learning. Epistemological beliefs were investigated in five dimensions including the purpose of science, changeability of science, role of experiments in developing scientific theories, coherence of science and source of science knowledge. The students' epistemological beliefs were found to be a mixture of naïve and sophisticated understanding. The students having more sophisticated views about the purpose of science viewed scientists as active agents in recreation of scientific ideas. They also viewed scientific knowledge as changing over time and arising from reasoning and testing. Students who believed that they were active seekers of science hold similar beliefs about the nature of scientists' sources. The students who believed in the changeability of science knowledge also believed that knowledge derived from thinking and testing and they believed that knowledge does not come from teachers and experts. The researcher also broadened the study by investigating the relationship between epistemological beliefs of the students and science learning. Elementary students who hold

more sophisticated epistemological beliefs were found to perform better on assessment of circuits and electricity than did students who held less sophisticated beliefs. In a separate study, Conley et al. (2004) examined the changes in epistemological beliefs of fifth grade elementary students in relation to gender, ethnicity, socioeconomic status and achievement in nine week hands-on science unit. Conley and her colleagues used Elder's instrument that measured the epistemological beliefs of the students with four dimensions of (1) Source (beliefs about knowledge residing in external authorities); (2) Certainty (belief in a right answer); (3) Development (beliefs about science as evolving and changing subject); (4) Justification (role of experiments and how individuals justify knowledge. The researchers found out that students who had higher levels of achievement also had more sophisticated epistemological beliefs. Moreover, it was seen that young children's epistemological beliefs about science change over time, but they 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. The researchers suggested that students in constructivist learning environments developed more sophisticated epistemological beliefs compared with the ones in traditional classrooms. In another study, Smith et al. (2000) assessed the impact of elementary science experiences on sixth-grade students' epistemological views. They showed that students attending constructivist classroom improved their epistemological beliefs about science, while students in the traditional classroom developed an epistemology that focus on science as involving simple activities and procedures, or acquiring factual knowledge.

In line with these findings, current study investigated the effect of 5E learning cycle instruction on sixth grade students' cell concepts achievement and scientific epistemological beliefs.

In the study, cell topic was chosen due to its curricular significance. It is the fundamental part of the elementary science curriculum and considered to be abstract topic for students (Dreyfus & Jungwirth, 1988). In Turkey, cell concepts is taught in 6<sup>th</sup> grade as a part of "Reproduction, Growth and Development in Living Organism" and "Body Systems; in 7<sup>th</sup> grade in the context of "Body Systems", in the 8<sup>th</sup> grade as a part of "Cell Divisions and Inheritance" units. Thus, an understanding of cell is a prerequisite for systemic understanding of different biological concepts. In an effort to promote meaningful understanding, the present study sought to explore the following research question: What are the effects of methods of teaching on sixth grade students' achievement in cell concepts, and scientific epistemological beliefs when their prior-achievement and pre-epistemological beliefs test scores are controlled?

## **2. METHOD**

### **2.1. Participants**

The sample of the study consisted of a total of 153 sixth grade students in four intact classes of the elementary school which located in rural area were participated in the study. Two classes were randomly assigned as control and the other two as experimental groups. Experimental groups (n = 77) received 5E learning cycle instruction and control groups (n = 76) received traditional instruction. All the students involved in the study were instructed by the same science teacher and exposed to identical syllabus-prescribed content.

### **2.2 Instrument**

The data gathered from students included two kinds: Cell Concept Test, and Epistemological Belief Questionnaire.

### 2.2.1. Cell Concept Test (CCT)

The Cell Concept Test was used to measure student's achievement in cell concepts before and after the treatment. This test was developed by researchers by the examining the related literature and by taking the national science curriculum taking into consideration. The test assessed mainly students' achievement of basic concepts in cell, organelles, and types of materials transport in the cell. It consisted of 15 multiple-choice questions. 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 same area. The reliability coefficient of Kuder-Richardson 20 (KR20) was found to be .70.

### 2.2.2. Epistemological Belief Questionnaire (EBQ)

A 26-item Epistemological Belief Questionnaire was developed by Conley et al. (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 researchers. The reliability coefficient computed by Cronbach alpha estimates of internal consistency was found to be .83.

## 2.3. Research Design and Data Analysis

The non-equivalent control group design as a type of quasi- experimental design was used in the study. This design is characterized by the random assignment of already formed classes to experimental and control groups and administration of pretest and posttest to each group. Intact classes were used because it is too disruptive to the curriculum and too time consuming to take students out of their classes for treatment. In addition, because of administrative rules not students but the classes were chosen randomly. Four intact classes of 6<sup>th</sup> grade students were randomly assigned into two treatment groups: 5E learning cycle instruction (5E-LCI) and traditional instruction (TI). The participants in each group were tested immediately before and after the treatment. During that period, each group received an equivalent amount of instructional time and was provided with similar materials and assignments.

In this study, the independent variable was the instructional methods (5E-LCI and TI) and the dependent variables were student achievement and their scientific epistemological beliefs. Multivariate analysis of covariance (MANCOVA) was conducted on the two dependent variables, with pretreatment measures as the covariates, to determine any significant differences between the experimental and control groups. Wilks' lambda was utilized to test the difference between the two groups on the achievement and scientific epistemological beliefs posttest means. A level of confidence was set at .05.

## 2.4. Procedure

This study was conducted over a 3 weeks period. The classroom instruction for all 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. While the control groups received the traditional instruction which included lecture/discussion methods to teach concepts, the experimental groups taught by 5E learning cycle instruction. In order to facilitate the proper use of 5E-LCI 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 when needed. In this study, CCT and EBQ were administered to all students in the experimental and control groups before the treatment to determine their existing knowledge about cell concepts, and to understand their scientific epistemological beliefs, respectively. After the treatment, same instruments were administered to each experimental and control groups to determine the effect of treatment on students' cell concept achievement, and scientific epistemological beliefs.

Students in the experimental groups received 5E learning cycle instruction for the cell concept. Two separate 5E learning cycle lessons, one for cell and organelles and one for transportation of materials were designed. In the first phase, Engagement, students' interest and motivation were promoted by asking questions about cell and organelles. By this way, teacher tried to activate students' prior knowledge. In the Exploration phase, group of students engaged in an investigation in which they gathered their own data, explored and observed phenomena, and attempted to make sense of observations. At this time, teacher acted as a facilitator by providing materials, giving directions, asking questions, and encouraging student exploration. In this phase, for example, students provided with materials and prepared wet mount slides. Then, they examined both animal (epithelial cell), and plant cells (onion cell) under the microscope and recorded their observations on a worksheet provided by teacher and identified main parts of cell. They also identified the similarities and differences between animal and plant cells. Then, they discussed their observations with their peers. The third phase, Explanation, permitted students to make sense of their explorations. At this time, the teacher asked students to report their observation to the class and interpret the collective findings. Next, appropriate scientific vocabulary including cell, cell structure, and cell organelles was introduced. In this phase, each group of students was expected to prepare "identity card" for each cell structure. In these cards, they were requested to write the names and functions of the organelles found in the cell. The next phase, elaboration, gave the students the opportunity to extend their knowledge of concepts to other contexts. In this phase, for example, students were expected to make models of two cells- one plant and one animal using materials provided by teacher. Students also examined unidentified prepared slides showing various plant and animal cells. While examining each slide under the microscope, they labeled each sample as plant or animal. Each groups also shared their results. The final phase is Evaluation in which students' achievements were assessed by asking several open-ended questions about cell. In addition, they were asked to prepare a concept map related to cell and organelles.

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. After that, the teacher pursued the textbook to conduct experiments related with the cell concepts. Teacher prepared the slides by himself in the front of classroom. The students did not actively participate in this process; they only observed onion and epithelial cell under the microscope. After observation, students answered the questions posed by the teacher.

### 3. RESULTS

#### 3.1. Descriptive Statistics

Table 1 presents the means and standard deviations for the variables of the study. As can be seen from the post-test results, traditional instruction has limited success in both promoting cell concepts achievement and epistemological beliefs compared to the 5E learning cycle instruction.

**Table 1: Means and Standard Deviations of the Variables**

Variable	Experimental Group (N= 77)		Control Group (N= 76)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Pre-CCT	8.37	3.47	6.61	3.79
Pre-EB	88.94	12.51	87.34	9.68
Post-CCT	11.25	2.65	8.75	2.85
Post-EB	102.54	9.11	88.55	10.25

After checking the key assumptions, Multivariate analyses of covariances (MANCOVA) was conducted (Table 2) to determine the effect of method of teaching on students' achievement and scientific epistemological beliefs when pre-test scores of these tests were controlled as covariates.

**Table 2. MANCOVA Summary for Comparing Collective Variables of Achievement and Epistemological beliefs with respect to Mode of Instruction**

Source	Wilks' Lambda	F	Significance ( <i>p</i> )	Eta Squared
Pre-ACH	.759	23.502	0.000*	.24
Pre-EB	1.0000	.036	.964	.000
Group	.604	48.578	.000	.396

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

A statistically significant mean difference was found between the experimental and the control groups with respect to the collective dependent variables  $F(2,148) = 48.578, p = .000$ . The multivariate  $\eta^2$  based on *Wilk's A* showed that 40 % of multivariate variance of the dependent variables was associated with the treatment. This finding implied that the magnitude of the difference between the groups was very strong. The analysis also indicated significant effects for the covariates pre-CCT score,  $F(2, 148) = 23.502, p = .000, \eta^2 = 0.24$ .

A univariate ANOVA result for each dependent variable revealed that there were statistically significant effects of the method of teaching on students' cell concepts achievement,  $F(1,149) = 20,742, p < .05, \eta^2 = 0.12$ , and scientific epistemological beliefs,  $F(1,149) = 78,592, p < .05, \eta^2 = 0.35$ , when pre-test scores were controlled.

### 4. DISCUSSION AND CONCLUSION

This study explored the effect of 5E learning cycle and traditional instructions on sixth grade students' achievement of cell concepts, and their scientific epistemological beliefs. Multivariate analysis of covariances indicated a statistical significant difference between methods of instruction on students' cell concepts achievement in favors of 5E-LCI. Analysis also revealed that students who experienced 5E-LCI showed a significant change in their epistemological beliefs after the treatment, whereas students who experienced TI did not. The effects of students' prior knowledge and scientific

epistemological beliefs were covaried so that any statistically significant differences in achievement between the experimental and control groups could be attributed to the mode of instruction. In fact, analysis showed significant effects of students' prior knowledge on their achievement.

The present study indicated the effectiveness of 5E learning cycle approach over traditional instruction on students' cell concepts achievement and their epistemological beliefs. Indeed, the instructional strategies utilized in experimental group supported change in elementary students from passively receiving knowledge to actively examining their own conception. Students in the experimental group participated in activities that helped them think about their prior knowledge and reflect on it. Students were allowed to form connections among the concepts by themselves through explorations and discussions. In control group, on the other hand, this connection was made by the science teacher. In fact, the vital part of the 5E learning cycle instruction was the intensive interaction between teacher and student and student and student. Cavallo, Miller, and Saunders (2002) claimed that such interaction facilitates understanding, encourages conceptual restructuring, and gives opportunities for greater involvement. Five E learning cycle, according to Barman et al. (1996), provides opportunities for student interaction, learning experiences and activities in each of the well-known phases. In addition, students became aware of what they are learning by the help of the activities, experiments and projects that they involved in each phases of 5E. To be brief, 5E learning cycle instruction helped students to learn cell concepts through conducting experiments, drawing conclusions, solving problems relevant to their experiments, and by discussing their observations and findings with their peers and with the whole class.

The positive effect of 5E-LCI on students' achievement was supported by previous studies in the literature (Barman & Allard, 1993; Boddy, Watson, & Aubusson, 2003; Purser & Renner, 1983; Renner, 1986; Schneider & Renner, 1980; Saunders & Shepardson, 1987). For example, Barman and Allard (1993) revealed positive gains in student achievement in learning cycle instruction over the traditional lecture/laboratory format. Studying with primary school students, Boddy et al. (2003) showed that students found the unit of work fun and interesting and were motivated to learn. Present study is also consistent with the results reported by earlier studies that indicate positive effect of 5E-LCI on students' epistemological beliefs. For example, Smith, et al. (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) indicated that fifth-grade students' epistemological beliefs were modestly related to their learning in science and pointed to the importance of considering different types of learning. In her study, epistemological beliefs were also found to be integrally linked learning process skills only when those skills were embedded in a context of learning rich conceptual knowledge. The study by Baxter, Elder and Glasser (1994) 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 epistemological beliefs. Also, Smith et al. (2000) 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 et al. (2004) studied the change in young children's epistemological beliefs over the course of instruction in hands-on science classrooms. Such instruction leads 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. Conley et al. argued that this type of instruction is quite 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. Authors reported although the changes in epistemological beliefs were not large that students became more sophisticated in their beliefs about the source of knowledge and 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.

Overall results of the present study suggest that when students receive appropriate instruction which help them understand relevant ideas, sound understanding of cell concepts can be achieved. Present study, thus, contributes the classroom practices in the teaching of science concepts in general, cell in particular, and the development of suitable materials promoting students' achievement in different science concepts. This study, however, has some limitations to be considered. The study was conducted at a public school located in a rural area by utilizing intact classes. Data from other school districts and from different school types might give different findings. This study was limited to cell unit and 153 six grades. The results, therefore, may not be reliable if generalized beyond students enrolled in a similar situation.

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## GENİŞLETİLMİŞ ÖZET

Bu çalışmanın amacı 5E öğrenme modelinin 6.sınıf öğrencilerinin hücre konusundaki başarı ve bilimsel epistemolojik inançları üzerine etkisini araştırmaktır. Öğrenme evresi Piaget'nin ileri sürdüğü zihinsel gelişim kuramına dayanan bir öğrenme yaklaşımıdır. Bu yaklaşım ilk kez 1960'larda Karplus ve arkadaşlarının Fen Programını Geliştirme Çalışması (The Science Curriculum Improvement Study) adlı projede ortaya konmuştur. Bu yaklaşımın sınıftaki uygulaması için üç aşama önerilmektedir: keşfetme, kavram tanıtımı ve kavram uygulamasıdır. Öğrenme evresinin bu üç aşaması Piaget'nin zihinsel gelişim kuramının özümleme, düzenleme ve denge ilkelerine karşılık gelir. Daha sonraki yıllarda beş aşamalı (5E) ve yedi aşamalı (7E) öğrenme evresi tanımlanmıştır. Bu basamakların sayısı ne olursa olsun, öğrenme evresi modeli öğrencinin doğal dünyayı öğrenmesi ve anlamasını teşvik ederek ve aynı zamanda aktif katılımını sağlayarak başlar. Öğretmenin rolü ise öğrenmeye elverişli bir ortam oluşturmak ve öğrencilerin öğrenmelerine rehberlik etmektir. Keşfetme etkinliklerinden sonra, öğretmen bir tartışma ortamı yaratarak öğrencilerin gözlemlerini ve düşüncelerini birbirleriyle paylaşmasını sağlarken, bir yandan da yeni fen kavramlarını öğrencilerine sunar. Bir sonraki evrede ise öğrenciler yeni kazandıkları kavram ve becerileri yeni durumlara uygularlar. Yapararak ve düşünerek öğrenmeyi ön plana çıkaran 5E öğrenme modeli giriş, keşfetme, açıklama, genişletme ve değerlendirme olmak üzere beş aşamadan oluşur. 1960'lardan beri öğrenme evresi modeli çeşitli fen kavramlarının öğretiminde başarıyla uygulanmaktadır: diffüzyon ve osmoz (Odom & Kelly, 2001), bitkilerin besini (Lee, 2003), bitkilerde fotosentez ve solunum (Balci, Cakiroglu & Tekkaya, 2006), mitoz (Lawson, 1991), ekoloji (Lauer, 2003) ve hücre (Wilder & Shuttleworth, 2004). Bu çalışmada ayrıca 5E öğrenme modelinin öğrencilerin bilimsel epistemolojik inançlarına olan etkisi incelenmiştir. Epistemolojik inançlar bireylerin sahip olduğu bilginin ve öğrenmenin doğasına ilişkin inançları olarak tanımlanabilir (Hofer & Pintrich 1997; Schommer, 1990). Litaratürde kullanılan öğretimin öğrencilerin epistemolojik inançlarına olan etkisini inceleyen bir çok çalışma bulunmaktadır (Conley, Pintrich, Vekiri, & Harrison, 2004; Elder, 1999; Valanides & Angeli, 2005; Smith, Maclin, Houghton & Hennessey, 2000; Solomon, Scott, & Duveen 1996; Songer & Linn, 1991; Qian & Alverman, 1995). Bu bağlamda bu çalışmada iki farklı öğretim yönteminin (5E Öğrenme Modeli ve geleneksel öğretim yöntemi) altıncı sınıf öğrencilerin hücre konusundaki başarılarına ve bilimsel epistemolojik inançlarına olan etkisinin incelenmesi hedeflenmiştir. Bu amaç doğrultusunda, bu çalışma bir ilköğretim okulunun 4 ayrı sınıfında öğrenim gören toplam 153 altıncı sınıf öğrencinin katılımı ile gerçekleştirilmiştir. Sınıflardan ikisi deney grubu (n=77), diğer ikisi ise kontrol grubu (n = 76) olarak seçilmiştir. Üç hafta kadar süren uygulama sırasında deney grubundaki öğrenciler dersi 5E öğrenme modeli ile işlerken, kontrol grubundaki öğrenciler ise dersi geleneksel öğretim yöntemi ile işlemişlerdir. Öğrencilerin hücre konusundaki başarıları 15 adet çoktan seçmeli sorudan oluşan Hücre Kavram Testi ile ölçülmüştür. Öğrencilerin epistemolojik inançları ise Conley, Pintrich, Vekiri ve Harrison (2004) tarafından geliştirilen Bilimsel Epistemolojik İnanç Ölçeği ile

ölçülmüştür. Bu ölçek 26 adet madde ve 4 alt boyut içermektedir (bilginin kaynağı, bilginin kesinliği, bilginin gelişen doğası ve bilginin doğrulanması). Veriler çokyönlü varyans analizi (MANCOVA) kullanılarak analiz edilmiştir. Ön-test sonuçları ortak değişken olarak atanmıştır. Sonuçlar her iki grup arasında deney grubu lehine anlamlı bir fark olduğunu ortaya koymuştur ( $F(2,148) = 48.578, p = .000$ ). Analiz sonuçları; öğrenme evreleri yaklaşımı ile öğrenim gören deney grubu öğrencilerinin hücre konusundaki başarılarının ve bilimsel epistemolojik inançlarının, kontrol grubu öğrencilerine göre anlamlı derecede yüksek olduğunu göstermiştir. Bu çalışmanın sonucu, 5E öğrenme modelinin 6. sınıf öğrencilerinin hücre konusundaki başarılarında ve bilimsel epistemolojik inançları üzerinde etkili bir yöntem olduğunu göstermiştir.