A MODELING STUDY: THE INTERRELATIONSHIPS AMONG ELEMENTARY STUDENTS' EPISTEMOLOGICAL BELIEFS, LEARNING ENVIROMENT PERCEPTIONS, LEARNING APPROACHES AND SCIENCE ACHIEVEMENT

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ABSTRACT

A MODELING STUDY: THE INTERRELATIONSHIPS AMONG ELEMENTARY STUDENTS' EPISTEMOLOGICAL BELIEFS, LEARNING ENVIROMENT PERCEPTIONS, LEARNING APPROACHES AND SCIENCE ACHIEVEMENT

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This study is aimed to explore the relationships among elementary students' epistemological beliefs of science, perceptions of learning environments, learning approaches and science achievement. For this purpose, a model of the associations among these variables was proposed and tested by structural equation modeling. In this model, it was hypothesized that a) students' perceptions of their learning environments would directly influence their epistemological beliefs of science and learning approaches, b) students' epistemological beliefs of science would directly influence their learning approaches and science achievement, c) students' learning approaches would directly influence their science achievement. A total of 2702 students from 139 public elementary schools from İstanbul, Ankara, İzmir, Diyarbakır, Van, Antalya, Afyon, Eskişehir, and Samsun were administered three instruments to assess their epistemological beliefs of science, perceptions of learning environments, and learning approaches. Students' previous year final report card grades were used as the indicator of their science achievement.

Confirmatory factor analyses were conducted to determine the structure of students' epistemological beliefs of science, perceptions of learning environments, and learning approaches. Although multidimensionality of epistemological beliefs of science was supported, a different factor structure was obtained for Turkish elementary school students compared to the theoretically proposed structure for the instrument.

The results of the structural equation modeling generally supported the proposed hypotheses. The final model obtained in the study revealed that students' perceptions of the classroom environments directly predicted students' epistemological beliefs and learning approaches. Students' epistemological beliefs predicted their learning approaches and science achievement, and students' learning approaches influenced their science achievement.

Keywords: Epistemological Beliefs, Learning Environments, Learning Approaches, Science Achievement, Structural Equation Modeling

ÖZ

BİR MODELLEME ÇALIŞMASI: İLKÖĞRETİM ÖĞRENCİLERİNİN EPİSTEMOLOJİK İNANÇLARI, ÖĞRENME ORTAMLARI İLE İLGİLİ ALGILARI, ÖĞRENME YAKLAŞIMLARI VE FEN BAŞARILARI ARASINDAKİ İLİŞKİLER

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Bu çalışmada ilköğretim öğrencilerinin bilimle ilgili epistemolojik inançları, öğrenme ortamları ile ilgili algıları, öğrenme yaklaşımları ve fen başarıları arasındaki ilişkilerin incelenmesi amaçlanmıştır. Bu amaçla, sözkonusu değişkenler arasındaki ilişkileri açıklayan bir model önerilmiş ve yapısal eşitlik modellemesi kullanılarak test edilmiştir. Bu modelde, a) öğrencilerin öğrenme ortamları ile ilgili algılarının bilimle ilgili epistemolojik inançlarına ve öğrenme yaklaşımlarına doğrudan etki edeceği, b) öğrencilerin bilimle ilgili epistemolojik inançlarının öğrenme yaklaşımlarına ve fen başarılarına doğrudan etki edeceği, c) öğrencilerin öğrenme yaklaşımlarının doğrudan fen başarılarını etkileyeceği öne sürülmüştür. Istanbul, Ankara, İzmir, Diyarbakır, Van, Antalya, Afyon, Eskişehir ve Samsun illerinde bulunan 139 farklı devlet okulunda öğrenim gören toplam 2702 öğrencinin bilimle ilgili epistemolojik inançlarını, öğrenme ortamları ile ilgili algılarını ve öğrenme yaklaşımlarını belirlemek için üç farklı ölçüm aracı uygulanmıştır. Öğrencilerin bir önceki yıl karnelerindeki fen notları fen başarılarının göstergesi olarak kullanılmıştır.

Öğrencilerin epistemolojik inançlarının, öğrenme ortamlarıyla ilgili algılarının ve öğrenme yaklaşımlarının alt boyutlarını belirlemek için doğrulayıcı faktör analizi yapılmıştır. Sonuçlar epistemolojik inanışların çok boyutlu doğasını desteklemekle birlikte, Türk ilköğretim öğrencileri için kullanılan ölçüm aracının kuramsal olarak önerdiği faktör yapısından farklı bir yapı elde edilmiştir.

Yapısal eşitlik modellemesinin sonuçları genel olarak öngörülen hipotezleri desteklemektedir. Çalışmada elde edilen nihai model öğrencilerin öğrenme ortamlarıyla ilgili algılarının bilimle ilgili epistemlojik inançlarını ve öğrenme yaklaşımlarını doğrudan etkilediğini ortaya çıkarmıştır. Öğrencilerin bilimle ilgili epistemolojik inançları ise, öğrenme yaklaşımlarına ve fen başarılarına etki etmekte ve son olarak öğrencilerin öğrenme yaklaşımları fen başarılarınıetkilemektedir.

Anahtar Kelimeler: Epistemolojik inançlar, Öğrenme Ortamı, Öğrenme Yaklaşımları, Fen Başarısı, Yapısal Eşitlik Modeli

To My Parents

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AGFI: Adjusted goodness-of-fit index
CFA: Confirmatory factor analysis
CLES: Constructivist learning environment survey
CT: The changing and tentative feature of science knowledge
GFI: Goodness-of-fit index
IC: The invented and creative nature of science
LAQ: Learning approach questionnaire
ML: Meaningful learning
RL: Rote learning
RMR: Root-mean-square residual
RMSEA: Root-mean-square error of approximation
SCIACH: Science achievement
RCG: Report card grade
SEM: Structural equation modeling
SES: Socio-economic status
SEV: Scientific epistemological views questionnaire
SON: The role of social negotiation
S-RMR: Standardized root-mean-square residual

CHAPTER 1

INTRODUCTION

Science and technology plays an important role in most aspects of our daily life, and by the expanding role of science and technology in today's world, it becomes crucial to make all citizens scientifically literate (Rutherford, 2001). Today, scientific literacy is the common goal of science education in all over the world. Understanding nature of science and its' interdependence with the society is emphasized in reform documents (American Association for the Advancement of Science, 1990; Ministry of Education, 2004; Vazques-Alonso & Manassero-Mas, 1999). Similarly, in their report called "Beyond 2000: Science Education for the Future" Millar and Osborne (as cited in Osborne, 2007) stated that the primary and explicit aim of the science education is to enhance scientific literacy; which is necessary for all young people whatever their career aspirations or aptitudes are.

Scientific thinking should be understood by individuals in order to provide science to affect society in a positive way. Scientific literacy and scientific thinking is seen as compulsory skills in today's rapidly changing world. One of the main goals of science education is to provide scientific literacy in a public sense with an understanding of nature of science and its relationship with society; it's important to realize the role of science in daily life. Therefore, for the students who will be future citizens, science education should have a role to enable them to live and act with reasonable comfort and confidence in a society influenced and shaped by science (Osborne, 2007). Besides international (American Association for the Advancement of Science, 1990), national documents also emphasize the important function of science education to promote scientific literacy (Ministry of National Education, 2004).

According to Osborne (2007), for promoting the scientific literacy, science education should consists of four elements: the conceptual element building students' understanding of the knowledge and ideas in science, the cognitive element attempting to develop students' critical thinking ability in a scientific manner, ideas-about-science element attempting to develop students' understanding of the epistemology of science, and the social and affective element attempting to develop students' ability to work collaboratively and offering an engaging and stimulating experience to them. Since scientific literacy is not only seen as learning science concepts, but includes some aspects related to nature of scientific knowledge; more specifically the purpose of science, the development of scientific knowledge over time including scientists works and their interactions etc., epistemological understanding have been the particular interest to educators.

Emphasizing the importance of epistemological beliefs of science, independent from the advocated pedagogical or curricular focus, it has been documented in many curricular reforms and research reports that developing students' conceptions about the nature of science or in a broader sense epistemological views of science, has been a perennial objective of science education (American Association of the Advancement of Science, 1990; Lederman, 1992; National Research Council as cited in Tsai, 1999a). Therefore, it is universally accepted that understanding the epistemology of science is an essential part of any comprehensive science education (Osborne, 2007). Driver, Leach, Millar and Scott (1996) stated that there are some arguments for teaching science and more particularly teaching about science. These are: knowledge of the nature of science supports successful learning in science, contributes to more successful use of scientific knowledge in later life, and will enhance students' appreciation of science as a human endeavor.

Science education research has focused on students' views about epistemology of science in recent years. This increasing interest in students' epistemological beliefs in science stem from the assumption that these beliefs are important for students' science learning. Science educators indicated that students' epistemological views of science is an important factor in science learning, since it has effect on students' cognitive operations, conceptual change, learning approaches and attitudes toward science lessons (Edmondson, 1989; Hofer & Pintrich, 1997; Songer & Linn, 1991; Tsai, 1996; 1998a; 1999a). The findings in the studies suggest that in order to provide students' meaningful learning of science, it is imperative to develop their epistemological views of science. However, the research studies revealed that students generally have inadequate views or in other words empiricist views about the epistemology of science (Carey, Evans, Honda, Jay, & Unger, 1989; Driver, Leach, Millar, & Scott, 1996; Lederman, 1992).

The contemporary epistemological views of science, focused on the tentative, historical and humanistic features of scientific knowledge (Abd-El-Khalick & Lederman, 2000) and students' inadequacy in terms of having sophisticated epistemological views of science, initiated a reform movement in science education area (Duschl, 1990). Parallel to the contemporary epistemological views of science, Duschl (1990) stated that the goal of science education is to help students to understand the development of scientific knowledge besides helping for science knowledge acquisition. Science education should also teach how scientific knowledge is constructed, change and develop through time. The role of interaction among different views, cultural and social effects should also be given. However, it is known that with the traditional science education, teaching is only focused on the gaining of some scientific facts and give little attention to the process itself.

Students' beliefs about knowledge and knowing, or in other words epistemology of science affect their science worldview. The way students interpret science related activities may also have an effect on their science learning and even their career choice. Therefore, it is important to investigate how students think about science and its relationships with their lives, how they view science and its purposes (Boujoude & Abd-El-Khalick, 1995).

There are various studies in the literature examined the epistemological beliefs in relation to specific learning characteristics contributing or mediating the effects of those beliefs on science learning (Buehl, 2003). In classroom environments, individual students may approach the learning process in quite different ways, depending on whether they view knowledge as a set of isolated facts or an integrated set of constructs, or whether they feel themselves passive receptors or active constructors of knowledge. Therefore, their epistemological beliefs determine the way they make meaning of the encountered information (Hofer, 2002). Research have shown that students' who view science as a dynamic nature were less likely to believe that learning science depended on memorization, and therefore achieved a more integrated understanding of the topic under study (Songer & Linn, 1991).

Research on students' personal epistemology recognized that students' beliefs about the nature of knowledge affect their views on learning and how they learn (Elder, 1999). As Lederman (1992) stated, besides students, teachers also may have limited understanding of the nature of science. However, studies in the related literature have shown that view of the nature of science affect or at least related to learning (Pomeroy, 1993; Songer & Linn, 1991, Trautwein & Ludtke, 2007; Tsai, 1998a; 2002). Accordingly, there is a consensus on the science education research area that examining students' views about the epistemology of science is an important issue to promote students' better science learning.

Sophisticated epistemological beliefs are seen as the both an important aim of today's science education and a variable influencing science achievement (Hofer & Pintrich, 1997). There has been a growing interest on epistemological beliefs since the late 20th century (Chan & Elliot, 2004). Many researchers in the science education area have been interested in students' views about nature of science and epistemological beliefs about science (Boujaoude, 1996; Cano; 2005; Carey, Evans, Honda, & Unger, 1989; Chan, 2003; Conley, Pintrich, Vekiri, & Harrison, 2004; Duschl, 1990; Elder; 1999; Lederman, 1992; Lederman & Druger, 1985; Pomeroy, 1993; Rubba & Andersen, 1978; Ryan & Aikenhead, 1992; Smith, Maclin, Hougton, & Hennesey, 2000; Solomon, Duveen, & Scott, 1994; Tsai, 1996; 1998a; 1998b; 1999a; 2000a; 2000b; 2002). Researchers found significant relationships between achievement and epistemological beliefs in several studies; it has been showed that more sophisticated understanding of epistemology of science contributes better science learning outcomes (Hammer, 1994; Ryan, 1984; Schommer, 1990, 1993; Schommer, Crouse, & Rhodes, 1992; Songer, & Linn, 1991; Tsai, 1998b; 2000a).

and students' understandings of scientific knowledge are believed to be limited by their inadequate views of nature of science (Driver, Leach, Millar, & Scott, 1996).

Research in different cultures since 1970s has shown that learning approaches are the important variables explaining students' specific learning outcomes and academic achievement. The learning approach adopted by a student affects how he or she integrates knowledge and experience in a classroom. The learning process which is one of the main interests of researchers in education has prompted them to examine different approaches of individuals to learning process; in other words different learning approaches, and the factors associated with these approaches. In last years, research interest pays an increasing attention to one of these factors: beliefs about knowledge and learning or epistemological beliefs (Chan, 2003). Students' beliefs about the nature of knowledge and knowing have shown to influence their approaches the learning task in science (Edmondson & Novak, 1993; Lederman, 1992; Tsai, 1998a; 1999a, 2000b; Saunders, 1998). As the students develop more sophisticated view of epistemology of science, they more likely to use meaningful learning strategies in their science learning, and their attitude toward science become more positive.

The learning approaches utilized by the learners is accepted to be a variable potentially influencing the way the learners experience learning process and the strategies they used to learn (Cano, 2005). The type of learning approach that adopted by the learners, namely meaningful or rote learning, are affected by various factors. There are several studies in the science education literature investigating the students' learning approaches (Cavallo & Schaffer, 1994; Cavallo, 1994; 1996; Cavallo, Rozman, Blickenstaff, & Walker, 2004; Cano, 2005; Chan, 2003; Williams & Cavallo, 1995). Since 1970s numerous studies found out that gender, age, learning environment, time and learning experience were the variables believed to have an influence on students' learning approaches (Chan, 2003).

Research on learning approaches and its relationship to academic performance showed that deep approaches rather than surface approaches promote students' academic success (Bernardo, 2003; Boujaoude, 1992; Boujaoude & Giuliano, 1994; Cavallo, 1996; Cavallo & Schafer, 1994; Sadler-Smith, 1996;

Snelgrove & Slater, 2003; Van Rossum, 1984; Zeegers, 2001). Furthermore, it can be added that while students adopting deep approach generally perform better; surface approaches to learning negatively correlate with achievement (Watters & Watters, 2007). Similarly, Cavallo (1996) and Cavallo and Schafer (1994) found that meaningful learning was found to be related with course performance. Therefore, it can be said that meaningful understanding of science requires utilizing meaningful learning or deep learning.

It was also showed that school science experiences can dramatically affect students' development of scientific thinking about science in elementary school years. Smith, Maclin, Houghton, and Hennesey (2000) found that elementary grade students in constructivist classroom showed a clear development in terms of their epistemological views of science compared to students in a traditional science classroom.

Another line of research received an increased attention by the science education researchers is the classroom environment as a variable influencing epistemological beliefs of science, learning approaches and consequently science learning of students. There is an increasing recognition about the importance of the classroom environments in education research over the past 30 years in terms of conceptualization, assessment, and investigation of students' perceptions of the learning environments at elementary, secondary and also higher education levels (Alridge, Fraser, & Huang, 1999). There are some studies suggesting a relationship between classroom environment, instructional activities and epistemological beliefs of students (Carey, Evans, Honda, Jay, & Unger, 1989; Jehng, Johnson, &Anderson, 1993; Lederman & Druger, 1985; Roth, 1997; Smith, Maclin, Houghton, & Hennesey, 2000; Solomon, Duveen, Scott, & McCarthy, 1992; Tsai 1998a; 1999b; 2000b; Valanides & Angeli, 2005; Windschitl & Andre, 1998). Lederman (1992) emphasized that the most important variables affecting students' beliefs about nature of science are the specific instructional behaviors, activities, and decisions implemented within the context of lessons.

Yılmaz-Tüzün, Çakıroğlu and Boone (2006) found that students' attitudes toward chemistry class improved when the students perceived that their class as providing more opportunities for critical voice, shared control, student negotiation, personal relevance and uncertainty for scientific knowledge. Similarly, Lederman and Druger's study (1985) shows us that inquiry oriented instruction and a supportive classroom environment can help students to develop better understanding of nature of science.

Tsai (1998a; 1999b; 2000b) made several research studies examining the classroom environment and epistemological beliefs relationships in science learning contexts. Based on these studies, it can be said that appropriate learning environments (e.g implementing STS instruction) facilitated the development of constructivist oriented epistemological views of science for the students. Students holding constructivist views about science prefer learning science in a more constructivist learning environments. Therefore, it can be concluded that there is a close relationship between learning environments, epistemological beliefs and science learning of students. Supporting to this conclusion, Valanides and Angeli (2005) based on their research findings suggested that students' epistemological beliefs can change, when they are given the opportunity to work collaboratively, reflect their thinking and evaluate their beliefs.

In addition to the relationship among classroom environments, epistemological beliefs, and science learning, there are also relationships among classroom environments and students' learning approaches utilized in science learning. Students utilizing deep approach in learning perceived their classrooms as more personalized, more encouraging or active participation and they thought that they used inquiry skills. Providing a classroom environment in which personalized and investigative skills are used results with the students using deep approaches of learning (Dart, Burnett, Boulton-Lewis, Campbell, Smith, & McCrindle, 1999; Dart, Burnett, Purdie, Boulton-Lewis, Cambell, & Smith, 2000).

Since the understanding science requires deep or meaningful learning, improving the quality of learning outcomes may be provided with the establishment of a learning environment encouraging deep learning (Trigwell & Prosser, 1991). Enwistle and Tait (1990) concluded that students' learning approaches can be seen as a reaction to their learning environment, at least in some part, and they added that good teaching causes utilization of deep approach.

As seen in the related literature, science educators believe that epistemological beliefs in relation with learning approaches affect learning and performance in the classroom. Therefore, epistemological beliefs can be used to improve science learning and understanding of students. Diagnosing students epistemological beliefs in science help science educators to interpret students' understanding and views about scientific phenomena and plan more effective science instruction (Driver, Leach, Millar & Scott, 1996). In the light of the previous research studies, it can be said that students' beliefs about nature of knowledge are important in order to contribute students' learning and understanding of science. Most of the studies in science education hold the assumption that these beliefs influence students' learning approaches and perceptions related to science classrooms and further performance in science learning.

Since it is known that epistemological beliefs are vital components of students' science learning, curriculum efforts have made to include objectives related to these beliefs explicitly and therefore students are expected to develop some understandings of nature of science from early elementary grades (Lederman, 1992). Although science educators and researchers believe the importance of epistemological beliefs of students in science learning, limited studies have done related to elementary aged students. Most of the studies focused on high school or college students, or adults (Hammer, 1994; Ryan & Aikenhead, 1992) However, students' first experiences in formal science education are important to develop these beliefs. Studies in the related literature such as Elder's study (1999) found that fifth grade students hold some beliefs about the nature of science. Therefore, as Elder (1999) said it is appropriate to begin asking elementary grade students about their epistemological beliefs.

Research in the science education area showed that epistemological beliefs are important for students' meaningful science learning. Therefore, both the epistemological beliefs, and the effects of these beliefs on students' learning seem to need further investigation. The careful investigation of these beliefs provides us the information needed for better understanding of student learning. Even though the role of epistemological beliefs and its relation to other learner characteristics and educational variables are recognized as fundamental in science education among science education community as stated above, little attention has been given to elementary school students' beliefs, since it was assumed that it was harder to identify younger students' epistemological beliefs (Conley, Pintrich, Vekiri, & Harrison, 2004).

Since the constructivist based curriculum has been implemented in last five years in Turkey, it is important for science educators to monitor how students view their science classes, and investigate the impact of constructivist classroom environments on students' epistemological views of science and science learning outcomes. Therefore, the students' perceptions of their science classrooms and their epistemological views of science may be evaluated as a feedback about the curriculum and its actualization in science classes, and may be used for improving science teaching and learning practices in Turkish classrooms.

In the light of the related literature, it can be proposed that students' epistemological views of science, learning approaches, perceptions of their classroom environments are related to their achievement in science courses at different grade levels. Therefore, the purpose of this study is to explore the possible relationships among 6, 7, and 8th grade students' epistemological views of science, learning approaches, perceptions of classroom environments, and their science achievement. Specifically, this study holds seven main assumptions based on the review of the literature. First, it is assumed that students' epistemological views of science directly affect their science achievement. Second, it is assumed that students' epistemological views of science also indirectly affect their science achievement through the mediating effects of learning approaches. Third, students' learning approaches directly affect their science achievement. Fourth, students' epistemological views of science directly affect their learning approaches. Fifth, students' perceptions of their classroom environment directly affect their epistemological views of science. Sixth, students' perceptions of their classroom environment directly affect their learning approaches. Finally, students' perceptions of their classroom environment indirectly affect their science achievement via the mediating effect of epistemological views of science and learning approaches. Taking into account these assumptions, a path model describing the relationships among above mentioned variables were developed (see Figure 1.1).

Based on the given theoretical perspective and assumptions, the following problems investigated in this study:

1. What are the nature and the number of factors that comprise the scientific epistemological views of Turkish elementary school students?

2. What is the scientific epistemological view profile of Turkish elementary school students?
3. What is the learning approach profile of Turkish elementary school students?
4. What are the Turkish elementary school students' perceptions of their classroom environment?
5. What is the nature of the interrelationships among students' perceptions of learning environment, epistemological views of science, learning approaches, and their science achievement?

1.1 Overview of the Proposed Model

The possible relationships between students' epistemological views of science, learning approaches, learning environment, and science achievement are presented in Figure 1.1. This initial theoretical model was developed based on the researcher's review of the related literature.

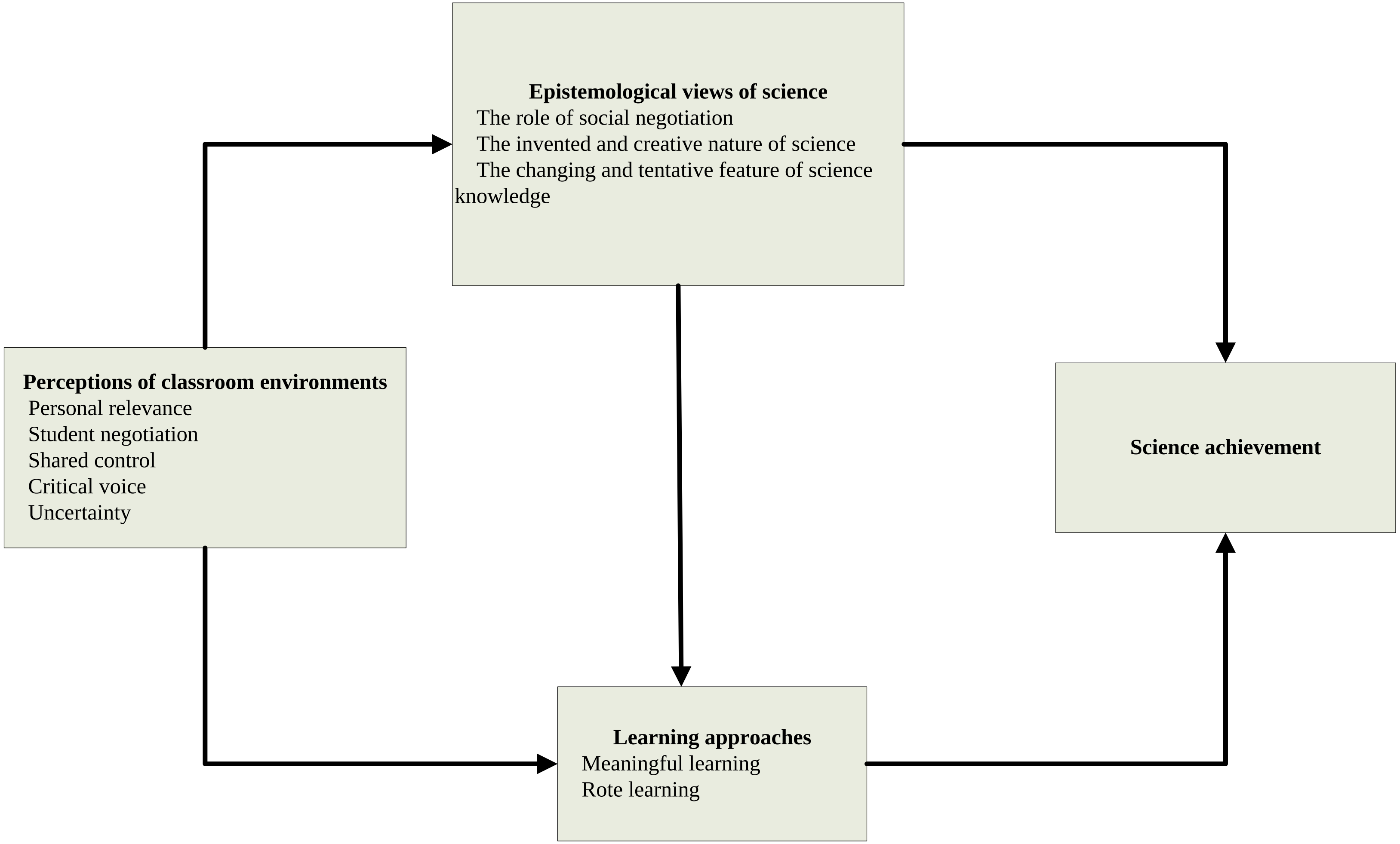

Figure 1.1 Model of the proposed relationships between students' epistemological views of science, learning approaches, perceptions of learning environment, and science achievement

In this model, there are four main components: students' epistemological views of science, learning approaches, perceptions of classroom environment, and science achievement. Students' perception of their science classroom environment, epistemological views of science and their learning approaches are represented by a number of sub-dimensions in the model. Perceptions of classroom environment are represented with personal relevance, student negotiation, shared control, critical voice, and uncertainty dimensions. The second component of the model, namely the epistemological views of science is characterized by three sub-dimensions in this study; these are: The role of social negotiations, the invented and creative nature of science, and the changing and tentative feature of science knowledge. The third component learning approaches has two sub-dimensions: meaningful learning and rote learning. The fourth component of the model is science achievement and it is unidimensional. Therefore, the current model hypothesized in this study proposed to identify the relationships among perceptions related to learning environments, epistemological views of science, learning approaches and science achievement.

1.2 Proposed Relations in the Model

The relationships among the sub-dimensions of the proposed model are displayed in Figure 1.2. In this section, the proposed paths and potential relationships as given with the multiple paths from and to the constructs in Figure 1.2 are explained. In this study, this hypothetical model was assessed and tested.

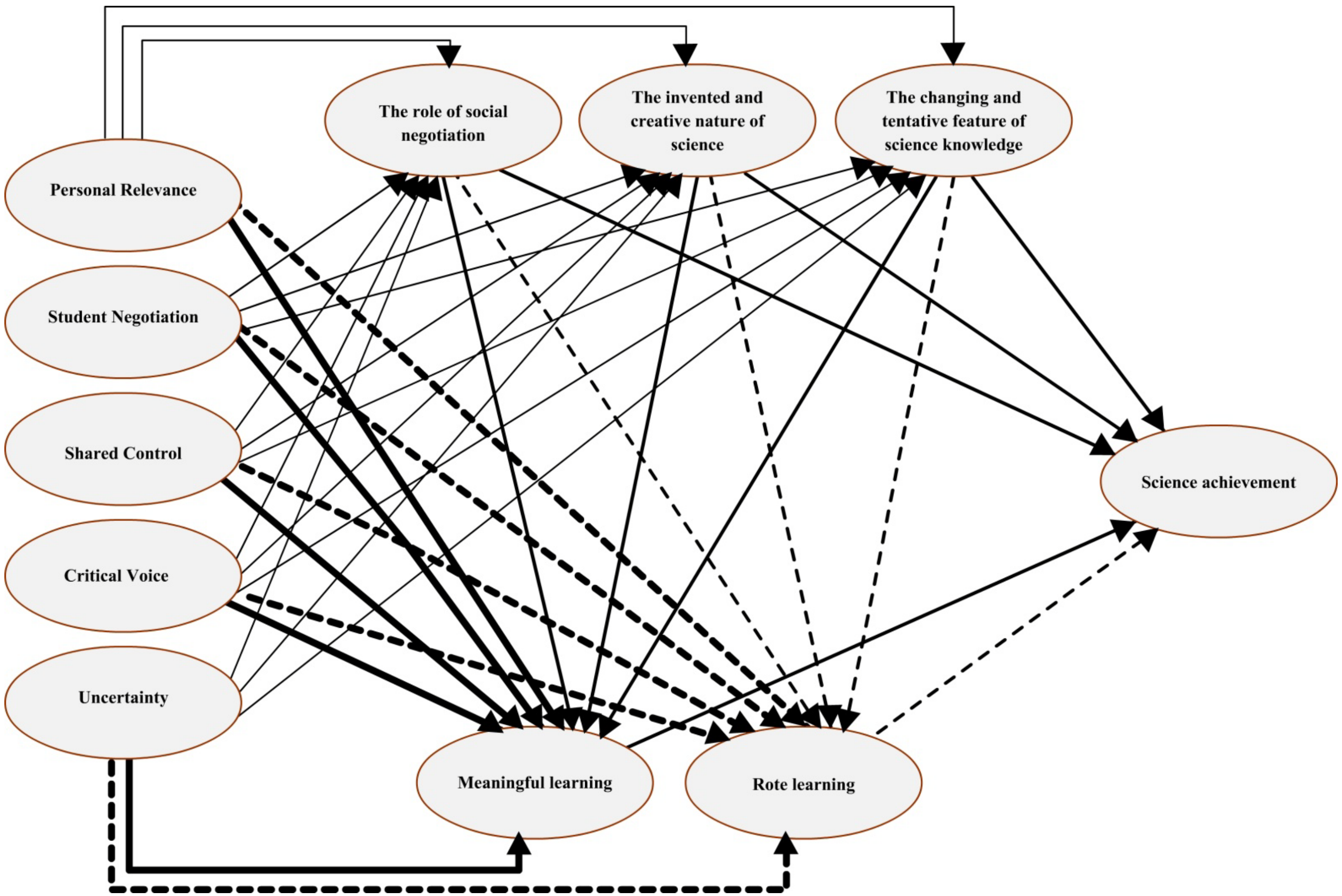

Figure 1.2 The hypothesized structural model

Note. The solid lines indicate paths hypothesized to be positive. The dotted lines indicate paths hypothesized to negative.

Students' epistemological views, learning approaches, and perceptions of classroom environment are represented by a number of sub-components. Epistemological views are composed of three dimensions namely; the role of social negotiation, the invented and creative nature of science, and the changing and tentative feature of science knowledge. There are two components of learning approaches; these are meaningful learning and rote learning. The third component of the model, perceptions of classroom environment includes five sub-dimensions: Personal relevance, student negotiation, shared control, critical voice and uncertainty.

Based on the related literature, first, it is assumed that perceptions of classroom environment will have a direct effect on the students' epistemological views about science and their learning approaches. In detail, it can be said that in science classes students' who found their studies classes more relevant, who feel more that they have a shared control over their learning, who feel more that they are free to express their opinions about their learning, who feel more that they are able to interact with peers for better learning, and who perceive more that science knowledge is tentative, have more constructivist views related to epistemology of science and will more likely to adapt meaningful learning approach in their science learning. On the other hand, perceiving their studies in class less relevant to themselves, feeling less that they have a shared control over their learning, feeling less that they are free to express their opinions about their learning, feeling less that they are able to interact with the classmates for better learning, and perceiving science knowledge as static and unchanging, have more empiricist views related to science and will more likely to adopt rote learning approach in their science learning.

Second, students' epistemological views related to epistemology of science will directly influence their learning approach and science achievement. More specifically, students' having more constructivist views related to epistemology of science, more clearly, believing that development of science requires the communications and negotiations of scientists, understanding that human imagination and creativity has an important role in growth of scientific knowledge, and believing the conceptual change in the progress of scientific knowledge and therefore its tentative nature, will more likely to adapt meaningful learning strategies and more likely to be high achievers in science and technology course. On the contrary, students having more empiricist views of science will more likely to adapt rote learning strategies and they are less likely to be high achievers in science and technology course.

Third, it is assumed that students' learning approaches will have a direct effect on their science achievement. That is, students with a meaningful learning approach will expected to be high achievers in science. On the contrary, students adopted rote learning approach will be expected to be less successful in science.

In addition to the direct relationships, there are also indirect influences of some variables in the hypothesized model. As stated earlier, students' views related to epistemology of science and their learning approaches will hypothesized to influence their science achievement directly. The model also proposed that students' epistemological views of science indirectly affect their science achievement via the mediating effect of the learning approaches. Similarly, students' perceptions related to their science classroom environment indirectly influence their science achievement via the mediating effects of epistemological views of science and learning approaches as depicted in Figure 1.2.

1.3 Null Hypothesis

The problems stated in the study were tested with the following hypothesis which is stated in the null form.

H_0: The model between personal relevance, student negotiation, shared control, critical voice, and uncertainty of classroom environment, the role of social negotiations, the invented and creative nature of science, the changing and tentative feature of science knowledge, meaningful learning, rote learning and science achievement is not significant.

1.4 Significance of the Study

Variety of researchers conducted research studies on epistemological beliefs and their relationships with learning in some particular areas, most notably in mathematics and science. Understanding students' epistemological beliefs within a particular subject area provide us considerable implications to understand and reveal how students learn in that area. Therefore, this study first of all is hoped to be useful for science education research area in Turkey.

The studies in the literature showed that there is a need for more research on young students' epistemological views on science. Diagnostic studies related to epistemologies of students give important clues for how to plan instruction in science lessons to develop students' views and eventually to improve their science learning. Since science courses deal with data, experiments, observations, use of evidences, making inferences from the given data and observations, comparing and contrasting different ideas, it can be used as a very efficient area for improving students' epistemological views. Although students' beliefs in epistemology of science believed to have an influence on their learning, and consequently performance in science, few research studies specifically focused on the relationship between elementary students' science achievement and their epistemological beliefs, much of the studies have focused on older students, and tends to generally ignore elementary graders except a few investigations.

Therefore, it is important to study elementary school students' views on epistemology of science and the relationship among those views and other variables related to their science learning. This study and other similar ones may lead science education researchers to study on students' epistemological views of science, and the interaction between these views, perceptions of classroom environment, learning approaches and science achievement from earlier ages.

As found in the literature epistemological beliefs are influenced by education and culture. However, there are not many studies investigating the effect of Turkish culture and education system on students' epistemological beliefs, therefore it is important to investigate Turkish students' epistemological beliefs. Findings obtained from this study and other similar studies may also enlighten the progress of reform efforts in science and technology education. More specifically, this study may give more information about the effect and progress of more student-centered; constructivist curriculum started to be implemented in line with the reform efforts. The findings of the study may enlighten first of all, how students perceive their own science classroom environments, how classroom environments affect their learning approaches, epistemological views of science and in relation with those variables consequently science learning.

Beyond investigating students' epistemological views of science, it would be useful to study the relationship between learning environment, epistemological views of science and learning approaches of students in order to understand students' science learning and help teachers to assist their students to make them better achievers in science. Better understanding the factors that affect students' approaches to learning, their view about the learning process and the possible impact of the particular educational variables may be useful for science teachers to plan science lessons and improve their teaching practice. Findings of this study is also hoped to provide better insights for science teachers and to make them better understand the role and values of students' views about science, perceptions of classroom environments, and approaches in learning science, in science learning and teaching.

There are limited studies investigating the dynamic interaction of elementary school students' perception of their classroom environment, epistemological views of science, learning approaches and science achievement, and effect of this interaction of those variables on science learning and achievement for Turkish culture. Since those variables and interaction among them have shown to be important for science learning in different cultures, this study is thought to fill the gap in the literature for Turkish elementary level students. Therefore, the results of this study may point to the need for taking into account the epistemological views of students and to indicate the need to investigate the ways for improving these views for better science education in Turkey. This research may have implications for planning, development, and implementation of school science programs aimed to achieve more sophisticated epistemological views of students. Also, the results of this study may help to see the point that students' perception of their classroom environment have an effect on their science learning more than ever been thought, and motivate science educators to think about the planning for making classroom environments more student centered and appropriate for shared decision making, peer negotiation, more student control over their learning, and giving opportunity to make students realize the uncertain nature of science knowledge. Overall, it can be concluded that this study is hoped to contribute to science teachers, researchers, curriculum developers and textbook writers who are concerned about the science literacy and therefore students' views, perceptions, and approaches utilized in science learning.

This study also may contribute to the science education research, more specifically epistemological beliefs research in Turkey, by adapting and using a multidimensional instrument originally developed for another culture, and revealing the Turkish elementary grade students' epistemological views of science profiles. One more important point is that as Costa (1995) stated, generally, science and technology education is considered to be served to an elite group of students. And the most interested group of students in science and technology courses are the students who want to attend a science related, for example medicine or engineering programs at university. Other students who do not think themselves as future scientist, or engineers or in a science related other areas of career are generally ignored. Therefore, although schools aim to promote students' scientific thinking and appropriate views of science, minority of students develop a so called scientific worldview. As future citizens, the remaining majority of students see science and its relation to everyday life as an outsider. However, it is argued that scientific literacy is a must for all citizens coming from various socio-economic levels, and different career and future aspirations. In this respect, this study is also important when its sample is considered. Generally, in most of the science education researches in Turkey, samples are selected from central parts of cities and schools that can easily be reached and therefore studies are conducted with sample of students with mostly middle and high socio economic levels. This study was conducted with a sample of students attending to Educational Volunteers Foundation of Turkey (TEGV). TEGV was founded to contribute the basic education of children between the ages 7-16 by providing non-formal educational opportunities for their educational needs. The foundation’s activity locations are generally settled in less privileged urban and rural areas throughout Turkey to develop particularly vulnerable children and youth personally and socially, and enhance their practical life skills. Children come to TEGV activity locations after school hours and at weekends, and enrolled in extra curricular programs both to support their school leaning in various diciplines and develop different skills in areas like music, sports, drama that they can not have to do by their personal opportunities. Generally, TEGV activity centers are located in low socio economic parts of the cities and served to a group of students coming from mostly low and middle socio economic level families Therefore, this study is also thought to be important to reach an “untouched” part of students in science education research studies.

Finally the method of analysis in this study was Structural Equation Modeling, which is an analysis helping to illustrate the relationships between variables. Through this study investigating influential causes, nature of students learning in science may be partly enlightened and be better understood. The findings of the study are hoped to be used to improve effectiveness of science teaching and learning in elementary schools in Turkey.

1.5 Definition of the Important Terms

For the purposes of this study, the following definitions are provided.

<u>Epistemological Views of Science:</u> “…conceptualization of epistemological beliefs in science which are more narrowly defined as beliefs about the nature of knowledge in science” (Elder, 1999, p.20)

<u>The role of social negotiation:</u> “The role of social negotiations means that the development of science relies on the communications and negotiations among scientists (the constructivist view). The opposite position (empiricist or positivist –

aligned view) is that science is a process of individual exploration, mainly depending on personal efforts" (Tsai & Liu, p.1623).

The invented and creative nature of science: "The dimension of Invented and Creative nature of science is to assess whether students understand that scientific reality is invented rather than discovered (the constructivist-oriented view). In addition, it has the notion that human imagination and creativity is important fort he growth of scientific knowledge" (Tsai & Li, 2005, p.1624).

The theory laden exlorations: "The Theory-Laden exploration dimension adresses the idea that scientists' personal assumptions, values, and research agendas may influence the scientific explorations they conduct (the constructivist view). An opposite (empricist-aligned) view asserts that scientific knowledge is derived from totally objective observations and prcedures" (Tsai & Liu, 2005, p.1624).

The cultural impacts: "The dimension of the Cultural impacts refers to the culture-dependent nature of the development of scientific knowledge" (Tsai & Liu, p.1624).

The changing and tentative feature of science: "The Changing and Tentative feature of science knowledge refers to the conceptual change of science progression. It asserts that scientific knowledge is always changing and its status is tentative (constructivist oriented view), which opposes the idea that science provides the truths of the nature (empiricist aligned view)" (Tsai & Liu, 2005, p.1624).

Perceptions of classroom environment: "A new learning environment instrument is needed to assist researchers to assess the degree to which a particular classroom environment is consistent with a constructivist epistemology, and to assist teachers to reflect on their epistemological assumptions and reshape their teaching practice. The constructivist classroom environment survey (CLES) was developed to meet this need" (Taylor, Fraser, & Fisher, 1997, p.3).

Personal relevance: "The personal relevance scale focuses on the connectedness of school science to students' out-of-school experiences, and with making use of students' everyday experiences as a meaningful context for the development of students' scientific and mathematical knowledge" (Taylor, Fraser, & Fisher, 1997, p.296).

Student negotiation: "The student negotiation scale assesses the extent to which opportunities exist for b students to explain and justify to other students their newly developed ideas, to listen attentively and reflect on the viability of other students' ideas and, subsequently, to reflect self-critically on the viability of their own ideas" (Taylor, Fraser, & Fisher, 1997, p.296).

Shared control: "The shared control scale is concerned with students being invited to share with the teacher control of the learning environment, included the articulation of learning goals, the design and management of learning activities, and the determination and application of assessment criteria" (Taylor, Fraser, & Fisher, 1997, p.296).

Critical voice: "The critical voice scale examines the extent to which a social climate has been established in which students feel that it is legitimate and beneficial to question the teachers' pedagogical plans and methods, and to express concerns about any impediments to their learning" (Taylor, Fraser, & Fisher, 1997, p.296).

Uncertainty: "The uncertainty scale assesses the extent to which opportunities are provided for students to experience scientific knowledge as arising from theory-dependent inquiry involving human experience and values, as evolving, non-foundational, and culturally and socially determined" (Taylor, Fraser, & Fisher, 1997, p.296).

Learning Approaches: Cano (2005) defined learning approaches as "…how learners experience and define their learning situation, the strategies they use to learn and the motivation underlying their conduct" (p. 206).

Meaningful Learning: Meaningful learning is defined as an approach to learning in which the learner has the intention to understand the learning material by constructing the meaning of the content (Cavallo, 1996), by relating the ideas, concepts and information (Ausebel, 1963). In meaningful learning, the learner tries to relate the old and new information in a learning task (Williams & Cavallo, 1995).

Rote Learning: "Rote learning is characterized by students memorizing or compartmentalizing ideas, concepts, and information. Connections are not made between new and existing ideas in th students' mind" (Williams & Cavallo, 1995, p.312).

Science Achievement: Science achievement of students is identified by the students' previous final report card grade for science and technology course and ranges from 1 to 5.

1.6 Organization of the Dissertation

This dissertation is composed of five chapters. The first chapter gives a brief summary about the theoretical background of the study, introduces the hypothetical model, gives important definitions of the terms that are related to the study, and based on the background underlies the importance and the significance of the study. The second chapter of the dissertation presents a detailed review of the literature about epistemological views of science, learning approaches, learning environments. The literature review also provides the theoretical background and supports for the hypothetical model, and proposed paths included in the model. The method of the study is presented in the third chapter. This chapter gives the issues and methodologies used for the sample, data collection instruments, analyses, and structural equation modeling. The results obtained from the study are presented in the chapter four. In the final chapter, results are compared and contrasted with the findings obtained from the previous studies. Also, conclusions inferred from the findings, implications, limitations, and suggestions for future studies are given in the fifth chapter.

CHAPTER 2

LITERATURE REVIEW

The purpose of the literature review is to provide a framework for the investigation of the interrelationships among students' epistemological beliefs, learning environments, learning approaches, and their science achievement. For this specified purpose related literature are reviewed and presented in three main sections. The first section is dedicated to students' epistemological beliefs. Students' epistemological beliefs are first examined within the historical perspective, then its' relationships with academic performance in different areas and learning approaches are addressed. The second section of the review deals with the students' learning approaches and its relationships with academic achievement. The final section is about the learning environments, its' relationship with students' epistemological beliefs, and learning approaches.

2.1 Research on Students' Epistemological Beliefs

The section of the review provides an overview of the epistemological beliefs research by first presenting the historical review of the epistemological beliefs studies, the relationships of epistemological beliefs with specific learner characteristics, academic performance and learning approaches.

2.1.1 Epistemological Beliefs within the Historical Perspective and Its Relationships with Learner Characteristics

Epistemology as a philosophical enterprise, deals with the origin, nature, limits, methods, and justification of human knowledge (Hofer, 2002).

Epistemological beliefs in general can be described as the individuals' beliefs about the nature of knowledge and learning (Schommer, 1990). Ryan and Aikenhead (1992) used the term nature of science to refer epistemology of science including characteristics of scientific knowledge, the values and assumptions related to science, reaching an agreement in scientific communities. Lederman (1992) defined nature of science part of the epistemology of science as an individual's beliefs concerning whether or not scientific knowledge is amoral, tentative, empirically based, a product of human creativity, or parsimonious.

Smith, Maclin, Houghton and Hennesey (2000) described epistemology of science as the network of ideas that students have about how knowledge is acquired and justified in science. They further defined the sophisticated or constructivist epistemology as an epistemology in which students are aware of the central role of ideas in knowledge construction and the importance of the prediction, argument and test in developing and revising the scientific ideas. Elder (1999) defines epistemological beliefs as the views that are hold about the nature of knowledge more specifically about the purpose of science, sources of scientific knowledge, role of evidence and experiments, changing nature of knowledge and coherence of scientific knowledge.

Research on epistemological beliefs began 40 years ago with Perry (1998) in his study of personal epistemology by interviewing Harvard undergraduates. He conducted a four year long study with college students by using interviews. Based on the interviews with college students, Perry developed a model describing the development of epistemological beliefs. The model covers four broad developmental steps; dualistic view, multiplicity, relativistic world view, and commitment with relativism. Person holding a dualistic view see statements about reality as right or wrong, and they believe that experts provide the right answers. This dualistic view is followed by the conception of multiplicity, in which different views about reality are accepted, but the person with a multiplicity conception still thinks that future research will provide the right answers to the unresolved questions. In the relativistic world view, knowledge is started to be seen as the human product which is uncertain and has the potential of change. In the final stage of development, namely the commitment with relativism, it is accepted that there is no absolute truth or certain knowledge; specific approaches of reality are examined and judged in terms of their quality and appropriateness to reality. Results of Perry's study showed that most of the first year students in college believe in simple, unchangeable facts and they also believe that knowledge comes from authority. As the students grow older they began to think that knowledge is complex and tentative and it comes from reasoning and inquiry. Therefore, it can be concluded that students follow a developmental path in terms of their epistemological beliefs as they grow older. Following Perry, many studies were conducted about students' epistemological views (Cano, 2005; Cavallo, Rozman, Blickenstaff, & Walker, 2003; Chan, 2003; Conley, Pintrich, Vekiri, & Harrsion, 2004; Elder, 1999; Pomeroy, 1993; Schommer, 1990, 1993; Tsai, 1998a). Similar to Perry's view of developmental stages, King and Kitchener (2004) also hold a unidimensional epistemology view and proposed a seven stage developmental scheme for personal epistemologies. According to this scheme, at the first stage knowledge is seen as certain and given by authority. At later stages, knowledge is started to be seen as cumulative and open to judgment of different individuals in nature. In this view, individuals pass through these stages according to their cognitive development.

After Perry's study, several researchers have studied the structure of epistemological beliefs. Schommer (1990) have been accepted as the pioneer in studying the identification of epistemological beliefs dimensions. Based on her studies, other researchers have also examined the structure of epistemological beliefs. The development of epistemological beliefs questionnaires as a parsimonious alternative to interview based assessment was accepted as a milestone in epistemological beliefs research (Trautwein & Ludtke, 2007). The best known instrument is Schommer's (1990) questionnaire on beliefs about knowledge and knowing covering four dimensions. Different from Schommer's focus on both nature of knowing and knowledge, Hofer and Pintrich (1997) favored concentrating only on the beliefs on nature of knowledge as source of knowledge and justification of knowledge as the core research dimensions of epistemological beliefs.

Schommer (1990), different from Perry, considered that one dimensional view of epistemological beliefs could not explain the complicated structure of these beliefs and proposed a multidimensional structure to explain them. In the beginning, she hypothesized five dimensions, namely source, certainty, structure, control and speed. In the source dimension, the source of knowledge is ranged from knowledge is handed down by omniscient authority to reasoned out through subjective means. The certainty of knowledge ranges from knowledge is absolute to knowledge is constantly evolving. The structure of knowledge ranges from knowledge is compartmentalized to knowledge is integrated and interwoven. The control of learning ranges from ability to learn is determined by genetics to learning occurs through experience. The speed of learning ranges from learning is quick or not at all to learning is a gradual process.

Perry's and Schommer's research on epistemological beliefs prompted various studies examining the epistemological beliefs and their relations to other constructs. There were two general research areas regarding epistemological beliefs. First area has been dealing with the students' personal epistemologies examining the nature of development of how students think about knowledge and knowing since the earliest studies in the area. The second research area in general is a more recent interest compared to first one and has been dealing with the effect of students' epistemological beliefs on their understanding, reasoning, thinking, learning and achievement (Conley, Pintrich, Vekiri, & Harrison, 2004). However, it is seen that there is a need to continue studies related to epistemology of science especially with young students since we still have limited information about their epistemological thinking and development.

In epistemology research literature, there are some studies holding a holistic view of epistemology and proposing one general dimension for epistemological thinking which is supposed to change over time like in Perry's (1999) and Pomeroy's (1993) studies. On other hand, there are other studies proposing a number of dimensions regarding epistemological thinking (Hofer & Pintrich, 1991; Schommer, 1990; Pintrich, 2002; Schraw, Bendixen, & Dunkle, 2002; Tsai; 2002). This study like the above mentioned studies investigated the epistemological views of students in a number of dimensions since it has been shown that one may have sophisticated view regarding one aspect of epistemological thinking and may have naïve views regarding others (Tsai, 2002). That's why; it is believed that the holistic perspective can not give a detailed and accurate picture of one's epistemological views. Pintrich (2002) supports this belief and suggested that models with a number of dimensions may offer the best agreement taking into account the lack of consensus about this issue.

Schommer (1990) is the first who looked at the epistemological beliefs in more or less independent dimensions. She viewed epistemological beliefs as a multidimensional construct which composed of relatively independent beliefs about the nature of knowledge and nature of learning. Nature of knowledge aspect is examined in terms of the knowledge's structure and source. The structure of knowledge refers to whether it has simple or complex and absolute or tentative nature. The source of knowledge refers to whether the knowledge is coming from an authority or from reasoning. Nature of learning aspect is examined in terms of speed of learning as either quick or gradual and in terms of one's ability to learn something as either an innate ability which is viewed as fixed or something that can be improved through time. Based on this view, Cano (2005) stated that according to Schommer's view, a student might have a sophisticated belief in one or more dimensions but not necessarily in others. For example, a person may believe that knowledge is complex and involves a complex network of ideas, and at the same time the same person may believe that knowledge is certain and never changes (Schommer & Walker, 1995).

Schommer (1997) actually proposed three major hypotheses stemmed from the previous theories related epistemology of science. First, she stated that epistemological beliefs are composed of more or less independent set of beliefs. Therefore, there should be multiple beliefs that need to be considered. These beliefs do not need to be necessarily developed in a parallel way. For example, a student may have a strong belief that deep learning is progressive and at the same time he/she may believe that knowledge is composed of isolated pieces of information. Second, epistemological beliefs are hold as frequency distributions rather than dichotomies. Individuals may differentiate as sophisticated or unsophisticated regarding their beliefs in terms of the percentage attributed to each category of epistemological beliefs. Third, epistemological beliefs are thought to be changed over time, in contrast to the belief that epistemological beliefs are inborn characteristics of individuals.

Based on these three hypotheses, Schommer (1990) developed a 63 item questionnaire called Epistemological Beliefs Questionnaire (EBQ) to examine individuals' system of epistemological beliefs in four dimensions: 1) malleability of learning ability (Fixed Ability), 2) structure of knowledge (Simple Knowledge), 3) speed of learning (Quick Learning), 4) stability of knowledge (Certain Knowledge). By this questionnaire, she aimed to assess individuals' default epistemological beliefs (Schommer, 1997).

Schommer's work for the multidimensional conceptualization and assessment of epistemological beliefs was a considered as a revolution in the epistemology research; however it was subjected to criticism as well (Buehl & Alexander, 2001). In their study questioning the Schommer's proposed four dimensions of epistemological beliefs, Qian and Alvermann (1995) administered the Epistemological Beliefs Questionnaire to 212 high school students having similar characteristics with the sample of students in Schommer's original study. As a result of the exploratory factor analysis, the researchers obtained a different factor structure. The items belonging the Simple Knowledge and Certain Knowledge dimensions were loaded together to the same factor, and accordingly Qian and Alvermann (1995) obtained a three factor model of epistemological beliefs: Fixed Ability, Quick Learning, and so called Simple-Certain Knowledge.

There are a lot of studies in the epistemology literature based on the Schommer's model of epistemology. For example Schraw, Bendixen and Dunkle (2002) developed an inventory similar to Schommer's. With the results of the factor analysis conducted with the college students' data their Epistemic Beliefs Inventory proposed to have five dimensions as Certain Knowledge (dealing with the stability), Simple Knowledge (dealing with the structure), Omniscient theory (dealing with the source), Quick Learning (dealing with the speed) and Innate Ability (dealing with the control). Similarly, Hofer and Pintrich (1997) proposed four dimensions for measuring epistemological beliefs: Certainty of knowledge (stability), Simplicity of knowledge (structure), Source of knowing (authority), and Justification for knowing (evaluation of knowledge claims). They excluded the last two dimensions proposed by Schraw, Bendixen and Dunkle (2002), since they are related with the nature of learning more than the nature of knowing and knowledge.

Chan and Elliot (2004) compared and interpreted the findings of epistemological beliefs studies conducted in North America, Hong Kong and Taiwan in terms of the different cultural contexts and methodologies. Based on their cross cultural analysis they proposed a hierarchical multidimensional model explaining the structure of epistemological beliefs. In their hypothesis, there are two facets: the nature of knowledge and the process of knowing. They stated that epistemological beliefs are a set of clustered sets of beliefs in an individual's belief system. Figure 2.1 shows the hypothesis regarding the structure of epistemological beliefs.

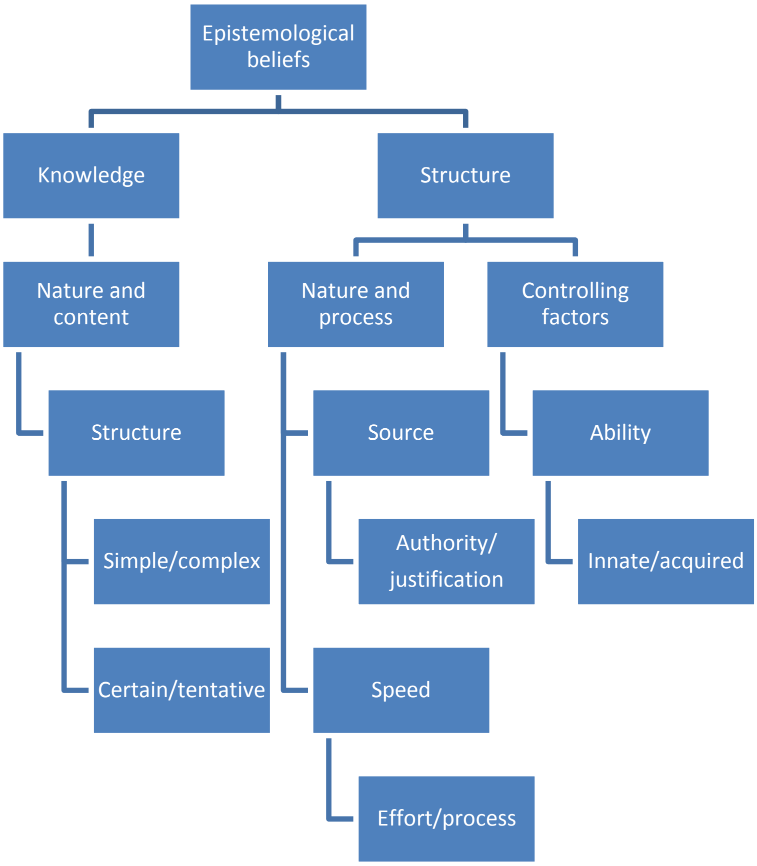

Figure 2.1 Proposed multidimensional structure of epistemological beliefs (Chan & Elliot, 2004).

Chan and Elliot (2004) validated the proposed four factor structure of epistemological beliefs by confirmatory factor analysis for Hong Kong students. They obtained a satisfactory goodness of fit index (GFI = .93, AGFI = .90, RMSEA = .058, RMR = .064).

In 1992, Schommer conducted a cross sectional survey with high school students in order to investigate whether their epistemological beliefs change in years or not. In this study, it was found that students' beliefs in simple knowledge, certain knowledge, and quick learning weakened from the freshman year to senior year. In addition, she found that there was a relationship between students' beliefs in quick learning dimension and their academic achievement; the less students believe in quick learning, the higher grade point averages (GPA) they get. Schommer, Calvert, Gariglietti and Bajaj (1997) conducted another study to see whether the results of Schommer's (1992) study could be replicated in a longitudinal design. They randomly selected 69 high school students in a sample of students from 1992 sample. The researchers examined the changes in epistemological beliefs of students and they again investigated the relationship between epistemological beliefs and academic achievement. Analysis of this second study revealed that students became more mature in all of the four epistemological beliefs dimensions. Compared to their first year in high school, students in their senior year were less tend to believe in fixed ability to learn ($F(1, 67) = 290.54$, $p < .001$), simple knowledge ($F(1, 67) = 19.18$, $p < .001$), quick learning ($F(1, 67) = 29.28$, $p < .001$), and certain knowledge ($F(1, 67) = 44.72$, $p < .001$). Furthermore, stepwise regression results showed that students' beliefs in quick learning in 1992 predicted their GPAs in 1992 ($F(1, 66) = 4.5$, $p < .05$, $MSE = .69$, $b = -.45$, R^2 change = .06). None of the beliefs in 1992 predicted GPAs in 1995. And students' belief in quick learning in 1995, predicted their GPAs in 1995, ($F(1, 58) = 18.35$, $p < .001$, $MSe = .36$, $b = -.49$, R^2 change = .24). Therefore, the results suggested that high school students' epistemological beliefs changed over time, and the second study in longitudinal design proved further evidence for developmental nature of epistemological beliefs. Both 1992 and 1997 studies showed that there is a relationship between students' beliefs in quick learning and their academic achievement.

In another study Schommer (1993) investigated the gender and grade level effect on high school students' epistemological beliefs. The sample of the study was 1000 students consisting of 405 freshman, 312 sophomores, 274 juniors and 191 seniors. Epistemological beliefs of the students were assessed by Schommer's (1990) questionnaire composed of 12 subsets of items to investigate students' preferences about knowledge and learning. In order to examine the changes in epistemological beliefs through high school years, the researcher carried out a 4 (year in school) x 2 (gender) multivariate analysis of variance (MANOVA) using the four epistemological factor scores as the dependent variables. The results of the analysis showed gender main effect ($F(4, 1171) = 18.63$, $p < .001$), and grade main effect ($F(12, 3519) = 3.59$, $p <.001$). The individual analysis of variance revealed that gender effect is significant for two of the four epistemological factors. Girls were found to be less likely to believe in fixed ability ($F(1, 1171) = 60.20$, $p <.001$) and quick learning ($F(1, 1171) = 35.35$, $p < .001$). In analysis of the effect of grade level, it was found that as students advanced through high school, they were less likely to believe in simple knowledge ($F(1, 1178) = 15.25$, $p <.0001$), quick learning ($F(1, 1178) = 16.09$, $p < .0001$), and certain knowledge ($F(1, 1178) = 12.81$, $p < .001$). The results indicated significant gender and grade level effect on students' epistemological beliefs, and therefore it can be said that epistemological beliefs changed significantly from freshman to senior years of school.

In order to investigate students' epistemological views about science, different research studies focused on different aspects of the epistemology of science. In an early research, Rubba and Andersen (1978) conducted a research related to creative, developmental, parsimonious, testable, unified and amoral aspects. Hammer (1994) investigated a study with college students in order to reveal their beliefs regarding coherence of physics knowledge and learning of physics. In their study with middle school students, Songer and Linn (1991), investigated the beliefs of students related to science learning and changing nature of knowledge in science. Driver, Leach, Millar, and Scott (1996) conducted a study on purpose of scientific work, the nature and status of scientific knowledge and science as a social enterprise issues. Some of the researchers had holistic epistemological views (e.g. Hammer, 1994; Songer & Linn, 1991), on the other hand some of them focus on some separate dimensions constituting those beliefs (e.g. Rubba & Andersen, 1978; Ryan & Aikenhead, 1992; Tsai, 1998a, 1998b, 1999a, 2000a, 2000b).

Tsai and Liu (2005) investigated 613 high school students' epistemological vies of science in five dimensions, namely the role of social negotiations, the invented and creative nature of science, the theory laden exploration, the cultural impacts, and changing and tentative feature of science on a five point Likert scale The mean score of students' responses was found to be lowest on the cultural impacts sub dimension (3.65). On the other hand, the mean score was found to be highest on the changing and tentative feature of science sub dimension (4.22).

Huang, Tsai and Chang (2005) developed the Pupils' Nature of Science Scale (PNSS) in order to investigate the students' views about the nature of science on three dimensions namely; the invented and changing nature of science, the role of social negotiation on science, and the cultural context on science. They conducted the study with 6167 fifth and sixth graders in Taiwan. 49.3% of the sample was boys and 50.7% of the sample was girls. The results of the study showed that the students had quite different perspectives toward the different dimensions of the scale. The highest mean item score was 4.36 for the invented and creative nature of science dimension, for the social negotiation of science it was 3.91, and for the cultural context on science it was 2.78. The researchers stated that the students had, on average constructivist oriented views toward the invented and changing nature of science and the social negotiation of science, but the students seemed not to support the view that the cultural context had an essential impact on the development of science. The researchers also stated that the findings of this study supported the findings of Tsai's (2002) previous study that people may have different perspectives on different dimensions of epistemology of science. A person may have a constructivist perspective toward a specific dimension of epistemology of science and at the same time may have less constructivist view toward another dimension. In this study Tsai (2002) observed the effect of STS (Science Technology Society) instruction on teachers' epistemological views of science. The teachers' views on the invented and theory laden dimensions of epistemology of science changed from empiricist to constructivist view after instruction; however the same teachers showed no difference on the other epistemology of science dimensions.

Huang, Tsai and Chang (2005) found that there is a statistically significant difference between 6th and 5th graders' views of invented and changing nature of science ($t = 3.51$, $p < .01$). Sixth graders had more constructivist perspective on this dimension than 5th graders. In addition, a difference was found between male and female students' perspectives. Males were found to have more constructivist perspectives toward the nature of science than the female students. Also, significant gender differences were observed on the views of tentative and changing nature of science dimension ($t = 3.34$, $p < .01$) and the role of social negotiation of science (t =

3.90, $p < .01$). Male students had more constructivist views of tentative and changing nature of science and the role of social negotiation dimensions than their female counterparts.

Haidar and Balfakih (1999) conducted a study with 160 United Arab Emirates high school students in order to investigate their views about the epistemology of science. The researchers selected 21 items from Views on Science-Technology-Society (VOSTS) questionnaire developed by Ryan and Aikenhead (1992). They kept only the stems of the items in their original format. They directed open ended questions to a total number of 60 students from 11th and 12th grade in order to produce the multiple choices of the selected 21 items. Based on the results of the study, the researchers categorized the students' views about epistemology of science into two views: uninformed and informed. In some of the cases, high percentage of the students responses indicated that they have uninformed views for example about the scientific method. On the other hand, students in some aspect of the epistemology of science hold informed views such as their view about the nature of observations. Generally, students have uninformed views about the topics related to scientific methods, hypotheses, theories, laws and scientific approach. On the other hand, most of the students had informed views related to the topics like the nature of scientific observation, the nature of classification schemes, scientific approach to investigations and uncertainty of scientific knowledge. Haidar and Balfakih (1999) stated that students' cultural background influenced their views about the epistemology of science. The basic fundamental beliefs related to their culture that no human being can claim that he/she can reach an absolute truth thought to play an important role in their responses.

Tsai (2000a) conducted an experimental study in order to investigate the effects of STS (Science-Technology-Society) instruction on a group of Taiwanese tenth grade female students. In this study, the researcher also investigated the effect of scientific epistemological beliefs on this potential change. The intervention was lasted in eight weeks with a total number of 49 students in traditional group and 52 students in the STS group. In the experimental group, the researcher infused the STS materials and activities into the existing physical science course which was regularly taught to Taiwanese tenth graders. The researcher investigated the cognitive structure change of students on three different topics, namely; light, electricity, and nuclear energy. For each of the assessment, 20 students from each group were randomly selected and interviewed by the use of standardized set of questions. In addition, Chinese version of Pomeroy's (1993) questionnaire was used to assess students' scientific epistemological beliefs. The results of the study showed that STS group students performed significantly better ($p < .05$) in terms of extent, richness, and connection of cognitive structure outcomes on all of the three topics compared to the students in the traditional group. Furthermore, it was revealed that STS instruction was especially beneficial to the students who have more constructivist oriented epistemological beliefs of science particularly in the beginning of the STS instruction.

Larochelle and Desautels (1991) conducted a study in which they examined 25 fifteen to 18 years old students' scientific epistemological beliefs. Semi structured interviews were conducted with the students, and they asked questions like "What is scientific knowledge?", "What is scientific theory?" etc. As a result of the analysis of the interview results, the researchers found that most of the students participating in the study had somewhat called "technico-empricist" view of the scientific knowledge. These students found strong associations between numbers, formulas, calculations, and laws with the scientific knowledge, and they attributed a little part for creativity. In another study, interview results showed that seventh grade students have limited epistemological views of science. When the researchers asked about how scientists acquire scientific knowledge, students talked about making observations, doing experiments, finding cures. The students did not talk about the role of evidences or interaction of different ideas (Grosslight, Unger, Jay, & Smith, 1991).

In a similar study, Solomon, Duveen and Scott (1994), interviewed 11-14 years old students about the purpose of experiments, the relationship between scientists' ideas and their experiments, and the nature of scientific theories. They also asked students to give an example for an experiment and explain how experiments help them to better understand the theories. The results showed that the students generally did not seem to understand that the experiments were purposeful activities to produce and test the explanations.

In their following study, Solomon, Scott and Duveen (1996) investigated British pupils' understanding of several aspects of the nature of science. The sample of the study was 800 pupils aged 14-15 years old who had been exposed to school views of science more than three years. The researchers not only interviewed the students in small groups but also watched them in lessons. In addition, they administered a set of simple questions about the nature of science. They also administered this questionnaire to 120 aged eight pupils and 80 aged 16-18 students who selected science as their specialist subject. By this way, the researchers aimed to investigate the possible progression of students' views about the nature of science. They asked questions like "Do you think scientists have a responsibility for the social implications of their discoveries?" and "Do you think that scientific knowledge is value free?". During the interviews the researchers saw that most of the average ability students had difficulty in putting into words what they meant by "experiment", "theory" or "scientific knowledge". Interview results showed that 15 year old students were using a mixture of school knowledge which depends on what their science teacher discussed with them and everyday science knowledge which comes from out of school. The students answered questions by using one of these two sources depending upon the question asked. Less than half of the pupils were capable of correctly describing an experiment related to theory. The students were generally found to be unfamiliar with the term "theory". When they asked to give an example of any theory they became silent. The students also had difficulty in identifying casual explanations. When they analyzed the results of year 8 and year 10 pupils, Solomon, Scott and Duveen (1996) found that older pupils more likely to say that "scientists know what they expect to happen in an experiment before they do it". By year 10 just over half of the pupils moved from the cartoon image of science to a more realistic view that believing that science is a deliberate search for explanation. By year 17-18, the percentage of students who had more realistic view increased to 80%. Based on their classroom observations, the researchers concluded that the class teachers exert a powerful influence on students' views of nature of science and most of the change in students' views seems to be attributable to teaching.

Songer and Linn (1991) conducted a study to investigate epistemological beliefs of eight grade students in terms of their responses to short answer and true/false items regarding the work of scientists, meaning of learning science, and the relationship between science inside and outside school. They found that 15% of their sample had dynamic views related to epistemology of science meaning that they believe science is not certain but changing, scientists use evidences when working, science inside and outside school are related to each other. In addition, they tended to understand instead of memorizing scientific ideas. On the other hand, 21% of their sample had static beliefs related to epistemology of science meaning that they saw science as a collection of facts and believe that these facts are mostly unchanging, and they did not see much relevance between the science inside and outside the school. Also, they also believe that science is something learning by memorizing. And finally the majority of the sample (63%) had mixed views related to epistemology of science.

In another study with middle school students, Schommer, Brookhart, Hutter, and Mau (2000) administered an epistemological beliefs questionnaire to understand students' beliefs about knowledge and learning using the multidimensional paradigm. The sample was 1269 grade 7 and 8 students. Schommer's epistemological beliefs questionnaire was revised to lower the number of items and to simplify the expression of ideas if necessary for middle school students. In this survey study, the researchers checked the appropriateness of the data obtained from middle school students to the four factor structure of epistemological beliefs previously found for high school and college students. The factor structure was examined by confirmatory factor analysis. The researchers obtained χ^2 : df ratio of 2.91, CFI for the hypostasized model was .67, and G.I was .87, smaller than the criterion of .90. Also, the RMR was .088 which was greater than the criterion of .05. The obtained indices for evaluation of the fit of the four factor model were inadequate. After removing some the items with low factor loadings better goodness of fit indices were obtained. However, four factor model obtained the samples of high school and college students did not fit the data obtained from a sample of middle school students; the nature and number of the epistemological beliefs were found to be different from the older students, the researchers excluded the structure of knowledge dimension from middle school students' model. The results obtained from this study were consistent with the results obtained from another study to investigate the effect of maturation on epistemological beliefs (Schommer, 1998). In this study, the researcher after controlling the effect of level of education found that maturation is a critical factor in the development of epistemological beliefs; age predicted growth in beliefs about learning.

Driver, Leach, Millar, and Scott (1996) conducted a study to determine epistemological beliefs of ninety 9, 12 and 16 years old students. They used interviews in order to reveal students' epistemological beliefs in purpose of scientific work, the nature and status of scientific knowledge and science as a social enterprise issues. They asked students some questions and expect them to categorize those questions as scientific or not. Analysis of the interview results revealed that 18% of the nine year old students, 20% of the 12 year old students and 28% percent of the 16 year old students said that empirical testability is a criterion in order to decide whether a question is scientific or not. The researchers found that by empirical testability, students mean a test to check whether a proposed phenomenon occurs or not. When the students become older, their rate of talking about empirical testability as a criterion for deciding on a question is increased. Researchers concluded that as they become older, students tend to use their everyday experience and try to relate the science inside and outside school when responding to questions. The researchers asked students definitions of theory and their use of evidence in evaluating theories related to a specific scientific phenomenon like electricity in order to understand their views on the nature and status of scientific knowledge. They gave cases like how a light bulb lights in a simple circuit and they asked to select one of the given explanations. The students were also given with some evidences to relate their selected explanation to the scientific phenomena. Results showed that 25% of the 9 year old students and 75% of the 16 year old students used available evidence in their explanations. The researchers also gave students some scenarios covering a theory of continental drifts and the process of food irradiation and expect them to comment on these topics in order to get their views on society's influences on science. They found that students viewed scientists as people working in isolation from society and they did not have an idea about societal influences on scientific studies.

Elder (1999) assessed 211 fifth grade students' epistemological views in four dimensions namely; Authority, Certainty, Developing and Reasoning. In general, the researcher found that students endorsed the adaptive or sophisticated epistemological beliefs that scientific knowledge is a reasoned endeavor (Reasoning) and evolves over time (Developing), and they reject naïve beliefs that scientific knowledge is static information (Certainty) and it comes from experts (Authority). Elder (1999) found that students hold sophisticated notions on some of the dimensions of epistemological beliefs such as believing the changing nature of scientific knowledge as a result of reasoned and constructive efforts. However, at the same time they have some naïve notions like viewing science as an activity instead of viewing it as a work directed by aims to explain phenomena in the world. It can be said that fifth grade students have some understanding of epistemology of science but they need development.

In Elder's study (1999) students did not seem to understand the purpose of science as explaining phenomena, they thought that science is doing activities or making discoveries. The students viewed science as a constructed endeavor instead of coming from authority. However, it was seen that ideas about coherence and purpose of science, coordination of theory and evidence are challenging dimensions about epistemology of science for fifth grade students.

Smith, Maclin, Houghton and Hennesey (2000) discussed the possible reasons of students having a limited understanding of epistemology of science. They summarized that the reasons as: 1) students' prior school experiences related to science may limit their understanding, 2) Everyday epistemological views may constrain their understanding, 3) general biological development of students may limit their thinking and reasoning. Carey, Evans, Honda, Jay, & Unger (1989) indicated that lack of opportunity to engage in inquiry based educational environments causes the limited fact based epistemological views of students. In general, students do recipe like laboratory experiments without reasoning and understanding what they do and then they try to memorize the facts related to science. This kind of science classroom activities limits students' understanding of epistemology of science. The students do not aware of the fact that different opinions may stem from different perspectives of frameworks, they simply think that the differences in opinions are caused by the lack of knowledge and further they believe that these differences will completely remove when all the facts are known, or when the evidences are valuated without bias (Hofer & Pintrich, 1997).

There are some studies in the literature investigating the epistemological views of teachers. Pomeroy (1993) investigated teachers' epistemological views of science in three dimensions namely, traditional views of science, traditional views of science education and nontraditional views of science. Survey was e-mailed to a group of researchers, and secondary science and elementary school teachers. Results of the study indicated that scientists had more traditional views of science than the teachers. Also, it was found that compared to women participated in the study, men had more traditional views of science and science education. When the teachers compared, secondary school teachers had more traditional views of science education than elementary school teachers.

Similarly, Yılmaz-Tüzün and Topçu (2008) investigated Turkish pre-service elementary science teachers' epistemological beliefs and the relationship among their beliefs, epistemological world views, and self efficacy beliefs. For the specified purpose of the study The Schommer Epistemological Questionnaire (in four dimensions namely, innate ability, certain knowledge, simple knowledge, omniscient authority), Epistemological World View Scale, and a self efficacy scale were administered to 429 pre-service elementary science teachers in five universities located in Ankara, Eskişehir and Van in Turkey. The Epistemological World View Scale used by the researchers is an instrument used to categorize the respondent teacher candidates' world views as realist, contextualist and relativist. According to this instrument, if teachers hold a realist world view, they use mostly teacher centered methods and they tend to view their students as passive knowledge receivers. If teachers hold a contextualist world view, they especially focused on the learning process itself rather than the type of outcomes that students need to learn. In this view, the teachers see themselves as guides or facilitators and encourage peer learning in their classrooms. And if teachers hold relativist world view, they believe that students can construct their own knowledge and mostly try to create student centered learning environments. The researchers conducted multiple regression analysis to explore relationships among pre-service science teachers' epistemological beliefs, self efficacy beliefs and epistemological world views. For innate ability, self efficacy, outcome expectancy and epistemological world view scores significantly contributed to the model and explained 29.6% of the variance ($F(1, 420) = 59.94$, $p < .01$, adjusted $R^2 = .296$). This result indicated that teachers believe that students' learning ability is not fixed at birth and it can be developed by effective teaching practices. For certain knowledge, only outcome expectancy significantly contributed to the model and explained 1.4%of the variance ($F(1, 420) = 7.07$, $p < .01$, adjusted $R^2 = .014$). The results for certain knowledge dimension revealed that teachers believing their students' potential to do well in science tend to feel confident about influencing their students' achievement only when that scientific knowledge is unchanging. For simple knowledge only epistemological world views significantly contributed to the model and explained only 0.8% of the variance ($F(1, 420) = 4.41$, $p < .05$ adjusted $R^2 = .008$). According to results, teachers believing the effectiveness of student centered approaches in learning tended to believe that science is best taught by requiring students to memorize facts and scientific knowledge. None of the predictor variables significantly contributed to explain scores on omniscient authority. In summary, the results of this study showed that pre-service teachers had very sophisticated beliefs in Innate Ability dimension and but in other epistemological beliefs dimensions their beliefs were found to be in simple level. Also, it was found that pre-service teachers believe that they will be unsuccessful in teaching science if scientific knowledge is continuously changing. In addition, they confidently use student centered teaching approaches if their students successfully memorize scientific facts and knowledge.

In another study with teacher education students, Chan and Elliot (2000) investigated the epistemological beliefs of 352 student teachers of the Hong Kong

Institute of Education. Schommer's 63 item questionnaire was used to assess students' beliefs. The factor analysis did not validate the five factor structure of Schommer's framework, instead three factor structure was obtained and the results were interpreted according to this three factor structure. The factors obtained in this study were called Fixed/Innate Ability, Omniscient Authority, and Certain Knowledge. The findings of this descriptive study suggested that teacher education students strongly believe that the knowledge which is handed down by the authority, and accordingly they do not criticize the knowledge given by experts or authority, and also find those knowledge clear and unambiguous. In addition similar to findings of the previous studies of college and high school students, the teacher education students also strongly believe in Innate/Fixed Ability in learning and quick learning. Different from the other studies, in this study, students' beliefs merged into related and complex factors rather than relatively independent dimensions obtained in the previous studies. These findings imply the importance of cultural factors affecting the epistemological beliefs of individuals.

2.1.2 Epistemological Beliefs and Academic Performance

Epistemological beliefs were found to have an influence on performance of several different learning tasks in the literature such as physics conceptual understanding (Hammer, 1994), text comprehension (Ryan, 1984; Schommer, 1990; Schommer, Crouse, & Rhodes, 1992), science learning (Qian & Alvermann, 1995; Songer & Linn, 1991), and general academic achievement (Schommer, 1993). Ryan (1984) also found that students' beliefs about knowledge affect their understanding of complex topics or complex academic tasks such as conceptual change learning. Eylon and Linn (as cited in Davis, 1997) stated that students' beliefs influence short term performance in science class as well as their long term progress. Shommer (1993), in her study with high school students, showed that naïve beliefs about epistemology are associated with low GPA's.

Several researchers in the science education literature investigated the students' beliefs about nature of science and the relationships between these beliefs and science learning and achievement since 1980’s (Carey, Evan, Honda, Jay, & Unger, 1989; Driver, Leach, Millar, & Scott, 1996; Hammer, 1995; Larochelle & Desautels, 1991; Qian & Alvermann, 1995; Solomon, Duveen, & Scott, 1994; Songer & Linn, 1991). Epistemological beliefs believed to contribute to understanding of science concepts, science learning and performance in science classrooms (Driver, Leach, Millar, & Scott, 1996; Hammer, 1994; Schommer, 1993; Songer & Linn, 1991; Tsai, 1998b; 2000a).

Schommer (1997) stated that there is relationship between epistemological beliefs and learning. In one of her studies with colloquies (Schommer, Crouse, & Rhodes, 1992), it was stated that more students believe that the knowledge is best characterized as isolated facts, the more difficulty they have in understanding information in complex domains such as statistics and medicine. Schommer (1993) also stated that academic achievement of students are not only directly influenced by the epistemological beliefs, but also indirectly influenced by the students’ learning approaches; epistemological beliefs may affect the students’ learning approaches and these approaches in consequence their influence academic achievement.

In her study with 1000 high school students, Schommer (1993) investigated the development of secondary school students’ epistemological beliefs and the influence of these beliefs on academic performance. The sample composed of 405 freshman, 312 sophomore, 274 junior and 191 senior high school students. Epistemological beliefs of the students were assessed by Schommer’s (1990) questionnaire composed of 12 subsets of items to investigate students’ preferences about knowledge and learning. In order to examine the influence of epistemological beliefs on overall academic performance, the researcher conducted regression analysis in which students’ GPA scores were regressed on the four epistemological factor scores. The results showed that all four epistemological factors predicted GPA. In the order of entry, they were belief in quick learning ($F(1, 863) = 61.87$, $p <.001$, $MSe = .77$), belief in simple knowledge ($F(1, 862) = 15.28$, $p < .001$, $MSe = .77$), belief in certain knowledge ($F(1, 861) = 7.05$, $p < .01$, $MSe = .76$), and belief in fixed ability ($F(1, 860) = 6.27$, $p < .01$, $MSe =.76$). The results revealed that less that students believed in quick learning, ($r = -.26$), simple knowledge ($r =-.20$), certain knowledge (r = -.12), and fixed ability (r = -.15), the better were their GPA scores. Therefore, it can be said that epistemological beliefs predicted students' GPAs.

In her another study, Schommer (1990) investigated the effect of epistemological beliefs on students' comprehension and interpretation of information. In this study, the students were required to read a passage and then completed the comprehension tasks. There were two passages; either in the domain of psychology or physical science (nutrition), and students were asked to read one of the passages. The sample of the study was 86 junior college students. After reading the passage, the students participated in the study were asked to write a conclusion paragraph about the passage, and also a mastery test was prepared for each passage. As an indicator of their prior knowledge, the students were asked to report the number of classes they had taken in psychology, sociology, biology, nutrition and health sciences. The classes that are relevant to the passage they read were totaled and used as an index of their prior knowledge. Students were also asked to rate their confidence in understanding the passage. Conclusions for the passages that students read were coded for simplicity and certainty. If students' written conclusions included oversimplified test information by describing a single point of view or avoided drawing a conclusion, they were scored as simple. If the written conclusions included elaborated text information or integrated key points, they scored as complex. For the uncertainty, the written conclusions were scored as certain or uncertain, depending on the inclusion of certain answers or suggesting uncertainty respectively. The researcher conducted multiple regression analysis epistemological factors for four taking verbal ability, prior knowledge and gender as the background variables. According to the results, quick learning predicted oversimplified conclusions ($F(1, 59) = 7.47$, $b = -.18$, $MSe = .17$), and certain knowledge predicted certain conclusions ($F(1, 57) = 8.5$, $b = -.33$, $MSe = .21$). Results suggested that the more students believed in quick, all or none learning, the more likely they were to oversimplify conclusions, and the more students believed in certain knowledge, the more likely they were to write absolute conclusions. As seen in the findings of the study, epistemological beliefs seem to have an influence on students' processing of information and comprehension.

In order to obtain a complete understanding of personal epistemology, and its' relationship with academic performance, Schommer-Aikins and Easter (2006) conducted a study with 107 college students. In this study, the researchers investigated two epistemic paradigms; namely ways of knowing (connected knowing and separate knowing) and epistemological beliefs (beliefs about the speed of knowledge acquisition-speed, the structure of knowledge-structure, knowledge construction and modification-construction, characteristics of successful students-success, and attainability of truth-truth). Students' academic performance was based on their scores on reading comprehension test and a university course grade. Path analysis revealed that the effects of ways of knowing on academic performance are mediated by belief in the speed of learning.

Kardash and Scholes (1996) conducted an interesting study to examine the influence of people's epistemological beliefs about the certainty of knowledge and the strength of their beliefs about a controversial issue on their tendency to enjoy effortful thinking on their interpretation of controversial information. The participants were 96 undergraduate students. They were required to write reflection paragraph after reading a controversial text about HIV and AIDS relationship. The researchers found that the less people believed that the knowledge is certain and the less extreme their initial beliefs related to the topic under study and the more they enjoyed the cognitively challenging tasks, the more likely they tend to write conclusions in conclusive and tentative nature about the text they read. On the contrary, Kardash and Scholes (1996) stated that if people believe certainty of knowledge strongly, and they extreme initial beliefs regarding the topic, and they do not prefer to engage in cognitively challenging tasks, they more likely to ignore the inconclusive nature of the text they read, and they tend to write biased reflections.

In a more specific area of research in terms of science education, Conley, Pintrich, Vekiri and Harrison (2004) conducted a correlational study in order to investigate the changes in 187 fifth grade students' epistemological beliefs in a nine week hands on science unit. The researchers assessed students' epistemological beliefs in four dimensions, namely Source, Certainty, Development and Justification by using Elder' (1999) instrument. They also collected data related to students' gender, ethnicity, socio economic status and achievement from school records. They used the combination of mathematics and reading test scores from the Stanford Achievement Test as an indicator of students' achievement. Students' epistemological beliefs were measured both at the beginning and at end of the unit. Results showed that, students' epistemological beliefs about source and certainty of knowledge became more sophisticated at the end of the unit meaning that students moved away from the beliefs that knowledge was certain and existed in external authorities. However, there were no significant changes in development and justification sub dimensions. The researchers also investigated the effect of gender, ethnicity, SES and achievement in the development of epistemological beliefs. The result showed that there were no main or moderating effects of gender or ethnicity, but effects of SES and achievement was observed. According to the results, students with low SES and low achievement levels had less sophisticated beliefs when compared to students with average SES and high achievement level. Also, they found that high achievers had more sophisticated beliefs. Correlation results showed that at the end of the intervention, it was found that there were significant correlations between all four epistemological beliefs sub dimensions and achievement, namely for Source ($r = .46$, $p < .01$), Certainty ($r = .51$, $p < .01$), Development ($r = .27$, $p < .01$), and Justification ($r = .22$, $p < .01$).

Conley, Pintrich, Vekiri and Harrison (2004) also added that, although they did not collect data related to contextual information, they observed that hands-on science instruction served students' development of more sophisticated epistemological beliefs. They collected data from classrooms in which students collected data, made observations, compared findings from studies and made claims using evidences, share and discuss their findings with their classmates. This type of instruction provided students an environment in which there was an opportunity for less reliance on teacher's authority and having a chance of making different inferences based on their results of the experiments and accordingly might serve the students' epistemological belief development.

Elder (1999) examined the correlations between epistemological belief dimensions and students' performance assessment scores for two science topics named Mystery Powders (N = 130) and Electric Mysteries (N = 122). The correlations indicated that very few links exist between epistemological beliefs and students' learning in those topics. The correlations ranged between .03 and .37. Based on the findings she discussed that these relatively low correlations may be due to the attempt that determine students' epistemological beliefs as including separate dimensions. The researcher added that elementary students may have a more holistic sense of epistemological beliefs, and it might be more appropriate to measure elementary students' epistemological views with holistic measures instead of try to capture their ideas about each individual dimension. Students' learning in science or in other words their science achievement may be related to more general sense of epistemological understanding. Based on this view, she created an index for students' overall epistemological understanding and group students as less or more naïve. The groups of students by epistemological beliefs were compared for the relation between their epistemological beliefs and learning by investigating the differences of their scores on the performance assessments. ANOVA results for Electric Mysteries topic showed that students' scores on that topic differed by the their relative sophistication of epistemological beliefs ($F(1, 122) = 4.379$, $p < .05$). Students' holding more sophisticated views of epistemological views scored significantly higher than students' with naïve epistemological views. On the other hand, for the Powders topic, students' performance did not differ by their sophistication of epistemological beliefs.

Kızılgüneş (2007) investigated the predictive influences of 1041 sixth grade students' epistemological beliefs, achievement motivation, learning approaches on achievement in classification concepts in science. She used the Turkish versions of Learning Approach Questionnaire, Epistemological Beliefs Questionnaire, Achievement Motivation Questionnaire and Classification Concept Test. Results of the study showed that most of the students believed tentative nature of science, they utilized meaningful learning approach during their science learning and they liked to learn something new. Students' achievement scores were found to be correlated with their epistemological beliefs, learning approaches and goal orientations. Regression analysis revealed that learning approaches explained 12% of the variance and epistemological beliefs explained 2% of the variance in students' achievement.

Songer and Linn (1991) investigated the relationship between 153 eight grade students' epistemological views about science and their ability to integrate scientific knowledge about thermodynamics. The participant students enrolled in a one semester physical science class. A nine item measure called The View of Science Evaluation was used to collect data from students about their beliefs about science. As a result of the analysis, students' beliefs were categorized into three groups: a) dynamic beliefs, b) static beliefs, and c) mixed beliefs. Students who had dynamic beliefs about science were likely to view scientific knowledge as controversial and changing. On the other hand, students who have static beliefs about science were unlikely to recognize the controversy in science knowledge. These students believed that scientific knowledge is unchanging. The researchers also found that students having dynamic views related to epistemology of science were more likely to demonstrate understanding of heat and temperature topic than students having more static views of science. In other words, students believing changing and developing nature of scientific knowledge were more likely to integrate concepts in thermodynamics than students believing that scientific knowledge is certain and stable. Songer and Linn (1991) explained that if students believe that science consists of separate and isolated pieces of knowledge, they may not able to integrate the knowledge presented in science classes. They added that, if science is presented to students as relatively unrelated pieces of information, it will be made science learning even harder. Students can integrate science knowledge properly, if they are presented with an appropriate nature of science view and with an instruction parallel to this constructivist view.

Similarly, in a survey study with 1269 grade 7 and 8 students to examine epistemological beliefs, Schommer, Brookhart, Hutter, and Mau (2000) also investigated the predictive value of epistemological beliefs in students GPA scores. The students in the study completed the revised version of Schommer's epistemological beliefs questionnaire. Only some part of the students' GPA scores could be obtained from school records. Therefore, to ensure that students with GPA scores were not substantially different from the entire sample, the researchers conducted chi-square analysis to compare students with and without GPA score information. No significant differences were found for gender or for grade level in school. The researchers further tested the representativeness of beliefs of students with obtained GPA information using one way multivariate analysis of variance incorporating the availability of GPA predictor and epistemological belief scores as the criterion measures. There were no significant differences obtained for the epistemological beliefs sub dimension scores. Since the researchers revealed that the students with available GPA scores were found to be comparable with the entire sample, they continued with the regression analysis. In order to investigate the predictive value of epistemological beliefs, students' GPA scores were regressed on epistemological beliefs scores in stepwise regression. At each step of the analysis, the variable accounting for the largest variance entered the equation. Two of the predictor variables were found to be significant; belief in fixed ability ($F(1, 356) = 28.47$, $p < .001$, $\beta = -.24$, $MSe = .52$), and belief in quick learning ($F(1, 356) = 8.65$, $p < .01$, $\beta = -.18$, $MSe = .51$). It can be concluded that there was a relationship between students' epistemological beliefs and their general achievement in school, more specifically, the less students believed in fixed ability to learn and quick learning, the better GPA they had.

Stathopoulou and Vosniadou (2007) investigated the relationships between secondary school students' physics-related epistemological beliefs and physics conceptual understanding. The researchers first developed an instrument called Greek Epistemological Beliefs Evaluation Instrument (GEBEP) in order collect data about students' physics related epistemological beliefs. Then, they investigated the hypothesis that sophisticated physics related epistemological beliefs is a good predictor of physics conceptual understanding. First, the researchers administered the GEBEP to 394 tenth grade students, then they selected students who were scored highest 10% on GEBEP (38 students) and scored lowest 10% on GEBEP (38 students) and measured those students conceptual understanding in physics by using Force and Motion Conceptual Evaluation Instrument (FMCE) developed by Thornton and Sokoloff. The results of the study showed that students having sophisticated physics-related epistemological beliefs had significantly higher scores on FMCE compared to the students having less sophisticated beliefs ($t = 5.209$, $df = 47$, $p < .001$). Stepwise regression analysis with FMCE scores as the dependent variable and scores on Structure of Knowledge, Construction and Stability of Knowledge, Attainability of Absolute Truth and Source of Knowing as the predictors was carried out. The analysis resulted with two components; Stability of Knowledge and Structure of Knowledge accounting for the 19.5% of the variance, ($R = .441$, $F(2, 73) = 8.827$, $p <.001$). Both Stability of Knowledge and Structure of Knowledge component were found to be statistically significant predictors, with standardized β coefficients .281 and .240 respectively. Therefore, the results showed that beliefs regarding the Construction and Stability of physics knowledge and the Structure of physics knowledge were good predictors of physics conceptual understanding. The researchers concluded that sophisticated physics related epistemological beliefs are necessary for physics understanding and epistemological beliefs should be taken into consideration in physics education.

Qian and Alvermann (1995) conducted a study in which they examined the relationship between 265 secondary school students' epistemological beliefs about science and their conceptual change learning. The sample of study involved students from ninth to 12th grade. In this study, a refutational expository text titled "Newton's Theory of Motion" was used, which directly confronted misconceptions about Newton's first law of motion. The researcher adapted Schommer's Epistemological Beliefs Questionnaire for high school students and used to assess the epistemological beliefs of selected sample of students. A 10 item Learned Helplessness Questionnaire indicating the difference between learned helplessness and mastery orientation was used. In addition to these instruments, a prior knowledge test and an achievement test were used in the study. The prior achievement test was used to screen and classify students' existing knowledge about Newton's law of motion. The achievement test consists of two subtests, one for assessing conceptual understanding and the other for application reasoning. The epistemological beliefs questionnaire, learned helplessness questionnaire, and prior knowledge test were administered two weeks before the start of the experiment. Then, students were required to learn the

Newton's theory of motion by reading the refutational text. The students were given 15 minutes to read and study the text. At the end of their study, the students were given 15 minutes to complete the achievement test. In order to investigate whether students who had immature beliefs about learning, knowledge and ability, and who were helpless would fail to overcome their naïve theories in conceptual change learning, canonical correlation analysis was conducted, with one set of variables including Quick Learning, Simple-Certain Knowledge, Innate Ability, and learned helplessness and the other set variables including conceptual understanding and application reasoning. The researchers found that in predicting conceptual change learning, simple-certain knowledge and quick learning were important predictors with the structure coefficients of -.87 and -.48 respectively. In contrast, learned helplessness (R = -.30) and innate ability (R = -.35) were not important. The results obtained from this study about the importance of contribution of students' beliefs about simple-certain knowledge is consistent with the findings obtained from Schommer and Dunnell's (1992) and Ryan's (1984) studies. Therefore, it can be said that students having immature epistemological beliefs, especially in simple-certain knowledge dimension, are less likely to experience success in conceptual change learning. Also, the results of the study imply that there is a need for the development of instructional strategies that can be used to improve students' epistemological beliefs of students and consequently improve their physics learning.

In another study, Qian and Alvermann (2000) reviewed the previous studies done in order to examine the relationship between the secondary school students' epistemological beliefs about science and conceptual change learning. Based on the previous studies done in the literature, the researchers first established that students have naïve beliefs about nature of science, especially the purpose of science and the notion of scientific facts. Results of the review indicated that students holding immature beliefs about science are less likely to acquire integrated understanding of particular science concepts and also they are less likely to change their conceptions once they are formed. The researchers stated that students who have naïve epistemological beliefs are less likely to meet the challenges and achieve conceptual change compared to the students who have more mature and complex beliefs.

Since there were relationships found between students' epistemological beliefs, knowledge integration, learning of complex topics and conceptual change in science in science (Songer & Linn, 1991; Qian & Alverman, 1995; 2000), the results obtained from studies imply that students learning of science concepts and conceptual change in science learning may be impeded by the immature epistemological beliefs, and therefore improving students' epistemological beliefs in science is imperative for better science learning of students. There are various ways to promote students' mature epistemological beliefs, such as use of reflective inquiry (Carey, Evans, Honda, Jay, & Unger, 1989), use of stories from history of science (Solomon, Duveen, & Scott, 1994), and examining teachers' epistemological objectives (Hammer, 1995).

In a study to investigate epistemological beliefs-academic performance relationship, Tsai (1998b) explored the interrelationships between students' general science achievement, scientific epistemological beliefs and their cognitive structure outcomes on the topic of basic atomic theory. Chinese version of Pomeroy's (1993) questionnaire was administered to 48 Taiwanese eight grade students in order to collect data about their scientific epistemological beliefs. Students' science achievement was represented by the by their scores on two school wide science exams. The scores of these two tests were accepted as the indicator of students' prior achievement level in the study. In order to determine students' cognitive structures of the atomic model, a two period, the total of 100 minutes treatment lesson was taught to all participating classes of the study. After finishing the treatment lesson, every subject of the study was interviewed about what he/she had learned about the lesson. Correlation analysis showed that students who held more constructivist oriented scientific epistemological beliefs tended to perform better in terms of generating more ideas ($r = .42$, $p < .01$) and the number of complex linkages generated ($r = .42$, $p < .01$) compared to the students who hold more empiricist oriented scientific epistemological beliefs. Therefore, it can be said that there was a positive significant correlation between constructivist oriented scientific epistemological beliefs and better cognitive structure outcomes. However, the correlation between students' science achievement and scientific epistemological beliefs did not found to be significant.

In a longitudinal study, Trautwein and Ludtke (2007) examined the relationship between epistemological beliefs, specifically the certainty of knowledge and school achievement and the choice of college majors of German students. The researchers collected data in the final year of the high school (Time 1) and early in the college (Time 2) as a part of a large scale longitudinal study called the Secondary School System and Academic Careers (TOSCA). The data analyzed in this study stem from 90 randomly selected upper secondary students from the above mentioned large scale study. The researchers also measured the students' cognitive ability from the Figure Ability and Verbal Ability sub scales of a Cognitive Ability test. Also, they collected final overall grade of students from school records as a broad index of the students' achievement. In Germany, final school grade of high school has a high importance for the university choice. This grade provides access to the students when they choose their field of study. In this study, students were also asked for their parents' type of school and the jobs and a composite SES score was calculated using these data based on the International Socio Economic Index of Occupational Status (ISEI). The higher the ISEI score the higher the socio economic status of students. Also, the number of books possessed by the family was also asked to the students as an additional indicator of family background. Results of the study showed that certainty beliefs was found to be correlated significantly and negatively with family SES ($r = -.09$, $p < .05$), cultural capital ($r = -.17$, $p < .05$), cognitive abilities ($r = -.18$, $p < .05$), and final school grades ($r = -.23$, $p < .05$). There was no significant correlation found between certainty beliefs and age or gender. The researchers further examined the role of certainty beliefs as predictors of school achievement using structural equation modeling. The certainty beliefs were specified to be mediating the influence of cognitive abilities and family background on final school grades. Family background, cultural capital, cognitive abilities, gender, age, were used as the predictors of certainty beliefs and final school grade as an indicator of achievement. The fit of this hypothetical model was found to be good ($\chi^2 = 478.47$ with $df = 115$, RMSEA = .033, SRMR = .025). Similar to the findings of the other studies in the literature, the certainty beliefs in the model had a negative significant effect on final school grade ($\beta = -.15$, $p < .001$).

2.1.3 Epistemological Beliefs and Learning Approaches

Recent research in the science education literature has shown that there is a relationship between students' epistemological beliefs and their learning approaches. There are lots of studies in the literature investigating the relationship between students' learning approaches and epistemological views of science (Cano, 2005; Cavallo, Rozman, Blickenstaff, & Walker, 2003; Chan, 2003; Edmondson, 1989; Edmondson & Novak, 1993; Hammer, 1995; Lederman, 1992; Saunders, 1998; Schommer, 1990; Songer & Linn, 1991; Tsai, 1996; 1998a). According to a conceptual model proposed by Watters and Watters (2007), learning approaches of students are influenced by their goals, prior experiences, ability, and the nature of the material being taught, in addition to students' epistemological beliefs.

Based on the previous research findings, Cavallo, Rozman, and Potter (2004) stated that students who see science as an unchanging fixed body of already known knowledge may believe that science is learned best by memorizing the body of knowledge. Similarly, Edmondson (1989) and Hammer (1995) indicated that students having constructivist view of science employ more meaningful activities when learning science, on the other hand, students having empiricist view of science tend to employ more rote like strategies when learning science. Constructivist students prefer in depth understanding of science concepts, they tend to apply what they learn in school in other situations, and they mainly motivated by their interest in science. Whereas, empiricist students think that science has no application in real life and they are generally motivated by the grade or exam pressure.

Tsai (1996) found that students having epistemological views more oriented to the constructivist oriented instructional activities, employ a more active mode of learning, utilize more meaningful strategies to enhance their learning and assess their understanding, and have more pragmatic and socially contextualized ideas about learning science and applying scientific knowledge when compared to the students who were more oriented to the empiricist epistemology of science. Similarly, Edmondson (1989) and Tsai (1998a) found that students having more constructivist views of science tended to employ meaningful learning strategies, and on the other side students having more empiricist view of science tended to employ rote learning strategies. Edmondson (1989) further explained that since their conception of knowledge is static, logical positivists tended to use rote learning strategies. As long as knowledge is static, unchanging, it seemed natural to them to memorize the absolute truths, rather than attempt to organize ideas as elements of larger conceptual frameworks which would be subject to revision.

Tsai's works (1996; 1998a; 1999a; 2000a) revealed that constructivist oriented views about epistemology of science help students to develop better knowledge frameworks and learning strategies in science. As the students develop more sophisticated views of epistemology of science, they more likely to use meaningful learning strategies in their science learning, and their attitude toward science become more positive. Qian and Alverman (2000) also stated that students' naïve beliefs about the nature of knowledge and learning are strongly related to their less sophisticated learning strategies. Several studies consistently found that students' who have naïve epistemological beliefs; more specifically who believe in fixed intelligence, simple knowledge, and quick learning generally tend to avoid obstacles and use ineffective learning strategies when they confront a difficulty or a challenging situation in a learning environment (Dweck & Leggett, 1988; Ryan, 1984; Schommer, 1990).

Roth and Roychoudhury (as cited in Chin & Brown, 2000) stated that students' view about epistemology of science not only affect their learning strategies, but also their attitude toward the classroom activities. According to their view, positivist students who think that scientific knowledge is the absolute truth see the textbook as storage of knowledge and therefore try to memorize information inside it. These students would not try to find things out; they would have a tendency to rely on textbooks, peers or teachers in learning. On the other side, students who have constructivist view of science would try to construct their own knowledge through laboratory activities, and try to relate the information they get in a meaningful way.

Cano (2005) investigated the relationship between students' epistemological beliefs, learning approaches and academic performance by a cross-age study. The sample of the study was 1600 Spanish secondary school students. The learning approaches of students were measured by The Learning Process Questionnaire as surface, deep and achieving. Epistemological beliefs of the students were measured by the Schommer's Epistemological Beliefs Questionnaire, and the academic achievement of students was measured by using the end of year examination results. Results of the study showed that students' epistemological beliefs became less naïve and more realistic as they advanced through the high school. In addition, girls' epistemological beliefs for all grade levels were found to be more realistic than boys. It was also found that learning approaches of girls and boys were similar at the beginning of the secondary education and became different at the end. Male students were found to have higher surface approach scores in junior high and senior high grades. In senior high grade, female students had higher deep approach scores compared to male students.

In his study, Cano (2005) hypothesized a model in which epistemological beliefs and learning approaches were assumed to influence academic achievement directly, and furthermore epistemological beliefs influence academic achievement indirectly through the effect of learning approaches. The model was tested by using linear structural equation modeling and gave good fit indices (GFI = 1.00, AGFI = .99, RMR = .01). Results of the study showed that both epistemological beliefs and learning approaches influenced students' achievement directly. Epistemological beliefs also influence achievement indirectly by effecting learning approaches of students.

In another study, Chan (2003) examined the relationships between epistemological beliefs and learning approaches of Hong Kong teacher education students (N = 292). The researcher used two instruments in the study; one for measuring epistemological beliefs of students and the other for measuring learning approaches. The researcher developed a thirty item questionnaire on a five point Likert scale called EBQ by adapting Schommer's sixty three item epistemological beliefs questionnaire. The questionnaire was composed of four sub scales called

Innate/Fixed Ability, Learning Effort/Process, Authority/Expert Knowledge, and Certainty Knowledge. The second instrument called SPQ measuring students' approaches to learning as Surface, Deep and Achieving. Results of the study showed that four dimensions of the epistemological beliefs were found to be significantly correlated with three study approaches. Chan (2003) found that for epistemological beliefs except the dimension Learning Effort/ Process, all of the remaining dimensions have mean sub scale score below 3, which means that students' belief scores in Innate/Fixed Ability, Authority/Expert Knowledge, and Certainty Knowledge lie at the lower end of the five point scale. It can interpreted that the students participated in the study do not believe that ability is fixed and innate, that knowledge is handed down by authority or experts and that knowledge is certain and permanent. On the other hand, relatively high mean score in Learning Effort/Process sub dimension indicated that the students believed that learning requires effort and a process of understanding. Further Chan (2003) found that the Innate/Fixed ability dimension was found to be positively related to Surface Approach ($r = .21$, $p < .001$), Learning/Effort Process was positively related to Deep Approach ($r = .22$, $p < .05$), Authority/Expert knowledge positively related to Surface Approach ($r = .19$, $p < .01$). Certainty Knowledge was found to be positively related to Surface Approach ($r = .16$, $p < .01$). The results obtained from the study suggested that the students with the naïve belief believing that ability is fixed and innate tended to use the Surface Approach. Students believing that learning require effort and a process of understanding tended to use the Deep Approach when learning. Students believing in Authority/Expert Knowledge tended to use Surface Approaches instead of Deep Approach, and students believing that knowledge is certain and unchanged adapted the Surface and Achieving Approaches. The researcher also studied the relationships between epistemological beliefs and learning approaches by using Structural Equation Modeling and obtained satisfactory goodness of fit indexes confirming the proposed model of relations between the dimensions of epistemological beliefs and study approaches (GFI = .98, AGFI = .90, RMSEA = .099). According to the model obtained by the study, Innate/Fixed Ability dimension of epistemology of science affected Surface Approach, Learning Effort/Process affected Deep Approach and

Achieving Approach, Authority/Expert Knowledge affected both Surface Approach and Deep Approach and Certainty of Knowledge dimension affected Surface Approach and Achieving Approach.

Davis (1997) investigated 180 eight grade middle school students' particular beliefs about the process of scientific inquiry and their beliefs about learning science, more specifically whether they prefer to memorize concepts or try to understand them. The research conducted in a physical science classroom in which an innovative curricula and technology was used to improve students' science learning. Students were required to complete projects during the course. The assessment instrument was administered online as pre and post test, and students were required to answer 19 multiple choice and some open ended questions. The students' academic performance was measured by using their grades of the projects that they prepared during the course and their grade on the final exam of the course, which covered all the concepts that they have learned throughout the semester. In addition, 24 students were interviewed about their epistemological beliefs, and nine of the interviews were used as the qualitative data to the study. The epistemological belief dimensions that were investigated in the study were: Process of scientific decision making (dynamic or static), Strategy for Learning (understand or memorize), and Autonomy for Learning (personal or external responsibility). At the end of the 17 weeks of semester, positive change was observed in terms of students' epistemological beliefs. Paired samples t-test results showed that students' views in both Strategy ($t[167] = 3.227$, $p < .05$) and Autonomy ($t[167] = 2.168$, $p < .05$) dimensions were improved significantly. In other words, students were more likely to see understanding as a good strategy for science learning, and they were also more likely to see themselves as responsible agents for their learning. The results of the study also indicated that students who thought that science has a dynamic nature preferred to understand the concepts in science lessons, whereas students who thought that science has a static nature, preferred to memorize the facts. In addition, it was found that the students believing understanding is the best strategy in learning science scored highest in the final science exam.

Tsai (1998a) conducted a study to investigate the interaction between scientific epistemological beliefs and learning orientations of Taiwanese eight grade students. First Pomeroy's (1993) questionnaire was administered to 202 students, and then 20 information rich students were determined as the final sample of the study and interviews were made with these students. In order to choose appropriate students for interviews following criteria were used: 1) they were above average achievers, 2) they expressed a strong certainty and clear tendency regarding their scientific epistemological beliefs based on the questionnaire results. The researcher grouped students as having constructivist, empiricist and mixed views of scientific epistemological views. The scores on the two school wide science examinations were used as an indicator of the science achievement of students. Among those average achieving students, six were selected randomly from the group of students who scored in the top 15% on Pomeroy's questionnaire, eight were selected from the average group who are holding both constructivist and empiricist views about science, and six were again selected randomly from the bottom 15% group. Qualitative analysis results showed that, students holding constructivist epistemological beliefs about science tended to learn through constructivist oriented instructional activities and use meaningful learning strategies when learning science. On the other hand, students holding more empiricist epistemological beliefs tended to use more rote learning strategies when learning science. Also, it was seen that knowledge constructivist students mainly motivated by the curiosity and interest when learning science, whereas knowledge empiricist students were mainly motivated by the performance on the examinations.

Tsai (1998a) also found that constructivist students were the learners who think deeply, apply what they learned in everyday life and ask questions immediately if they do not understand. On the other hand, empiricist students were the learners who tend to listen carefully in classes and do more problem solving activities. The researcher stated that constructivist students tended to employ more meaningful learning strategies in learning science emphasized the importance of conceptual understanding and empiricist students tended to employ more rote learning strategies and believed the importance of more problem solving activities. Based on these results, the researcher concluded that, students' scientific epistemological views play an important role on their learning orientations. When students asked for their opinions about the most important factors for the success of learning science, constructivist students emphasized the importance of conceptual understanding (five of them) and critical review of their own ideas (two of them) in their responses. When the same question was directed to empiricist students, they emphasized the more problem solving practices (four of them) and to listen carefully what the teacher says in class (two of them).

Cavallo, Rozman, Blickenstaff and Walker (2003) conducted a study to explore college students' learning approaches, reasoning abilities, motivational goals, and beliefs about the nature of science relative to science concept understanding and course achievement. The study was conducted with 291 science major students enrolled in biology or one of two different physics courses. Among the sample of the study, for the biology major students, meaningful learning was significantly and positively correlated with learning goals ($r = .46$). Rote learning was significantly and positively correlated with performance goals ($r = .37$) and negatively correlated with learning goals ($r = -.35$). Also, they found that performance goals were significantly and negatively correlated with epistemological beliefs ($r = -.23$, $p < .05$), which means that high performance goals were related to beliefs that science is fixed and authoritative. For biology students meaningful learning and tentative view of science were positively related to learning goals. This means that these variables may underlie the motivation to learn for just learning. Moreover, it was found that for biology students, the reasoning ability, learning goals and scientific epistemological views were positively correlated with course grade.

Saunders (1998) investigated the relationships between college students' learning approaches and epistemological views of science. The sample consists of 232 college students enrolling in an introductory chemistry laboratory course. According to the results of the Learning Approach Questionnaire, some of the students used meaningful learning approach, some of them used rote learning approach and some used both of the approaches. Similarly students' scores on the Science Knowledge Questionnaire ranged between received to moderate views of epistemology of science. There were no students believing the tentative nature of science. Saunders (1998) found that meaningful learning approach was not related to students' epistemological views of science. On the other hand, negative but small correlation was found between rote learning approach and students' epistemological views of science ($r = -.14$, $p < .05$). Regression analysis showed that epistemological views of science were the only significant predictor of rote learning approach. The students believing that the knowledge comes from an external authority has a tendency to memorize the information rather than trying to make sense of the information. Generally the research has shown that epistemological views of students influence students' learning orientations and it seems that having constructivist views of epistemology is related to more meaningful learning.

2.1.4 Summary of the Literature on Students' Epistemological Beliefs

Epistemological beliefs research dates back to 1940s. Since this date, epistemological beliefs and its relationships with other learner characteristics have continuously been interest of many researchers (Cano, 2005; Cavallo, Rozman, Blickenstaff, & Walker, 2003; Chan, 2003; Conley, Pintrich, Vekiri, & Harrison, 2004; Elder, 1999; Pomeroy, 1993; Schommer, 1990, 1993; Tsai, 1998a). Research has revealed that gender, age, amount of education, culture, domain, learning environments affect individuals' epistemological beliefs (Chan, & Elliot, 2000; Huang, Tsai, & Chang, 2005; Schommer, 1992; 1993; Solomon, Scott, & Duveen, 1996). Epistemological beliefs have shown to have an influence on students' approaches to learning and different learning outcomes like general course performances, text processing, conceptual change, and science achievement. Significant relationships were found in the literature between students' epistemological beliefs and learning outcomes (Hammer, 1994; Ryan, 1984; Schommer, 1990; Schommer, Crouse, & Rhodes, 1992; Schommer, 1993; Qian & Alvermann, 1995; Songer & Linn, 1991). More sophisticated the students' epistemological beliefs, the better the learning outcomes they have. Also, there are studies revealed a relationship among students' sophisticated epistemological beliefs and meaningful learning outcomes (Chan, 2003; Edmondson, 1989; Hammer, 1995; Tsai, 1996; 1998a).

2.2 Research on Learning Approaches

Learning approaches can generally be defined as the learners' ideas or conceptions of learning, how they experience or define learning, and the strategies they use to learn (Cano, 2005). Similarly, Biggs (1991) described learning approaches as the ways students use through their academic tasks and have an influence on the learning outcome. Diseth and Martinsen (2003) included motives in the explanation of learning approaches and stated that they refer to the individual differences in intentions and motives when facing with a learning situation.

In the learning approaches literature, Ausubel (1963) was the first used the terms meaningful and rote learning and defined the meaningful learning as the non-arbitrary relationships in the learners' minds; in other words the viable relationships among ideas, concepts and information. According to Ausubel (1963) to learn meaningfully, students must actively connect relevant prior knowledge to new concepts. On the other hand, in rote learning, students memorize or compartmentalize ideas, concepts or information. In a more recent study, Williams and Cavallo (1995) described rote learning as the memorization of the knowledge when learning, and meaningful learning as trying to relate the old and new information in a learning task. However, as Novak (1988) stated many students do not tend to learn in a meaningful way in science learning; they have difficulty in relating the previously learned materials in science to the new ones and to the daily life experiences. Instead, the students tend to learn scientific concepts by memorization.

In a similar classification following Ausebel (1963), Marton and Saljö (1976) introduced the deep and surface approaches to learning. Biggs (1991) also classified approaches to learning as deep and surface, and added achieving approach. Students who utilize the surface approach are motivated extrinsically like fulfilling requirements or avoiding failure and try to memorize and reproduce the knowledge

(Biggs, 1991), and intend to reproduce the learning material generally by the motivation of fear of failure (Diseth & Martinsen, 2003). The surface approach to learning is related to different forms of rote learning (Diseth & Martinsen, 2003). On the other hand, students who utilize deep approach are generally motivated intrinsically by an interest in the subject matter and they try to learn for self actualization and employ meaningful learning strategies like integrating knowledge and personal experience, relate knowledge pieces to reach a conclusion, and using evidence (Biggs, 1991; Diseth & Martinsen, 2003). Students who utilize achieving approach are generally motivated by the need for achievement and employ organizational strategies when studying (Biggs, 1991).

Although there are different terminologies used in the literature about learning approaches, there is a consensus on a point for the two approaches; deep or meaningful and rote or surface. The most important aspect of the distinction between the two approaches is the intention or absence of intention to understand. Employing the surface or rote approach, there is no intention to understand. The student using surface approach rely on the memorization as a strategy for learning the task or material and the outcome is generally little or no understanding, whereas the students employing the deep approach have the intention of understanding the material (Kember, 1996). Biggs (as cited in Kember, 1996) summarized the contrasting characteristics of students using deep and surface approaches. A students using deep approach is interested in the academic task and enjoys carrying it out, searches for the meaning inside the task, tries to make it meaningful to his/her own experience and to the real world, integrates the parts of the task as a whole, sees the relationships between the task and the previous knowledge, tries to theorize about the task and form hypothesis. On the other hand, a student using surface approach sees the task as a demand to be met, or as a goal to be reached, sees the parts as discrete pieces and unrelated to each other or to other tasks, feel an anxiety about time, avoid personal meanings, relies on memorization and attempts to reproduce the surface aspects of the task.

There are opposing views about the stability of learning approaches in the literature. Some of the research studies showed that some students have predisposed learning orientations for meaningful learning and other have for rote learning (Edmondson, 1989; Enwistle & Ramsden as cited in Chin & Brown, 2000). On the other hand, some other researchers like Marton (1983) argues that learning approaches are context dependent, and should not be seen as the stable traits of the students, utilizing surface or deep approach is a response to a specific learning situation. Similarly, Enwistle and Ramsden (as cited in Chin & Brown, 2000) clarified the importance of teaching and learning contexts and stated that learning approaches are not stable constructs; they are dependent on the learning contexts.

Marton and Saljo (1976) were the researchers who actually initiated the research on students' learning approaches. The researchers examined the learning behaviors of a group of Swedish university students. Students were asked to read some text passages within time limits and then they were asked specific questions about the passage and also required to explain what was the passage was about. Then, the students were also asked open questions in order to understand how he or she tackled the process of reading. By this way, the researchers not only examined the processes and strategies that the students used during learning, but also the outcomes in terms of what is understood and remembered from the texts. At the end of the qualitative data analysis, they found two different clearly distinguishable levels of processing, and they called these levels as deep level and surface level processing. The researchers stated that in the case of surface level processing, the learner focused on the text itself, and he had a reproductive learning conception which means that he utilized rote learning strategy. On the other hand, in the case of deep level processing, the learner focused on the intentional content of the material, and concentrated on understanding what the author of the text actually wanted to say about. In a similar classification of achieving approach proposed by Biggs (1991), Enwistle and Waterson (1988) later introduced the strategic approach in addition to deep and surface approaches and explained it as the intention to achieve the best grades possible depending on the requirement of the assessment. Diseth and Martinsen (2003) stated that strategic approach may be combined with the deep or surface approach. The underlying motivation in strategic approach is achievement rather than interest in ideas different from the case of surface or deep approaches.

The general framework and defining features of the deep and surface approaches were described by Biggs (as cited in Snelgrove & Slater, 2003). Biggs described a system model of learning called the presage-process model. This model explains learning in terms of the factors that have an influence both at the beginning and during the learning process. Personal characteristics of the learner such as IQ, personality, and background are treated as the presage factors. Learning approaches of the students which composed of learning motives and study strategies are treated as the process factors. Based on the Marton and Saljö's (1976) formulations of deep and surface approaches to learning, Biggs (1979) described three different study approaches as deep, surface and achieving which composed of a motive and a corresponding study strategy. According to Biggs model, a student using mostly surface approach learns superficially, and views the task as a demand to reach a goal, uses rote learning and has the aim of achieving minimum requirements. On the other hand, a student using deep approach is motivated by the self satisfaction, attempts to link the past information with the present one, and interested in obtaining a meaningful understanding of the task. Finally, a student using achieving approach is motivated by taking high grades, utilizes systematic approach when learning and uses time efficiently, and may use either deep or surface approach in order to achieve the specific goal.

There are several studies in the science education literature investigating the students' learning approaches (Cavallo & Schaffer, 1994; Cavallo, 1994; 1996; Cavallo, Rozman, Blickenstaff, & Walker, 2004; Cano, 2005; Chan, 2003; Williams & Cavallo, 1995). In order to have better learning outcomes, science educators generally agree that meaningful learning approach should be used. However, generally science educators complain about the students that they extensively tend to use rote memorization when learning science concepts (Roth, 1989).

In order to achieve a complete understanding of science concepts, students must link the prior and new information, concepts, and processes of science, meaning that students must construct the knowledge by using these links (Cavallo, Rozman, & Potter, 2004). These interrelationships and links among science information, concepts and processes which are formed by the students are described as the meaningful learning (Ausebel, 1963). According to Ausebel (1963), for meaningful learning, a) the concepts presented to the learner must be potentially meaningful and therefore provide the learner an opportunity to form non arbitrary relationships within existing conceptual frameworks, b) the learner must have a prior knowledge to which new information can be linked, c) the learner must start a meaningful learning set, which means that the learner must attempt to link the information, concepts and processes.

There are numerous studies in the literature studying students' learning approaches since 1970s (Chan, 2003). Gender, age, learning environment, time and learning experience were the variables believed to have an influence on students' learning approaches. Zeegers (2001) stated that age has a significant effect on students' learning approaches; older students generally displayed high deep approach and achieving approach and a lower surface approach.

In a study to investigate the gender differences on students' learning approaches, Cavallo (1994) conducted a research with 140 tenth grade students in New York. Learning Approach Questionnaire was used in order to get information about students' learning approaches besides collecting information from teachers. In this study, teachers also classified their students as rote learners or meaningful learners. According to teachers' views females were found to be more rote learners than males when learning biology topics. However, results obtained from the Learning Approach Questionnaire indicated no significant differences between male and female students. Since the views of the students and teachers were found to be different, the researcher administered open ended and multiple choice questions in order to understand both students' performance and approaches. Analysis of these questions revealed that there is no difference between students' approaches to learning, but male students' scores on the multiple choice questions were significantly higher than female students.

Chin and Brown (2000) conducted a study to explore eight grade students' learning approaches to learning science in greater depth. For this specific purpose students of one class were observed and taped during the laboratory activities in a chemistry unit. A 31 item Learning Approach Questionnaire was administered to the students in order to determine their learning approaches as deep or surface approach. As a result of the consultation to the teacher, six target students were also interviewed both before and after the instruction about the related science concepts. The selected students ranged in terms of the learning approaches they use in learning science. Analysis of the observations and interviews showed that there were five emerging categories in terms of differences in learning approaches, these are: generative thinking, nature of explanations, asking questions, metacognitive activity, and approach to tasks. Researchers found that when the students used deep approaches to learning, they attempted their ideas more spontaneously, gave more detailed explanations, asked questions focused on cause-effect relationships, predictions, and they were more engaged. They generated mental images, created analogies, hypothesized, constructed thought experiments and predicted possible outcomes, gave self explanations, invoked personal experiences and prior knowledge related to the subject, thought of specific examples and asked questions. On the other hand, students utilizing surface approach, gave explanations like the reformulations of the previously given explanations, in the form of more basic, factual or procedural information.

In a recent study, Smith and Miller (2005) investigated the effect of assessment type and discipline of study on students' learning approaches. The sample of the study composed of 93 psychology and 155 business students. Participants responded the Study Process Questionnaire and they told to assume they were in the context of preparation of a hypothetical exam. The exam was told to be in either essay or multiple choice formats. The researchers of the study assumed the rationale that students perceived the essay type examination as assessing high level cognitive outcomes and therefore, they more likely to tend employing deep strategies and motives when preparing for that kind of exam compared to a multiple choice one. On the other hand, students prefer using surface strategies and motives when they are making preparations for multiple choice exams since they perceived that multiple choice exams assess recalling of factual information. A 2x2x2 MANOVA between subject design was conducted with assessment type (multiple choice and essay), discipline of study (psychology and business), and gender being the independent variables and six sub scale scores being the dependent variables. Results of the MANOVA showed that discipline had significant main effects on students' deep motive, deep strategy, surface motive and surface strategy. Psychology students scored higher on the deep and lower on the surface strategy compared to business students. Gender had a significant main effect on students' achieving strategy. Female students had significantly higher score on achieving strategy compared to males. The researchers thought that personality traits like being more organized (in terms of note taking and assessment preparation) might cause the females having higher scores on achieving strategy. The results of the study indicated that assessment type had no influence on students' learning approaches; however discipline of study had an effect on the learning approaches.

Sadler-Smith (1996) investigated 245 business studies students' learning approaches and also the effects of gender, age and program of study on approaches to studying. The respondents' study approaches were assessed by a 38 item inventory in terms of three primary orientations: deep approach, surface approach, and strategic approach, and also lack of direction and academic self confidence sub dimensions. A three way analysis of variance by program of study by gender by age was conducted, but no significant interactions between variables were observed. Therefore, the researchers conducted a series of one way analysis of variance. One way analysis of variance for the program of study did not reveal any significant effects except strategic approach ($F(3, 223) = 3.00, p < .05$). Business studies students significantly scored higher than computing and business, accounting and finance, and other business related programs of study. In order to investigate the effect of age, the researchers treated age variable as a categorical variable as mature (students older than 23) versus non mature (students younger than 23). Significant effects of age were obtained for deep orientation ($F(1, 218) = 12.31, p <.05$), for surface orientation ($F(1, 220) = 4.68, p < .05$), and for lack of direction orientation ($F(1, 223) = 5.28, p <.05$). Results of the analysis showed that mature students tended to use deep approaches more compared to non mature students, whereas non mature students tended to use more surface approaches and lacked greater direction for study compared to mature students. The researcher also investigated the effect of gender on students' learning approaches. Significant gender differences were obtained for deep approach ($F(1, 218) = 13.01$, $p < .05$), surface approach ($F(1, 220) = 12.53$, $p < .05$), and academic self confidence of students ($F(1, 219) = 6.27$, $p < .05$). According to the results male students had higher levels of academic self confidence than females, and female students had more surface oriented learning approach than males. However, in general the whole sample perceived themselves utilizing deep and strategic approaches more compared to surface approach.

2.2.1. Learning Approaches and Academic Performance

In order to contribute to our understanding the pathway to better learning outcomes, we should understand, how students learn besides what they know and learn (Hazel & Prosser, 2002). The goal of the science education is providing students with the acquisition of conceptual knowledge about the world and how it works. Students should both acquire knowledge and link the knowledge to the previous related knowledge, and eventually create new ideas from what is already known (Cavallo & Schafer, 1994). Therefore, it can be said that meaningful understanding of science requires utilization meaningful learning.

At the opposite side, in rote learning students memorize science facts like an isolated bits of information, instead of attempting to construct relationships or links between information, concepts, ideas, and processes (Cavallo, Rozman, & Potter, 2004). It was reported that students who use rote learning consistently tend to form misconceptions or misunderstandings of science concepts (Boujaoude, 1992).

Students use either meaningful or rote learning approaches in science learning (Cavallo, 1996). However, research on this area showed that deep approaches rather than surface approaches promote students' academic success (Bernardo, 2003; Boujaoude, 1992; Boujaoude & Giuliano, 1994; Cavallo, 1996; Cavallo & Schafer, 1994; Sadler-Smith, 1996; Snelgrove & Slater, 2003; Van Rossum, 1984; Zeegers, 2001). Furthermore, it can be added that students adopting deep approach generally perform better; on the other hand surface approaches to learning negatively correlate with achievement. Qualitative findings from a study with 85 Australian first year biological sciences university students validated this conclusion (Watters & Watters, 2007).

Boujaoude (1992) conducted a study to investigate the relationship between high school students' learning approaches, prior knowledge and attitudes toward chemistry, and their performance on a misunderstanding test. Forty nine high school students enrolled in the study. The researcher observed the students for 16 weeks by attending eighty 50-minutes classes of a chemistry course. The typical week of the course included one laboratory period and four lecture periods. To diagnose students' misunderstandings about science, the Misunderstanding Test was used. In order to assess their approaches to learning, The Learning Approach Questionnaire developed by Donn was used. Also the Attitude Toward Chemistry Questionnaire and Differential Aptitude Test (DAT) were used as indicators of students' attitude toward chemistry and achievement level respectively. Students who score at or above the mean score of 39 items of the Learning Approach Questionnaire were labeled as the meaningful learners and students who scored below that mean were labeled as the rote learners. Correlation analyses showed that one of the highest significant correlations was found between the students' attitude toward chemistry and their learning approaches ($r = .56$, $p < .0001$). A stepwise multiple regression analysis was applied to data in order to determine variables which were the best predictors of performance on the Misunderstanding Post Test. The results showed that the students' performance on the misunderstanding pretest (36%) and their learning approaches (14%) accounted a statistically significant proportion of the variance on their performance of the misunderstanding posttest. Also, ANCOVA was conducted to compare the performance of meaningful learners and rote learners on the post test by using the scores on pretest, attitude questionnaire and Differential Aptitude Test as covariates. It was revealed that meaningful learners performed significantly better than the rote learners on the misunderstanding posttest ($F = 24.98$, $p < .0001$, with adjusted means $X_{meaningful} = 54.79$, $X_{rote} = 44.27$).

Boujaoude and Giuliano (1994) investigated the relationships between students' approaches to studying, prior knowledge, logical thinking ability, gender, and their performance on a nonmajors' college freshman chemistry course. The sample of the study was 220 students at a private university in New York State. The researchers used Approaches to Studying inventory and Test of Logical Thinking (TOLT) to assess students' studying approaches and logical thinking ability respectively. The approaches included in the former instrument were deep approach (active questioning in learning), relating ideas (relating ideas to other parts of the topic under study), intrinsic motivation (interest in learning for learning's sake), surface approach (preoccupation with memorization), syllabus boundness (relying on teachers to define learning tasks), extrinsic motivation (interest in courses for the qualification they offer), and achievement motivation (competitive and confident). Based on the scores obtained from these subscales, a meaning orientation score was obtained by averaging students' scores on the deep approach, relating ideas, and intrinsic motivation subscales, and reproducing orientation score was obtained by averaging students' score on the surface approach, syllabus boundness, and extrinsic motivation subscales. Students' grades on an exam administered early in the semester used as the indicator of prior knowledge and their cumulative final examination scores were used the indicator of achievement in chemistry. Results of the dependent samples t-test showed that students' scores on the reproducing orientation was higher than the meaning orientation ($t = 4.06$, $p < .0001$), and female students had higher score on meaning orientation than male students ($t = -1.76$, $p < .01$). Also, statistically significant correlations were obtained between final exam and pretest ($r = .51$, $p < .0005$), meaning orientation ($r = .16$, $p < .0005$), and logical thinking ability ($r = .24$, $p < .0005$). Moreover, achievement motivation and meaning orientation ($r = .27$, $p < .0005$), and achievement motivation and reproducing orientation ($r = .23$, $p < .0005$) were found to be correlated significantly. Since the variables were found to be correlated with one another, the researchers applied multiple regression analysis to determine which variables were the best predictors of performance on the final exam. The results of the multiple regression showed that prior knowledge, logical thinking ability, and meaning orientation were significant predictors of the performance on the final exam and these variables accounted for the 32% variance on the final exam scores.

In another study, Cavallo, Rozman and Potter (2004) investigated the relationships between learning approaches, motivational goals, self efficacy, epistemological beliefs, scientific reasoning abilities, understanding of physics concepts and course achievement. The sample of the study was 290 college students enrolled in a physics course. Tests and questionnaires related to the above mentioned learning and motivation constructs were administered at the beginning and at the end of the course. In order to assess students' learning approaches as meaningful or rote, 24 item Learning Approach Questionnaire was used. On the meaningful scale, high score means that students have a high meaningful learning approach, and on the rote scale high score means students have a high rote learning approach. Achievement Motivation Questionnaire was used to assess students' motivation to learn physics in three sub dimensions; learning goal orientation, performance goal orientation and students' self efficacy. High score in learning-goal dimension indicates a high desire to learn for the sake of learn, high score in performance goal orientation indicates a high desire to get a high score, and the high score in self efficacy dimension indicates high confidence in ability to learn physics. Science Knowledge Questionnaire was used o assess students' epistemological beliefs about science. Reasoning Ability Test and Force Concept Inventory was used for measuring students' reasoning ability and Newtonian physics misconceptions respectively. Course achievement scores of students were also obtained. Stepwise multiple regression analysis showed that higher self efficacy and reasoning ability were found to be the best predictors of students' concept understanding measured by the Force Concept Inventory, explaining the 33% variance of the test scores. Also, it was found that while self efficacy of students predicted course achievement significantly and positively, learning goals and rote learning strategies predicted the achievement negatively, together explaining the 45% of the variance in achievement scores. Findings also suggested that female students tended to use less meaningful learning from the beginning to the end of the course and males using more meaningful learning over the course time period. For males, learning goals and rote learning were found to be significant but negative predictors of understanding and achievement of the physics course.

Diseth and Martinsen (2003) analyzed the relationship among approaches to learning (deep, strategic, surface), cognitive style, motives, and academic achievement. In their study, 192 undergraduate psychology students were participated. A part of the Approaches and Study Skills Inventory for Students was used to measure students' learning approaches as deep, strategic, and surface approaches to learning. An 18 item Need for Cognition scale was used to assess participants' cognitive style by the indication of their relative agreement with statements like "I would prefer complex to simple problems" and "Learning new ways to think doesn't excite me very much". Also, students' assimilator-explorer styles were determined with a 34 item scale with high scores indicating explorer style and low scores indicating assimilator style, and their perceived affect in achievement situations with a 30 item achievement motives scale. Examination grades of students were used as the measure of academic achievement. Results of the correlation analysis showed that both the surface approach ($r = -.19$, $p < .05$) and the strategic approach ($r = .06$, $p < .05$) correlated with the academic achievement significantly. The total set of variables was analyzed using structural equation modeling to investigate their interrelationships and their relationship to academic achievement simultaneously. The model showed that deep approach to learning did not significantly predicted academic achievement. As evidenced by the correlation analysis, strategic and surface approaches predicted academic achievement significantly in the model ($r_1 = .19$, $r_2 = -.23$, $p < .05$, for strategic and surface approaches respectively). As a result of the study, it was found that approaches to learning predicted academic achievement, however, motives and styles had only indirect effects on achievement. Contrary to the expectations and the other studies in the literature, Diseth and Martinsen (2003) found that deep approach to learning did not predict academic achievement, while strategic and surface approaches significantly predicted achievement.

Snelgrove and Slater (2003) conducted a study with 300 student nurses in UK in order to investigate the relationship between learning approaches and academic achievement of the students. The 42 item Study Process Questionnaire was used to assess students' learning approaches as deep, surface and achieving. Relationships between the learning approaches and academic performance in biology, psychology, sociology and nursing examinations, a community nursing study and GPA were assessed by correlation analysis. Deep learning was found to be correlated significantly and positively with grade performance average ($r = .17$, $p < .05$) and sociology examination results ($r = .18$, $p <.05$). In addition, surface approach was found to be significantly and negatively correlated with the nursing examination scores ($r = -.22$, $p < .05$). Results indicated that deep learning appeared to have a positive influence on academic achievement.

In another study, Hazel and Proser (2002) addressed the relations between students' learning approaches and their learning outcome as a function of prior understanding in a first biology course in a university. The sample consists of a total number of 272 Australian university students, 125 students from University A and 147 students from University B. All the data were collected from the students in laboratories before the first and after the last weeks of their study on the topic of photosynthesis. The pretest consists of a short essay question and a concept mapping task focusing on students' understanding of the photosynthesis topic. The post test replicated the pre test and also included the topic specific versions of Biggs' Study Process Questionnaire and Ramsden's Course Experience Questionnaire. A cluster analysis revealed that students use three different learning approaches called understanding, reproducing and disintegrated. Correlation analysis revealed significant negative correlations between surface approach to learning and the indicators of learning outcome ($r_1 = -.14$; $r_2 = -.18$, $r_3 = -.21$, $p <.05$, for the three indicators of learning outcome respectively). The deep approach, on the other hand, correlated positively with all of the three learning outcomes but the only statistically significant correlation observed was the correlation with open ended question ($r = .12$, $p <.05$). The results of the study showed that students who had better prior understanding, took deeper approaches to their learning and felt that their environment was more supportive of deep approaches. These were the students who also did best on the measures of meaningful understanding of the photosynthesis topic. Researchers stated that only the one third of the whole student sample showed this coherent and also desirable learning pattern. The remaining students showed also a coherent but undesirable pattern of learning; focusing more on the surface approaches of learning and consequently showed worse learning gains and achievement. This study, in addition to the previous studies confirmed the significant relationship between surface approaches to learning and poorer quality learning outcomes.

Bernardo (2003) investigated the influence of learning approaches to learning on academic achievement of Filipino college students. The sample of the study consists of 156 male and 248 female students from a private university. The researcher used Biggs' Learning Approach Questionnaire to assess students' approaches to learning. As a measure of academic achievement, the students' grade point averages (GPA) were used. The results showed that deep and achieving sub scale scores were positively related to academic achievement even when the school ability and prior academic achievement was controlled, whereas surface motive sub scale scores and achievement was found to be negatively correlated. The correlation for surface motive and GPA scores was found to be $r = -.13$ ($p < .05$), for deep motive and GPA scores, it was $r = .17$ ($p < .01$), for achieving motive and GPA, it was $r = .13$ ($p < .05$). When the school ability and prior academic achievement scores were controlled, the correlation was found as $r = .19$ ($p < .01$) for deep motive and GPA score, $r = .14$ ($p < .05$) for achieving motive and GPA score, for $r = .16$ ($p< .01$) for achieving strategy and GPA score. Also, it was found that the relationship between learning approach sub scale scores and academic achievement of male and female students were generally similar.

Sadler-Smith (1996) investigated whether students' study approaches predicted their academic success and also the effects of gender, age, and program of study on approaches to studying. The sample of the study was a total of 245 business studies students. The respondents' study approaches were assessed by a 38 item inventory in terms of three primary orientations: deep approach, surface approach, and strategic approach. As the indicators of academic success both the students' end of semester scores on a core module assessed by a variety of methods (course work, multiple choice test, and essay), and their overall end of semester scores aggregated across 12 modules used. Results revealed moderately high positive correlations between deep and strategic orientations (r = .41, p <.01), and between surface and lack of direction orientations (r = .30, p <.01). The academic self confidence and surface orientations were found to be correlated negatively (r = -.43, p <.01), as did the strategic and lack of direction orientations (r = -.28, p <.01). For the entire sample of students, statistically significant correlation obtained for the overall academic performance and deep approach (r = .25, p <.01). However, for the sub groups, higher correlations were obtained. For the business computing sub group of students, lack of direction was found to be significantly correlated with the aggregate score as an indicator of academic success (r = -.43, p <.01), and for the accounting and finance sub group, deep approach significantly correlated with the aggregate score (r = .43, p <.01), and the strategic approach significantly correlated with the test score (r = .42, p <.01). As a summary, the researcher found that there were better relationships between students' approaches to study and some aspects of the academic success for some particular programs of study.

In a longitudinal study, Zeegers (2001) aimed to monitor the changes in students' approaches to learning in three year period, to evaluate the relationship between students' age, gender, and university entry mode on their approaches to learning and evaluate the predictive validity of learning approaches on students' academic achievement. The sample consists of 200 Australian freshman university students. The Learning Approach Questionnaire was administered to the students in a first year chemistry class and the administration was repeated after 4 and 8 months. Also, the questionnaire was posted after 16 and 30 months. The change over time was evaluated by paired samples t-test and repeated measures ANOVA. Also, in order to reveal the relationships, Pearson product moment correlation coefficients were used. The results of the study showed that students' approaches to learning had dynamic nature and changed as a result of the learning experience. Among the three approaches, achieving approach showed the greatest change with time. Independent from the change, deep approach showed a consistent positive correlation with assessment outcomes. At trial one, for deep approach the correlation was found as r = .11 and at trial 4, it was r = .42 (p < .01). Similar to deep approach, consistent positive correlations were obtained for achieving approach and academic achievement of students. At trial 1, it was low ($r = .04$), it had the highest value at trial 2 ($r = .22$, $p < .01$) and trial 5 ($r = .22$, $p < .01$). Also, a consistent negative approach was obtained for the relationship between surface approach and academic achievement; it ranged between $r = -.13$ at trial 5 and $r = -.19$ ($p < .05$) at trial 2. Similar to other studies in the literature, there was no gender effect observed.

In another study to examine learning approach and academic performance relationship, Cavallo (1996) investigated 189 tenth grade students' meaningful learning orientation and the relationship among those orientations, their reasoning ability, understanding of genetic topics and problem solving ability in a one group pretest-posttest design. Learning Approach Questionnaire was used to assess students' learning approaches. In order to assess students' reasoning ability Classroom Test of Scientific Reasoning, and to assess their understanding of genetic topics three tests were used. Results of the correlation analysis showed that there is no significant correlation between students' meaningful learning orientation and their reasoning ability. However, both meaningful learning orientation and reasoning ability were found to be positively and significantly correlated with performance on genetic topics tests. Meaningful learning orientation was also found to be correlated with problem solving ability. Stepwise multiple regression analysis revealed that students' meaningful learning orientation and reasoning ability predicted scores on the test of understanding genetics topic. Reasoning ability predicted 9% of the variance and meaningful learning orientation predicted 5% of the variance on the tests of understanding genetic topics. Both meaningful learning and reasoning ability were found to be related with course performance.

In a similar study, Williams and Cavallo (1995) investigated the 41 university students' meaningful learning approach, reasoning ability and their understanding of physics concepts. Learning Approach Questionnaire (LAQ), Test of Logical Thinking (TOLT) and Force Concept Inventory (FCI) were used to identify students' learning approaches, reasoning ability and understanding of physics concepts respectively. Results showed that students' reasoning ability and meaningful learning were found to be correlated to physics understanding. Students with higher scores on reasoning ability test and higher scores for meaningful learning approach showed more understanding on physics concepts, on the other hand students' with lower scores on reasoning ability test and had higher scores for rote learning approach were found to have more misconceptions related to physics concepts. In order to determine the best variable explaining the students' performance on FCI, a stepwise multiple regression analysis was performed with the scores on TOLT and LAQ entered as predictor variables. Stepwise multiple regression analysis revealed that reasoning ability was the significant predictor of having misconception in physics by explaining 37.3% of the variance ($r = .61$, $F = 23.239$, $df = 39$, $p = .000$). The LAQ was not found to be a significant predictor of students' physics understanding and was not included in the model ($r = .25$, $F = 2.496$, $df = 39$, $p= .122$). The researchers concluded that students' meaningful learning approach did not predict students' physics understanding more than the reasoning ability did. The researchers explained the results by the correlation between the meaningful learning and reasoning ability; since those two variables were found to be correlated, meaningful learning might be closely linked to reasoning ability, further it may be a part of reasoning ability required for physics learning.

Cavallo and Schafer (1994) explored the relationships of meaningful learning orientation, prior knowledge, instructional treatment, and the interactions between these variables and meaningful understanding of meiosis and genetics topics. The sample of the study included 163 10th grade students attending a public, suburban high school in central New York State. In this study, to measure students' meaningful learning orientations, the Learning Approach Questionnaire and the teacher ratings were used. At the end, a composite meaningful orientation rating was obtained. In order to get information about students' general aptitude, Differential Aptitude Test results of students were obtained from the school. Also the researchers collected data about students' achievement motivation by the use of Achievement Motivation Questionnaire. And finally students were required to provide a written description of their understanding of a particular topic to assess their mental model. In this study, a pretest-treatment-posttest experimental design was used. Stepwise multiple regression analysis conducted with the posttest scores of meaningful learning orientation, prior knowledge, and treatment as the predictor variables.

Results of the regression analysis showed that meaningful learning orientation, prior knowledge about meiosis were the significant predictors of the students' meaningful understanding of meiosis topic. Meaningful learning x prior knowledge interaction term was found as a significant predictor of meiosis ($F(1,92) = 17.62$, $p =.0001$, $R^2 = .16$), the procedural relationship ($F(1,92) = 12.16$, $p = .0007$, $R^2 = .12$), the conceptual relationship ($F(1,92) = 18.48$, $p = .0001$, $R^2 = .17$), and students' relationship statements ($F(1,92) = 5.32$, $p = .234$, $R^2 = .05$). The results of the study indicated that meaningful learning contributed to the students' meaningful understanding of the topic.

Similar to the findings of various studies summarized above, Watkins (2001) stated that generally deep and achievement approaches tend to be positively related with academic achievement, whereas surface approaches to learning tend to be negatively related with it. Secondary school students who employ surface approach to learning showed poor performance in mathematics; on the other hand students who use deep approaches obtained higher grades.

There are various studies in the literature investigating the learning approaches and various learning outcomes other than achievement. One of those studies was conducted by Leung and Kember (2003). In their study, Leung and Kember (2003) examined the association between students' learning approaches and stages of reflective thinking. The sample of the study was 402 undergraduate students from all years of study from a health science faculty in a university in Hong Kong. They used the revised version of Biggs' Study Process Questionnaire to assess students' learning approaches as deep and surface and the Reflection Questionnaire to differentiate between four stages of reflective and non reflective thinking. The Study Process Questionnaire consists of two sub scales of deep and surface approaches to learning. Both of the scales includes motive and strategy subscales. Reflection questionnaire includes four subscales corresponding to the four levels of reflective thinking namely habitual action, understanding, reflection, and critical reflection. Habitual action is defined as the activity which is learned before and as a result of the frequent use becoming an action that performed automatically or with little conscious thought. Understanding is defined as the understanding without relating to other situations. Reflection is the active, persistent and careful consideration of beliefs or a form of knowledge grounded on supports. And the critical reflection is represented the higher level of reflective thinking which includes becoming aware of why we perceive, think, feel, act as we do. The researchers hypothesized a model reflecting the relationships between approaches to learning and four stages of reflective thinking. In this hypothetical model, surface approach is significantly and positively correlated with the habitual action scale but not to the other stages of reflective thinking. A student using a surface approach tends to memorize facts without any understanding or reflection on the matter. Deep approach is significantly and positively correlated with the other three stages of reflective thinking. A students using deep approach is thought to attempt to understand the materials and try to relate it to the previous knowledge. Therefore, in this model, a student is thought to use at least one of the three higher stages of reflective thinking. Leung and Kember (2003) tested their model with the confirmatory factor analysis and the hypothesized model showed an acceptable fit to the data (CFI = .93, SRMR = .05). Furthermore, all the hypothesized paths were found to be statistically significant ($p < .05$). As hypothesized, a strong statistically significant positive correlation was found between surface approach to learning and habitual action ($r = .65$). Also, there were strong statistically significant positive correlations were found between the deep approach and the higher reflective thinking stages, namely understanding ($r = .50$), reflection ($r = .49$), and critical reflection ($r = .33$).

Hegarty-Hazel (1991) investigated the relationship between students' conceptual knowledge and study strategies. The sample of the study was a volunteer sample of 36 students from the university biology course. They were asked to attend a voluntary testing session once before the photosynthesis topic in the course and another after the topic. At the first time, the students were asked to complete a concept map, and at the second time they were again asked to complete a concept map and study-strategy questionnaire. Final exam grades were obtained from records as an indicator of achievement. In order to analyze the concept maps, the researcher examined the number of correct propositional statements, the number of branches in which a higher order concept is related to two lower order concepts, and the number of cross links in which one major section of the map is linked to another major section. These two major sections of the map called light reactions and dark reactions. The researcher identified three primary concepts which are considered to be central to understanding the reaction and three secondary concepts required for understanding and formed a scale for each of the reactions with a score of 5 indicating the correct use of the three primary concepts and three secondary concepts. The results showed that only changing variable was the proportion of correct propositions ($t = 1.82$, $p < .100$) from pre test to post test. Other variables showed little or no change. The correlations between the post concept map variables and surface study strategies were found to be negative and ranging between $r = -.25$ and $r = -.30$. On the other hand, the correlations between post concept map variables and deep study strategies were found to be positive and ranging between $r = .14$ and $r = .52$, which means that students with high deep strategy scores were more likely to have higher scores on post concept map. Also, achievement was found to be strongly negatively correlated to surface strategy ($r = -.63$, $p < .05$) and positively related to deep study strategy ($r = .26$, $p < .05$).

2.2.2 Summary of the Literature on Learning Approaches

In the learning approaches literature, Ausubel (1963) was the first used the terms meaningful and rote learning. Since Ausebel, different researchers used similar classification to define learning approaches, such as deep and surface approaches (Biggs, 1991; Marton and Saljö, 1976). Deep approach generally defined as the intention to understand the learning material (Kember, 1996). In surface approach, as a different form of rote learning, learning by memorization is used (Biggs, 1991; Diseth & Martinsen, 2003). There are various factors influencing the individuals' learning approaches adopted in different situations, either personal (like gender and age) or contextual (Cavallo, 1994; Sadler-Smith, 1996; Zeegers, 1991). Domain or discipline under study, learning environment, developmental differences may be the factors that explain the differences in adoption of specific types of learning approaches (Sadler-Smith, 1996; Smith & Miller, 2005). The research generally has shown that adoption of deep or meaningful learning approaches resulted with a higher academic outcomes. Meaningful learning correlates significantly and positively with achievement (Bernardo, 2003; Boujaoude, 1992; Boujaoude & Giuliano, 1994; Cavallo, 1996; Cavallo & Schafer, 1994; Sadler-Smith, 1996; Snelgrove & Slater, 2003; Van Rossum, 1984; Zeegers, 2001), whereas surface or rote learning approaches correlates negatively (Boujaoude, 1992; Watters & Watters, 2007).

2.3 Research on Learning Environments

The classroom environment sometimes called as the educational environment or classroom climate was described as the social atmosphere in which learning takes place (Johnson & McClure, 2004). There is an increasing recognition about the importance of the classroom environments in education research over the past 30 years in terms of conceptualization, assessment, and investigation of students' perceptions of the learning environments at elementary, secondary and also higher education levels (Alridge, Fraser, & Huang, 1999). The classroom environment research began in the United States with the use of Learning Environment Inventory (LEI) (Walberg as cited in Alridge, Fraser, & Huang, 1999) and the Classroom Environment Scale (CES) (Moos as cited in Alridge, Fraser, & Huang, 1999). Fisher and Fraser (1981) developed My Class Inventory for the primary level students and Fisher and Treagust (1986) developed College and University Classroom Inventory for higher education students. In 1990, Fraser (1998) developed and used a new instrument called Individualized Classroom Environment Questionnaire (ICEQ). In addition to use for assessing general classroom environment purposes, an instrument called Science Laboratory Environment Inventory was developed specifically to assess the environment of science laboratory classes (Fraser, Giddings, & McRobbie, 1995). Fraser (1998) summarized the approaches used in research studies regarding the learning environment as an important variable as systematic observations, case studies, and assessing teachers' and students' perceptions.

Since the traditional teacher centered classroom environments has been criticized, reform movements have been made throughout the world to create more student centered classroom environments promoting better understanding of the nature of knowledge development. Taylor, Fraser and Fisher (1997) stated that traditional teacher centered classroom environments based on a rationale dominated by two myths; first is the accepting the nature of scientific knowledge in an objectivist view and viewing the curriculum as a product to be delivered to the students by teachers who are experts and have the accurate versions of the scientific truths. However, by the reform movements in education throughout the world, the teachers' roles have been reconstructed as the facilitators to help students interpret and reconceptualize. Taylor and Campbell-Williams (as cited in Taylor, Fraser, & Fisher, 1997) conceptualized a new communicative relationship between teachers and students as an open discourse to provide a way for orienting towards understanding and respecting of each other's perspectives. The researchers stated that open discourse give opportunities for students to negotiate with the teacher for the nature of learning activities they will experience in the class, participate in the decision making process of classroom assessment activities, and also contribute to the process by self and peer assessment, engage in collaborative activities with their peers, and have a right to say in the arrangement and organization of social norms in the classroom. Based on this view and regarding students as the co-constructors of their own knowledge, Taylor and Fraser (1991) developed the Constructivist Classroom Environment Survey (CLES) to assess the extent of the classroom environments' suitability to constructivist pedagogy and enables researchers and teachers to monitor the development of constructivist approaches to teaching school science and mathematics (Taylor, Fraser, & Fisher, 1997). As Taylor and Fraser (1991) indicated because of the growing emphasis on constructivist related curriculum efforts, it is important to monitor students' perceptions of their learning environments in order to investigate the impact of the curriculum on classroom environments and consequently on students' learning outcomes. The research in the area of learning environments showed that students' achievement is better when there is a parallelism between students' preferred learning environments and their actual learning environments (Fraser & Fisher, 1983).

The above mentioned CLES survey (Taylor & Fraser, 1991) was found to be psychometrically sound and also to provide rich data about classroom environments in various studies in different countries (Lucas & Roth, 1996; Roth & Bowen, 1995; Roth & Roychoudhury, 1994), and it was indicated that the CLES can be used to evaluate particularly the constructive transformations of classroom environments and to understand the impact of the changes and possible counterproductive results of the teaching innovations and reform endeavors (Taylor, Fraser, & Fisher, 1997).

Dorman (2003) conducted a study to validate another instrument to assess students' perceptions about their classroom environment. "What is Happening in This Class?"(WIHIC) questionnaire was validated with a cross national data of 3980 Australian, Canadian, and British students from 8, 10 and 12 grades. The instrument includes seven sub scales: Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation, and Equity with six items in each of the sub scales. The reliability of the sub scales ranged from .76 to .85. Confirmatory factor analysis was conducted using LISREL to validate the seven factor structure of the scale. The analysis indicated a good model fit with the data (RMSEA = .048, GFI = .96, TLI = .97, RNI = .97, PGFI = .85, PNFI = .89). The researcher also conducted separate tests for invariant structure for country, grade level, and gender. Results indicated satisfactory model fit for all three grouping variables. The test for factorial invariance was resulted with GFI and TLI values of .99 and .98, respectively. The results supported the international applicability of the instrument as a classroom psychosocial environment measure.

Alridge, Fraser and Taylor (2000) conducted a cross national study about high school science classroom environment in Taiwan and Australia. They used Constructivist Classroom Environment Survey (CLES) to collect data from 1081 students from Australia and 1879 students from Taiwan. They used the 30 item format of CLES with five sub dimensions namely Personal Relevance, Student Negotiation, Critical Voice, Shared Control and Uncertainty. Also, the researchers used an eight item scale in order to measure the students' attitudes toward their science classes in terms of enjoyment, interest, and how much they look forward to science classes. In addition to these quantitative measures, they made classroom observations and conducted interviews with both teachers and students to provide richer insights to the results. Independent samples t-tests results showed that there was a statistically significant difference between students' perceptions related to their science classes from two countries. The Personal Relevance ($M = 3.30$ for Taiwan $M = 3.17$ for Australia, $t = 1.93$, $p < .05$), Uncertainty ($M = 3.67$ for Taiwan, $M = 3.28$ for Australia, $t = 6.88$, $p < .01$) and Shared Control ($M = 2.54$ for, Taiwan $M = 2.28$ for Australia, $t = 3.23$, $p < .01$) sub dimension scores that of Taiwanese students were higher than Australian students. On the other hand, the sub-dimensions score of Australian students on Critical Voice ($M = 3.25$ for Australia, $M = 2.73$ for Taiwan, $t = 8.37$, $p < .01$) and Student Negotiation ($M = 3.39$ for Australia, $M = 3.15$ for Taiwan, $t = 3.79$, $p < .01$) were higher than that of Taiwanese students. Taiwanese students had more positive attitudes toward their science classes than their Australian counterparts ($M = 2.64$ for Taiwan, $M = 2.35$ for Australia, $t = 3.55$, $p < .05$). Correlation analysis revealed that all CLES sub dimension scores were significantly correlated with attitudes toward science for both Taiwanese and Australian students ($p <.001$). Correlations were ranged between .27 and .51 for the individual as the unit of analysis and .50 and .88 for the class mean level for Taiwan, .27 and .50 with the individual as the unit of analysis and .47 and .71 for the class mean for Australia. The statistically significant multiple correlations (R) for the set of five CLES scales in Australia .54 and .77, and in Taiwan .55 and .85 were found for the individual and class mean as the unit of analysis respectively ($p < .01$). For further analysis to identify which classroom environment components contribute most to the variance in student satisfaction, the researchers examined the standardized regression weights (β). Three of the five CLES scales, namely Personal Relevance ($\beta = .40$ for Taiwan, $\beta = .39$ for Australia), Shared Control ($\beta = .15$ for Taiwan, $\beta = .09$ for Australia), and Student Negotiation ($\beta = .06$ for Taiwan, $\beta = .14$ for Australia) were found to be significantly, positively and independently related to student attitudes when all other scales were mutually controlled ($p <.01$) in both Taiwan and Australia using the individual as the unit of analysis.

In study of Alridge, Fraser, and Taylor (2000), analysis of the qualitative studies revealed some cultural differences, therefore some of the qualitative data supported the findings obtained from qualitative data and some did not. Observations confirmed that students in Australia had more opportunities to discuss their ideas when learning with their peers compared to the students in Taiwan where students generally have little opportunities for negotiation with their peers and experience more teacher centered learning environments. Similar to the quantitative findings, Australian students perceived Critical Voice and Student Negotiation as occurring more often than the Taiwanese students. However, during the interviews the researchers recognized that some cultural factors affected students' responses. For example Taiwanese students seemed to have high regard to their teachers compared to their Australian counterparts, and therefore they were less likely to criticize the teachers. Taiwanese students' scores on Personal Relevance scale were higher than that of Australian students. Interview results showed that in part, students' attitude toward science influence their responses. Taiwanese students' responses to interview questions revealed that they generally think that science was necessary for their future and their teachers' try to show them the lessons are relevant to everyday life. On the other hand, Australian students found science classes less relevant to the everyday life. In the light of the both quantitative and qualitative findings, the researchers suggested taking cultural differences into account when interpreting the data obtained by CLES.

In another cross cultural study, Alridge, Fraser and Huang (1999) compared classroom environments and investigated the socio cultural factors influencing the learning environment study conducted in Australia and Taiwan. The researchers used "What is happening in this class?" (WHICH) questionnaire to measure students' perceptions about their classroom environment. The instrument assesses students' perceptions in seven dimensions: 1) Students cohesiveness (extent to which students know, help and support each other), 2) Teacher support (extent to which the teacher helps, trusts and shows interest in students), 3) Involvement (extent to which students have attentive interest, participate in discussions, perform additional work and enjoy the class), 4) Investigation (emphasis on skills and processes of inquiry and their use in problem solving and investigation), 5) Task orientation (extent to which it is important to complete activities planned and to stay on the subject matter), 6) Cooperation (extent to which students cooperate rather than compete with one another on learning tasks), 7) Equity (extent to which students treated equally by the teacher). In addition to this instrument, students were also administered an eight item attitude scale to assess their satisfaction in terms of enjoyment, interest, and how much they anticipated science classes. The attitude scale is a part of the Test of Related Attitudes (TOSRA) scale. Both of the survey instruments were administered to a sample of 1081 grade 8 and 9 students from 50 classes in 25 schools from Australia and 1879 grade 7-9 students from 50 classes in 25 schools in Taiwan. Besides questionnaires, observations were carried out in the classes of four teachers in both of the countries. Also interviews were conducted with the selected students and teachers. Using the class as the unit of the analysis, result of the paired samples t- test showed that students in Australia perceived their classroom environment more favorable than did students in Taiwan. There was a statistically significant difference for Involvement, Investigation, Task Orientation, Cooperation and Equity scales ($p< .05$). An interesting finding in this study is that although students in Taiwan expressed a significantly more positive attitude toward science than did the students in Australia ($p < .01$), Australian students held more favorable perceptions about their learning environments. Students' interviews were generally found to be consistent with the perceptions obtained from the questionnaire. Furthermore, from the analysis of the qualitative data the researchers of the study found that learning environments of each country were influenced by the socio cultural factors and the education system. More specifically, the nature of the curriculum affects the learning environments in each country; the more examination driven curriculum resulted with the more teacher centered approaches in the classroom. Therefore, for example involvement of students is important for science education in Australian classrooms, on the other hand, it is not important or possible in science classrooms in Taiwan. The other factors that were found to influence learning environments were the pressures experienced by the teachers of the two country; the pressures related to implementing innovative ideas and tailoring the curriculum according to the needs of the students. Also the degree of respect that students held for their teachers appeared as another influencing factor. Australian students were found to be more disruptive in class, whereas in Taiwan classrooms were more quiet and free of disruptions. Parallel to this finding, it was found that students in Taiwan were found to have less tendency to ask questions to their teachers than their Australian counterparts.

Chang and Tsai (2005) investigated the effect of teacher centered and student centered computer assisted instruction on 10th grade students' learning outcomes and examined the effect students' preferences for learning environment on learning outcomes by an experimental study. Students' learning outcomes were measured by the Earth Science Achievement Test and Attitude Toward Earth Science Inventory. Students' preferences for learning environments were measured by the Chinese version of Constructivist Classroom Environment Survey (CLES). There were 131 students in the experimental group and 216 students in the traditional group. In the teacher centered instruction group (traditional group), instruction was composed of direct guidance, presentations, occasional demonstrations and explanations of important concepts. In addition to this instructional model, software was used by the teacher with a projector. In student centered groups (experimental group), students learned the concepts by themselves using a software on their individual computers. Pretest results showed that all groups were in the same achievement level and they had similar attitudes toward the course. Results revealed that treatment had no effect on students' achievement. Traditional group students had higher attitude scores than the experimental group students after instruction. Regression analysis showed that students' achievement was significantly predicted only by the achievement pre test scores, and students' attitude was significantly predicted only by attitude pre test scores.

Arısoy (2007) conducted a study to investigate elementary students' perceptions of their science classroom environment, their adaptive motivational beliefs and attitude toward science. The sample consisted of 956 eight grade students from Çankaya, Ankara. Students' perceptions related to their science classroom environment was measured by Constructivist Classroom Environment Survey (CLES), their attitudes toward science were measured by Test of Science Related

Attitudes (TOSRA) and their motivational beliefs were measured by Motivated Strategies for Learning Questionnaire (MSLQ). Results showed that students' perceptions about their science classroom environments were significantly correlated with their motivational beliefs. All sub dimensions of CLES were also found to be correlated with each other.

Cheng (1994) investigated the classroom environment in Hong Kong primary schools in terms of physical environment, social climate and management style and also its relationship to students' affective performance. The study was a cross sectional survey, and the data of the study was obtained from a large scale research project on education quality in Hong Kong primary schools. The unit of analysis was class. The sample includes 190 classes out of 678 classes. The social climate of the classroom was measured in nine dimensions: involvement, affiliation, teacher support, task orientation, competition, order and organization, rule clarity, teacher control and innovation. Students describe the social climate of their class on a five point response scale. Perceived quality of classroom environment in terms of physical facilities, spacing, neatness, cleanness, and lack of pollution was measured by an 11 item instrument developed by the researcher. Class master's leader behavior was assessed by the students by the 19 item Leader Behavior Description Questionnaire. Use of power in the class was also assessed. And the individual student affective performance was measured in self concept, attitude toward peers, attitudes toward school, attitude toward teachers, self efficacy of learning, feeling of homework overload, and intention to drop out sub scales. The correlation analysis revealed that students' self concept was found be positively correlated only with class master's reward power ($r = .24$, $p < .001$). Students' attitudes toward peers was found to be positively correlated with perceived physical environment ($r = .34$), class master's expert power ($r = .35$), personal power ($r = .24$), consideration ($r =.13$), and initiating structure ($r = .15$) and nine sub dimensions of the social climate of the classroom scale, and negatively correlated with class master's coercive power ($r = -.35$). Students' attitudes toward teachers and the school correlated positively with the perceived quality of physical environment, expert power, reward power, position power, personal power, consideration, and all climate measures except teacher control (with correlation coefficients ranging between r = .01 and r = .66), but negatively correlated with coercive power (r = -.38 and r = -.32 respectively). In addition, students' feeling of homework overload and intention to drop out were found to be negatively correlated with the quality of physical environment, expert power, consideration, and all the social climate measures except teacher control (with correlation coefficients ranging between r = -.05 and r = -.45), and positively correlated with class master's coercive power (r = .28 and r = .30, respectively). Canonical correlation analysis to predict values of the set of student affective measures with the set of classroom environment measures were conducted and these two set of measures was found be strongly correlated. The results generally showed that learning environment in terms of quality of physical environment, social climate and class master's management style related to the students' affective performance. Among the classroom environment measures, perceived quality of physical environment, class master's expert power, personal power, and coercive power were found as the strongest predictors of students' affective performance. The findings of the study suggested that classroom environment consisting both the physical and psychological elements is important for students' affective performance.

Using the widely used classroom environment, the Constructivist Classroom Environment Survey (CLES), Johnson and McClure (2003) provided insights into the classroom learning environments of beginning science teachers. The researcher used the same revised form of CLES, which was also used in this dissertation. The instrument has five dimensions namely, Personal Relevance, Uncertainty, Critical Voice, Shared Control, and Student Negotiation. The study presented by the researchers was the report of the large study funded by an organization called Teacher Research Network (TRN) to monitor beginning teachers' classroom practices. In the first year of the study, the instrument was administered to both 290 elementary, middle, and high school in service and pre service science teachers and to their students. Therefore, the researchers had the opportunity to compare the perceptions of teachers and their students. In addition, participating teachers were interviewed and observed in their classes. The comparison for a grade 7 science teacher's and students' perceptions about their class was presented in the study. The teachers' perceptions about his class fit with those that of students for some scales and found to be different for other scales. For the Personal Relevance scale, the teacher saw the relevance of the content in his classroom as being fairly high (M = 3.75) on a five point scale. His students' mean was found to be similar (M = 3.81). For the Critical Voice scale, the teachers and the students' views were different. The teachers' views of his class as having high degree of Critical Voice (M = 4.75), but the students' mean was lower (M = 3.80). This result implies that most of the students did not feel themselves to question the teachers' plans in the classroom as their teacher thought so. A similar finding emphasized in Fraser's study (as cited in Taylor, Fraser, & Fisher, 1997) was that the teachers tended to perceive their classroom environments more positive than did their students. Therefore, it can be said that there is a difference between students' and teachers' perceptions related to the same learning environment.

In order to investigate the effect of new Korean general science curriculum on classroom learning environment, Kim, Fisher and Fraser (1999) conducted a study with Korean students. The researchers used the Constructivist Classroom Environment Survey (CLES) to assess students' perceptions about their classroom environment. The CLES was administered to 1083 students and 24 science teachers in 12 different schools in Korea. Students responded both the actual and preferred forms of the questionnaire and a seven item Attitude to this Class scale which was based on the Test of Science Related Attitudes (TOSRA) scale. MANOVA and follow up ANOVAs were conducted to determine the differences between the means of the five sub scales of CLES actual and preferred forms between grade 10 and grade 11 students. Results revealed that grade 10 students perceived their classroom environment more constructivist except the uncertainty scale, and the results were found to be statistically significant ($p < .01$) for personal relevance, shared control, and student negotiation, but the effect sizes (eta square values) were .07, .07 and .13 respectively. The preferred means of students were higher than actual means for these five scales. The results suggested that students seemed to prefer to have more opportunities to be given personal relevance, to know the uncertain nature of science, to express their critical voice, to have a shared role in their class, and to negotiate with their peers than was perceived to be present in the science classroom. As a summary, Korean students preferred a more positive learning environment than the one they actually had. Also, simple and multiple correlations were used to assess associations between students' perceptions of the classroom environment and their attitude toward their class. Simple correlations between students' perceptions of the learning environment and attitude toward the class were found to be significant for most of the scales. Students' perceptions on personal relevance ($r = .39$), shared control ($r = .32$), and student negotiation ($r = .28$) for grade 10 and personal relevance ($r = .29$), uncertainty ($r = .24$), shared control ($r = .19$) for grade 11 were significantly correlated with students attitude toward their class ($p < .05$). Multiple correlations were also found to be statistically significant for both 10 and 11 grade students, and the results revealed that personal relevance was the strongest independent predictor of students' attitude toward their science classes ($\beta = .31$ for grade 10 and $\beta = .30$ for grade 11 students, $p < .01$).

Walberg, Singh and Rasher (1977) investigated students' perceptions of the social environment of learning in a cross cultural study. The data was collected from a random sample of five schools in each of the 26 districts of a state of India. The resulted sample was 83 general science and 67 social sciences classes. First of all, students in the selected classes were administered a sociometric questionnaire to identify the ten most studious and the ten least studious students, then they were determined. The final selected students in each class were administered an IQ test, an achievement test and the Learning Environment Inventory (Anderson & Walberg as cited in Walberg, Sigh, & Rasher, 1977). The Learning Environment Inventory consists of 15 seven item subscales namely, Cohesiveness, Diversity, Formality, Speed, Environment, Friction, Direction, Favoritism, Difficulty, Apathy, Democratic, Cliqueness, Satisfaction, Disorganization and Competition. Means of the 166 general science and 134 social science studies groups of studious and non studious students were treated as the unit of analysis. The correlations between students' perceptions of the learning environment and achievement were calculated, and it was found that the correlation coefficients ranged between .41 and .81 ($p < .05$). When IQ scores were partialled out, the correlations between students' perceptions and achievement ranged between .17 and .73 ($p < .05$). Generally, the results of this study suggested that there was a direct relationship between students' perceptions about their learning environment and their achievement.

Yılmaz-Tüzün, Çakıroğlu and Boone (2006) investigated the associations between Turkish high school students' perceptions of the learning environments and their attitudes, and also examined the differences in their perceptions by gender, grade level and academic achievement. Constructivist Classroom Environment Survey was translated and adapted to Turkish language by the researchers. Students' subject related attitudes were assessed by the enjoyment sub scale of the Test of Science Related Attitudes (TOSRA) scale. Students' self reports of previous semester chemistry course grades were used as the indicator of achievement. The sample of the study was 2290 grade nine to 11 students in 83 chemistry classes. Both simple and multiple correlation analysis were conducted to assess the associations between variables. The results of the simple correlation analysis revealed that all five CLES scales were significantly correlated with the students' attitudes toward chemistry class ($p < .01$) both at the individual and class mean level of analysis except the Uncertainty scale for class mean level. The simple correlations was found to be ranged between $r = .13$ and $r = .22$ for the individual mean as the unit of analysis and between $r = -.04$ and $r = .35$ for the class mean as the unit of analysis. The results of this analysis suggested that students' attitudes toward chemistry class improved when the students perceived that their class as providing more opportunities for critical voice, shared control, student negotiation, personal relevance and uncertainty for scientific knowledge.

Yılmaz-Tüzün, Çakıroğlu and Boone (2006) also found that for both the individual and class mean as the unit of analysis, CLES sub dimensions associated with the enjoyment scale of TOSRA as a result of the multiple regression analysis. Positive and significant independent relationships were found between attitude and personal relevance and shared control scales for both individual and class means. Uncertainty and critical voice dimensions significantly and positively correlated with the attitude when the individual means were taken as the unit of analysis ($p <.01$). Researchers also conducted MANOVA to determine the possible differences between students' perceptions of their classroom environments according to gender, grade level and achievement. The multivariate test was found significant for the main effect of gender, (Wilks' Lambda = .99, $p < .001$), for grade level (Wilks' Lambda = .98, $p < .001$), and for achievement (Wilks' Lambda = .96, $p < .001$). For gender, univariate follow up analysis revealed statistically significant differences between male and female students for uncertainty ($F(1, 2151) = 7.97$, $p <.05$, MSE = 2.42) and for critical voice ($F(1, 2151) = 9.30$, $p <.05$, MSE = 3.54) dimensions. Female students' mean scores of perceptions on uncertainty and critical voice scales were higher than that of male students. For grade level, follow up analysis showed significant differences on critical voice ($F(2, 2151) = 14.687$, $p <.05$, MSE = 11.512) and shared control ($F(2, 2151) = 9.63$, $p <.05$, MSE = 10.50) dimensions. Post hoc analysis revealed that 10th grade students perceived their classroom environment as more constructivist in terms of student negotiations than 9th and 11th grade students. ninth and 10th grade students also perceived their classroom environment more constructivist in terms of critical voice than students in 11th grade. For achievement follow up analysis revealed significant differences on personal relevance ($F(5, 2151) = 4.87$, $p <.05$, MSE = 4.87), critical voice ($F(5, 2151) = 2.46$, $p <.05$, MSE = 1.87), shared control ($F(5, 2151) = 6.7$, $p <.05$, MSE = 7.71), and student negotiation ($F(5, 2151) = 4.41$, $p <.05$, MSE = 4.55). Post hoc analysis showed that students' with previous course grade of 4 and 5 perceived their classroom environment more constructivist than that of students with course grades 1 and 2 on personal relevance and student negotiation scales. Also, students with previous course grades 5, perceived their classroom environment more constructivist than students with course grades 1, 2, 3, and 4, on critical voice and shared control scales.

2.3.1 Learning Environments and Epistemological Beliefs of Students

Recent research in the science education area shows us that students' views about epistemology of science mainly come from their school experience (Tsai, 1996). However, studies conducted about classroom instructional activities, teachers' epistemological beliefs, students' views about their classroom environment show that science courses are generally conducted in an environment supporting empiricist view of science. Therefore, it becomes inevitable to face with students having empiricist views of science. According to Cavallo, Rozman and Potter (2004) in classroom environment in which inquiry based learning take place, students may tend to see science in a more tentative nature. Similarly, the other studies in the literature revealed that a student centered instruction in which students make observations, conduct experiments, collect evidences, share and discuss findings and making inferences have an impact on improving epistemological awareness (Conley, Pintrich, Vekiri, & Harrison, 2004). Findings of the study conducted by Smith, Maclin, Houghton, and Hennessey (2000) supported this claim and concluded that elementary school students in constructivist classrooms developed a more sophisticated understanding of epistemological beliefs than do the students in more traditional classrooms.

There are some studies examining the relationship between classroom environment, instructional activities and epistemological beliefs of students (Carey, Evans, Honda, Jay, & Unger, 1989; Jehng, Johnson, &Anderson, 1993; Lederman & Druger, 1985; Roth, 1997; Smith, Maclin, Houghton, & Hennesey, 2000; Solomon, Duveen, Scott, & McCarthy, 1992; Tsai 1998a; 1999b; 2000b; Valanides & Angeli, 2005; Windschitl & Andre, 1998).

Studies in the literature like Lederman and Druger's study (1985) shows us that inquiry oriented instruction and a supportive classroom environment can help students to develop better understanding of nature of science. From the constructivist perspective, since students are accepted as the co-constructors of the knowledge, their perceptions related to the learning environment is important. Constructivist view describes the process of meaningful learning as a cognitive process in which individuals construct their own knowledge by negotiation and consensus building (Özkal, 2007). Lederman (1992) emphasized that the most important variables affecting students' beliefs about nature of science are the specific instructional behaviors, activities, and decisions implemented within the context of lessons. Science curriculum and the context in which this curriculum put in to practice is believed to have an impact on students' epistemological beliefs in science classrooms

(Carey, Evans, Honda, Jay, & Unger, 1989; Solomon, Duveen, Scott, & McCarthy, 1992).

Therefore, classroom environments and instruction are the two important variables believed to contribute students' epistemological growth. Research has demonstrated that a constructivist classroom environment (Carey, Evans, Honda, Jay, & Unger, 1989) and teaching nature of science through history of science (Solomon, Duveen, Scott, & McCarthy, 1992) had positive effects on developments of students' scientific epistemological beliefs.

An experimental study was conducted by Carey, Evans, Honda, Jay, and Unger (1989) in order to investigate the intervention effect on seventh grade students' epistemological beliefs about science. The intervention lasted in three weeks. During the study, students were expected to derive and test hypothesis, perform experiments and reflect on what they did. As a result of the intervention researchers found that students initially having naïve views about epistemology of science develop more constructivist and sophisticated views. Being involved in a learning experience to related to theory building and explanation of a scientific phenomenon, help students to understand purpose of experiments.

Kim, Fisher and Fraser (1999) conducted a study with 1083 Korean 10th and 11th grade students in order to investigate the relationship between students' perceptions related to their science classes and their attitudes toward science. Both students' perception about their actual learning environments and their preferences for the science learning environments were investigated. For this purpose both Actual and Preferred forms of the CLES were administered. In order to assess students' attitudes toward science a scale was constructed by selecting items from Test of Science Related Attitudes scale. As a result of the study 10th graders were found to perceive their learning environments more constructivist than 11th graders. Students from both of the grades reported that they preferred more constructivist learning environments than what they actual had. In addition, statistically significant correlation was found between constructivist classroom environment and students' attitudes toward science.

Lederman and Druger (1985) investigated the biology classroom characteristics affecting the students' epistemological views. The researchers determined students' epistemological views by using Rubba and Anderson's (1978) instrument; they specifically focused on students' views related to the developing nature of science. They found that students' epistemological views were affected by classroom characteristics such as a supportive environment, openness to students' thoughts and questions, students-teacher interaction, an environment relating school science subjects to everyday life, using a variety of instructional media and use of inquiry-oriented questions during instruction. The researchers concluded that instructional climate and teachers' approach affect students' beliefs about the nature of knowledge.

Smith, Maclin, Houghton and Hennesey (2000) conducted a research to assess the impact of elementary science experiences on students' epistemological views. The researchers aimed to test the claim that even elementary school students can progress in developing a sophisticated epistemology of science when they provided with a science curriculum that support students' thinking about epistemology of science. The study was conducted two demographically similar groups of 6th grade students. One group was taught from a constructivist perspective (N = 18) and the other was taught with a more traditional perspective (N= 27). In the constructivist classroom, the science curriculum focused on engaging students' own ideas, and the teacher acted like a facilitator in both small group works and large class discussions. Generally, students worked in groups of four to investigate a scientific phenomena and they developed their own models explaining the given phenomena. Students in this classroom also did some readings from books when they seek information to support their ideas. The researchers defined the constructivist environment as the environment in which students actively develop, test and revise their ideas through collaborative inquiry with their classmates. On the other hand, in the comparison group, teaching was more focused on traditional approach; the teacher presented the topics, and the students focused on learning facts and creating art like drawing, cutting, pasting etc. on that topic. Students were individually interviewed by the use of Nature of Science Interview (Carey, Evans, Honda, Jay, &

Unger, 1989). The interview included sections that probe students' conceptions of the goals of science, the nature of scientific questions, the purpose of experiments, the role of ideas in scientists' work, and the nature of the process by which the scientific ideas change. The results showed that in the constructivist classroom, the students developed a epistemological stance toward science that focused on the central role of ideas in the knowledge acquisition process and on the kinds of mental, social, an experimental work involved in understanding, developing, testing and revising these ideas. In particular, the students from the constructivist classroom were aware that science involved the development and modification of ideas about the world, experiments are useful to clarify and test ideas and collaboration is important for scientific development. The researchers also added that these students' understandings related to epistemology of science improved more than what has been previously reported in the literature for elementary grade students. Therefore, they provided evidence against the views that biological development of younger students limits their understanding of epistemology of science. The researchers concluded that elementary grade students are more ready to develop sophisticated views than many thought.

Solomon, Duveen, Scott and McCarthy (1992) conducted another experimental study investigating change in students' epistemological views about science. The researchers investigated the effect of teaching history of science on students' understanding of epistemology of science. The study conducted in five middle school classrooms throughout a school year. In this study, students learn science topics by reading historical material, performing laboratory activities, interpreting information from what they read related to their activities. Teaching materials were prepared in order to emphasize the social context of science and development of new concepts in history of science. Through the use of interviews and questionnaires, students' views about the interactive nature of experiment and theory and their images of scientists were collected as pre and post data. Results of the study showed that history of science instruction had a positive effect on students' views about nature of science. Students' images of scientists became more realistic after intervention. Students started to understand the complementary function of experiments and theories. When the pre and post test results were compared, researchers found that students understood the purpose of experiments as a way to explain phenomena instead of making discovery, started to think that scientists have expectations before doing an experiment, and understand that a theory is an explanation instead of a proven fact.

Tsai (1998a; 1999b; 2000b) made several research studies examining the classroom environment and epistemological beliefs relationships in science learning contexts. In his first study, Tsai (1998a) investigated the relationship between Taiwanese 8th grade students' scientific epistemological views and their learning orientations. The sample of the study consists of 202 students. The researcher used Pomeroy 's (1993) questionnaire in order to collect data about students' scientific epistemological views. Based on the results obtained from Pomeroy's questionnaire, the researcher selected 20 information rich students who were above average achievers and conducted interviews with those students. Among the 20 students, six were (three female and three male) scored in the top 15% of the Pomeroy' questionnaire, six were (four male and 2 female) selected from the bottom 15% scorers and eight (five male three female) were selected from the average scorers on the questionnaire. Tsai (1998a) grouped students as having constructivist, empiricist and mixed views of scientific epistemological views. Results obtained from the interviews revealed that constructivist students believed that science was closely related to everyday life and scientific knowledge has a dynamic and tentative nature. The same students thought that scientists' ideas came from their intuitions and or flashes of insight, theories proposed by the earlier scientists and even ancient folklore. However, none of the students mentioned the importance of observations. They believed that there is no certain method or a procedure in doing science, the existence of different theories came from the fact that scientists might take different theories into account, and they added that power or acceptance of a new theory caused changes in scientific theories. On the other hand, empiricist students saw science as a collection of facts and therefore they believed that scientific knowledge is valid and accurate, and believed the importance of experimental evidences. Among the six empiricist students, three of them believed the importance of scientists' intuitions in science, but most of them saw the observations as the main source of scientists' ideas. Empiricist students also believed that there is a "scientific method" and they thought that the existence of different theories explaining the same phenomena caused by the limitations of technology or inadequate observations. Tsai (1998a) stated that when asked to describe about an ideal learning environment of science during the interviews, constructivist students emphasized the opportunities to discuss with others, solving real life problems and controlling their own learning activities, whereas, empiricist students emphasized the clarification of teachers' lectures. Therefore, it can be said that, students holding constructivist views about science prefer learning science in a more constructivist learning environments.

Tsai (1999b) investigated the effect of STS (Science-Technology-Society) instruction on students' epistemological views of science with an experimental design. In this study 101 Taiwanese female 10th grade students were assigned to either traditional (52 students) or STS treatment (49 students) groups. The study was lasted in eight months and conducted within students' fundamental physical science course. In the experimental group, the instruction explored the relationships between science, technology and society by presenting the concepts in the context of human experiences and discussed the contemporary scientific issues using variety of materials like newspapers, World Wide Web and lessons from history of science and etc. The experimental group had a learner centered classroom environment and based on inquiry based exploration encouraging divergent thinking, cooperative learning, problem solving, issues based debating and discussion. The students in the experimental group were expected to spend more time for peer discussion compared to the traditional group. In the traditional group, fact based content was followed by using the nationwide textbook. The instruction method was lecturing and students solved tutorial based exercises and made book reading. Students' epistemological views of science were assessed by Chinese version of Pomeroy's questionnaire. The questionnaire includes bipolar agree-disagree statements on one dimension assessing learners on a continuum from empiricist to constructivist perspective. In addition to administering the questionnaire, 20 STS group students from the top, bottom and average scorers on Pomeroy's questionnaire were interviewed to further investigate the change in their epistemological views of science. Findings of the study showed that in the final survey (at the end of the eight month treatment) STS group students scored significantly higher than the traditional group students on the epistemological views of science questionnaire, meaning STS group students more constructivist oriented epistemological views compared to traditional group students ($t = 2.47$, $p < .01$). Taking the pretest as covariate ANCOVA results further confirmed that there was a statistically significant difference between STS and traditional group students ($F = 6.888$, $df = 1$, sum of squares = .328 $p < .05$). Therefore, it can be said that learning environment with STS instruction facilitated the development of constructivist oriented epistemological views of science for the students. The interview data also revealed that STS instruction showed progress toward constructivist oriented epistemological views of science which is consistent with the quantitative findings.

Tsai (2000b) conducted a study examining the relationship between students' perceptions about their learning environments and their scientific epistemological beliefs. The sample of the study consisted of 1283 eight grade students from 14 schools in Taiwan. The Chinese version of the Pomeroy's questionnaire was used to collect data about students' scientific epistemological views. And students' perceptions related to their learning environment was assessed with the Chinese version of Constructivist Classroom Environment Survey (CLES) in four sub dimensions, namely Negotiation, Prior Knowledge, Autonomy, and Student Centeredness. The questionnaire has two forms: actual and preferred. Results of the study revealed that students preferred learning environments which taking into account their prior knowledge and everyday experiences. Students thought that their actual learning environments did not match with their preferences. Moreover, students' epistemological views of science was found to be correlated with the Negotiation and Prior Knowledge sub scale scores of CLES actual form and Negotiation, Prior Knowledge and Autonomy sub scale scores of CLES preferred form. Students having more constructivist view of science tended to perceive their actual learning environments as having lack of enough opportunities to negotiate their ideas and integrate their new knowledge with the prior one. They also reported that, they preferred a learning environment in which they can interact with other students, integrate their prior knowledge and experiences to construct their own knowledge and like to control their own learning.

In an intervention study, Valanides and Angeli (2005) investigated the extent to which different instructional strategies can change students' epistemological beliefs. Specifically, the study investigated the effect of teaching critical thinking principles on university students' epistemological beliefs, the relationship between teaching approaches and epistemological beliefs. The sample of the study was 128 students. The students were randomly assigned to three different 65 minutes instructional interventions called General, Infusion, and Immersion approaches. Epistemic Beliefs Questionnaire was used to collect data. Students participated in the three different research sessions. Session I lasted in 40 minutes. In this session, after the introduction about the session and administration of demographic questionnaire, the participants individually read and summarized an article. In Session II after an introduction, students in pairs reviewed their summary of the article, and then they were administered the epistemic beliefs questionnaire. At the end of the Session II, students were participated in the interventions. In the "General" group, lecture was done and each pairs discussed the article and prepared an outline for a paper on the issue. In the "Infusion" group, each pair discussed the article and started preparing an outline for a paper on the issue and they reflected their thinking. After a short lecture, the students talked with the researcher and finally each pair completed an outline for a paper on the issue. In the "Immersion" group, each pair discussed the article and began to prepare an outline, and then they reflected their thinking in pairs. This part followed by a Socratic questioning with the researcher and finally students in each pair completed their outline for the paper. These three intervention groups differed only in the approach they adopted for the teaching of five general critical thinking principles, namely, analyzing the problem, generate solutions, develop the reasoning for each solution, decide which is the best solution, and use the criteria to evaluate your thinking. Repeated Measures ANOVA was performed taking the teaching method as the independent and participants' pre and post performance on epistemological beliefs questionnaire dependent variables. It was found that post epistemological beliefs of students was significantly higher than pre performance ($F(1, 105) = 19.769$, $p < .05$), and the main effect related to between subjects independent variable was significant ($F(2, 105) = 3.995$, $p <.05$). Post hoc comparisons showed that students assigned to Infusion teaching group outperformed those assigned the General teaching group, but not those assigned to Immersion group. Also, it was found that there was no significant difference between General and Immersion group students' epistemological beliefs scores. The results suggested that one contextualized instructional approach (Infusion) promoted significantly higher epistemological beliefs change than the decontextualized approach (General), but not the other contextualized approach (Immersion). It can be concluded based on the findings of the study that epistemological beliefs of students can change, when students are given the opportunity to work collaboratively, reflect their thinking and evaluate their beliefs.

Windschitl and Andre (1998) conducted a study investigating the effects of a constructivist versus objectivist learning environment on 250 college students' conceptual change. Students in the constructivist environment used a computer based cardiovascular simulation exercise in a context-bound framework and they were allowed to create and test their hypotheses about the topic. Students in the other group used the same simulation, but in a prescribed way to simply confirm the given information directed by a written guide. The researchers also investigated the interaction between constructivist versus objectivist learning environments with students' epistemological beliefs. Results of the study showed that constructivist approach resulted with a greater conceptual change compared to the objectivist approach for alternative conceptions among the students who initially had about the topic of human cardiovascular system ($F(1, 105) = 3.99$, $MSe = .23$, $p < .05$, $F(1, 76) = 4.03$, $MSe = .23$, $p < .05$, for two alternative conceptions respectively). It was also revealed that the treatment interacted with epistemological beliefs of students; students holding more advanced epistemological beliefs learned more from the constructivist learning environment, on the other hand, individuals with less advanced beliefs learned more from the objectivist environment. The findings of the study suggested that the effectiveness of different learning environments depends on the students' epistemological beliefs.

Jehng, Johnson, and Anderson (1993), examined the university students' epistemological beliefs as a function of their field of study. The sample consisted of 386 students from three different universities in central Illinois. Freshman and sophomores were classified as the lower division; junior and senior students were classified as the upper division, and master and doctoral students were combined as the graduate students for the educational level variable. The field of study variable has four groups: engineering and natural sciences, arts and humanities, social sciences, and business. The students completed the adapted version of Schommer's epistemological beliefs questionnaire. The researchers adapted the questionnaire by replacing the Simple Knowledge dimension with "Orderly Process". This dimension implies that "The learning process tends to be regular rather than irregular". Their factor analysis with the data of the study ended up with the five dimensions for the new adapted version of the questionnaire. These final dimensions were Certain Knowledge, Omniscient Authority, Innate Ability, Quick Learning and Orderly Process. MANOVA analysis showed significant main effect for both educational level and field of study ($F(2, 381) = 5.01$ and $F(3, 381) = 2.58$, $p < .05$, respectively). Graduate students' epistemological belief scores were significantly higher than those of both upper division ($F(1, 378) = 23.53$, $MSe = 17.34$, $p < .05$) and lower division students ($F(1, 378) = 23.16$, $MSe = 17.07$, $p < .05$) on Certainty of Knowledge dimension. Graduate students also scored significantly higher on Omniscient Authority and Orderly Process dimensions than those of either lower or upper division undergraduate students. There were no significant differences found between upper and lower division undergraduate students on these two dimensions. It can be summarized that graduate students showed significantly more sophisticated beliefs compared to undergraduate students and believing that knowledge is uncertain, independent reasoning is more crucial for gaining knowledge and learning is not an orderly process. Therefore, it may be stated that amount of education affects individuals' epistemological belief. Jehng, Johnson, and Anderson (1993) further categorized the students' field of study as hard (engineering and business) and soft fields (social studies and arts/humanities). The results revealed that these students beliefs significantly differed on Certainty of Knowledge ($F(1, 382) = 18.50$ $MSe = 13.67$, $p < .05$), Omniscient Authority ($F(1, 382) = 11.69$, $MSe = 6.46$, $p < .05$), and Orderly Process ($F(1, 382) = 8.83$, $MSe = 5.50$, $p < .05$), but no differences were found for the Innate Ability and Quick Process dimensions. The results suggested that students in soft fields were found to have a stronger belief that the knowledge is uncertain, they more relied on the independent reasoning ability, and stronger belief that learning is not an orderly process than those students in the hard fields.

Based on the results of their study, Jehng, Johnson, and Anderson (1993) pointed out that the social context of instructional environments might be an important factor accounting for the differences between beliefs of graduate and undergraduate students. In undergraduate level, most of the introductory courses include systematically organized content, exercises organized in an order; problems are well structured and require well known procedures or algorithms to solve. This instructional environment directly or indirectly impose the impression that learning occurs in an order and learners should follow a fixed or a predetermined sequence, knowledge is best handed down by authorities or experts and so on. On the other hand, at the graduate level, instructional methods and social context of learning environment change. The content of the courses becomes less structured; more discussions occur in the classrooms, sometimes contradictory viewpoints are presented, there are interpretations rather than one absolute truth. This instructional environment may make students become more aware of the uncertain nature of knowledge, importance of different perspectives in the formation of knowledge, openness of truth to individual interpretations. The difference in the context of learning environments in different fields of study may have a similar effect on students from different fields of study. Since for example, in engineering and natural sciences departments the knowledge is presented to the learners in a more systematic, sequential and structured way, problems are solved by well known procedures or algorithms and there is one right answer. Compared to these fields, the learning environment in social sciences or arts/humanities departments are less rigid.

Roth (1997) investigated the effects of high school constructivist physics lessons in classroom learning environments. The study conducted in the course of a two year physics course as a part of a three year research project designed to improve conditions for and understanding of learning in high school physics. The sample was 21 students enrolled in two years physics program at a private boys school in an urban area of Canada. During the study, the researcher administered the preferred form of CLES repeatedly. Also, students' written essays on knowing, learning, and classroom learning environment were analyzed and interviews were conducted. Students' responses to the surveys were used as the starting points for the interviews. The essays were written as responses to a set of statements about ontology, sociology, and epistemology of scientific knowledge. The students also wrote essays addressing the questions like "How do I know and learn physics?", "How does physics learned in the laboratory differ from that acquired from textbooks?", and "How does working in a group help you to learn?". In addition to written essays, related readings were done and afterwards whole class discussions were moderated and then analyzed by the researcher as an additional data. The analysis of the qualitative results generally showed that students adopted more constructivist views related to knowing and learning. However, there were also a small number of students found who resisted adapting constructivist physics learning environment. The researcher presented the two cases in detail from the whole sample of study. One of the participants of the study, in the beginning considered the lectures as the best ways to learn physics and tended to see laboratory activities as an additional option. He thought that scientific knowledge could be derived through experiments as a mirror of the nature. During the second year of the study, he had trouble to view scientific knowledge as emerging from the negotiations of scientists, and he started to reject the laboratory activities as a way of learning through experiments. At the same time, his responses to CLES in autonomy and student centeredness dimensions became significantly negative compared to his classmates. In spite of this characterization of scientific knowledge as tentative, uncertain and a product of negotiations, he did not prefer to learn science in an authentic environment. He accepted as the current scientific knowledge as truth. His approach to learning science could be described as pragmatic, since he preferred to memorize the necessary information without trying to understand and wanted to progress through the next stage.

Another student in Roth's (1997) study showed a radical development throughout the study. In the beginning, the student described the scientific knowledge as a mirror of the eternal order. However, over the two years, his view of scientific knowledge evolved from the philosophy of pragmatist to constructivist sociology of knowledge. He started to describe the scientific knowledge as a language describing and explaining our experience of the world. He viewed the uncertainty of scientific knowledge as a playful, joyful and obscene game and changed his approach to learning science parallel to this view. The two emerging cases given in detail may indicate the importance of students' dispositions or prior beliefs related to science on the efforts for development of epistemological beliefs.

2.3.2 Learning Environments and Learning Approaches of Students

There are some studies in the literature particularly focused the relationship between learning environment and students' learning approaches. Campbell, Brownlee and Smith (1996) found that there is a relationship between students' learning approaches, teacher's instructional processes and form of assessment.

Dart and his colleagues (Dart, Burnett, Boulton-Lewis, Campbell, Smith, & McCrindle, 1999; Dart, Burnett, Purdie, Boulton-Lewis, Cambell, & Smith, 2000) conducted two studies investigating the relationship between learning environments and students' learning approaches.

In the first study, (Dart, et al,, 1999) the researchers investigated the relationship between Australian students' perceptions related to their classroom environment and their learning approaches. The sample consists of 484 secondary school students ranging from 8th to 12th grade. Actual and preferred forms of Individualized Classroom Environment Scale (ICEQ), Learning Process Questionnaire (LPQ) and the Learner Self Concept Scale (LSC) were used to collect data from students. LPQ was used to measures students' motives for studying and learning approaches as Surface, Deep and Achieving. ICEQ was used to measure students' perceptions and preferences for learning environments in Personalization, Participation, Independence, Investigation and Differentiation sub dimensions. LSC was used to measure the relationship between learner self concept and learning strategies. Correlation analysis revealed that the high self concept scores of students were related with high Deep Approach, high Personalization, high Participation and high Investigation scores. Students utilizing deep approach in learning perceived their classrooms as more personalized, more encouraging or open to active participation and they thought that they used inquiry skills.

In a similar study Dart et al.. (2000) examined the students' conceptions of learning, their perceptions related to their learning environments and their learning approaches. The sample was 457 Australian students in grades 8 to 12. In this study, Conceptions of Learning Inventory (COLI) was used to measure students' conceptions related to learning as qualitative, quantitative and experiential perspectives. Qualitative perspective suggests that learning includes understanding of by relating new knowledge with the prior knowledge. Quantitative perspective suggests that learning is accumulation of knowledge. Experiential perspective suggests that learning is a product of daily experiences. In addition to COLI, Individualized Classroom Environment Survey (ICEQ) and the Learning Process Questionnaire (LPQ) were used. ICEQ has five dimensions namely, Personalization, Participation, Independence, Investigation and Differentiation. LPQ has three sub dimensions called Surface, Deep and Achieving. Results showed that students having qualitative conceptions related to learning utilized deep approach. On the other hand, students having quantitative perspective of learning utilized surface approaches. However, there was a significant positive correlation found between quantitative perspective of learning and deep approaches to learning. Students having qualitative perceptions of learning perceived their classroom as highly personalized and investigative. Providing a classroom environment in which personalized and investigative skills are used results with the students using deep approaches of learning and in these classroom environments, students have qualitative conceptions related to learning.

Enwistle and Ramsden (as cited in Trigwell & Prosser, 1991) conducted a study to reveal how academic environment is related to students' study approaches at both individual and class level utilizing both qualitative and quantitative analysis. Results of their study indicated that it was the students' perceptions of the learning environment-not necessarily same as the reality-that related to study approaches. If the students perceive the workload as heavy then they tend to utilize the reproducing orientation. At the whole class level, a perceived heavy workload and less freedom in learning again related to reproducing orientation, and on the opposite side perceived good teaching and more freedom in learning related to a meaning orientation. Similarly, Enwistle and Tait (1990) stated that it is the students' perceptions of their learning environment rather than the environment itself in an objective sense, influencing learning. Therefore, the effects of teaching and assessment procedures in the classroom at least some extent depend on the students' perceptions and evaluations of those experiences. Enwistle (1991) further commented on the indirect influences of the learning contexts on students' learning approaches with the mediating effects of individual students' characteristics. The researcher clarifies his comment by an example: Students who are consistently tend to use surface approaches prefer teachers providing digested information that are ready for learning, whereas students using deep approach prefer teachers who challenge and stimulate them. Therefore, he made a similar conclusion as Enwistle and Tait (1990) and stated that it is the students' perceptions of the learning environment that influence their learning approach, not necessarily the context itself.

Trigwell and Prosser (1991) examined the students' perceptions of the learning environment and its relation to approaches to study and qualitative differences in learning outcomes. The sample was 74 students from a first year nursing communications course. As a qualitative indicator, a question was directed to the students to make them describe what their course was about. Students' learning approaches were assessed by Approaches to Study Inventory as deep approach, surface approach and relating ideas. In deep approach, students try to understand and determine the meaning of the subject. In surface approach, they focus on memorizing the material, and in the relating ideas, students attempt to see the relation between prior knowledge and current material, to relate new ideas to real life, to integrate the subject into a whole, and to see the task in a wider perspective. It is indicated that Deep and Relating Ideas sub scales can be considered as the components of the Deep Approach described by Marton and Saljo (1976). Students' perceptions of the learning environment was assessed using Course Experience Questionnaire on five sub scales namely, good teaching, clear goals, appropriate workload, appropriate assessment, and emphasis on independence. The patterns of the relationships between approaches, perceptions, and outcomes were explored by using principal component analysis with varimax rotation. Results showed that factor one contains high negative loading on the Surface Approach sub scale, high positive loading on the Workload/Assessment variable and moderately high positive loading on the Good Teaching/Clear Goals/Independence variable. The researchers interpreted this result that a perception of high workload and assessment aimed at rote recall is associated with students adopting surface approach. Factor II contains high positive loadings on Deep/Relating Ideas variable, the Good Teaching/Clear Goals/Independence variable and the qualitative differences in learning outcome variable. This result implied that the students perceived that the teaching was good, that there were clear goals and some independence of learning adopted deep approach to study and had a higher quality learning outcome. By the examination of the correlation matrix, the researchers had further insight into the relationships between variables. Relating ideas approach was found to be more closely related to perceptions regarding learning environment than was a deep approach; statistically significant relationships was found between Relating Ideas subscale and Good Teaching/Clear Goals/Independence variable ($r = .27$, $p < .05$). The relatively large and negative correlations between the Surface Approach subscale and Appropriate Workload ($r = -.50$, $p < .05$) and Appropriate Assessment ($r = -.42$, $p < .05$) subscales were found. None of the correlations between learning outcomes and learning approaches and perceptions of learning environment were significant, but the correlations with Deep/Relating Ideas variable ($r = .15$), Clear goals ($r = .12$), and Appropriate Workload ($r = .20$) variables were found to be positive. Generally, the result of the study indicated that surface approaches to learning are related with perceived heavy workload and assessment emphasizing rote learning. Also, higher quality learning outcomes were found to be related with the deep approach to study, perceptions of good teaching, clear goals and some independence in learning. The results implied that improving the quality of learning outcomes may be provided with the establishment of a learning environment encouraging deep learning.

Eley (1992) investigated the associations between students' perceptions of the teaching in a course and the study approaches they adopted. The sample of the study consists of 74 students enrolled in biochemistry and microbiology units, 152 in financial accounting and business law unit, 54 in chemistry and either mathematics or statistics unit, and 40 in English literature and either politics or philosophy units. Two questionnaires were used Ramsden's School Experiences Questionnaire and Biggs' Study Process Questionnaire. The School Experience Questionnaire consists of 31 items in five dimensions, namely Teaching Support, Independence in Learning, Structure and Cohesiveness, Emphasis on Achievement, and Support for Higher Education Study. One hundred and fifty two of the students returned by completing the questionnaires properly. Results showed that students tended to report surface approaches higher when they perceived courses as emphasizing performance in formal assessment (Emphasis on Achievement, $r_1 = .26$, $r_2 = .31$, $p< .01$), and lower when they perceived them emphasizing independent learning (Independence of Learning, $r_1 = -.27$, $r_2 = -.21$, $p < .01$). On the other hand, students tended to report deep approaches higher when they perceived courses as high on each of the Teaching Support ($r_1 = .42$, $r_2 = .37$, $p < .01$) Structure and Cohesiveness ($r_1 = .38$, $r_2 =.30$, $p< .01$), Independence of Learning ($r_1 = .49$, $r_2 = .36$, $p < .01$) and Support for Higher Education Study ($r_1 = .54$, $r_2 =.43$, $p <.01$). Also achievement approach was found to be positively correlated with Emphasis on Achievement ($r_2 = .27$, $p< .01$), Structure and Cohesiveness ($r_1 = .24$, $r_2 = .22$, $p <.01$), and Support for Higher Education Study ($r_1 = .26$, $r_2 =27$, $p< .01$). Results implied that when students perceived their course unit to be generally supportive and encouraging of their learning, clear in definition of unit goals, sensitive to students' mental processing in learning, concerned with their capacity to learn independently, and supportive of study practices expected for higher education, they tended to use deeper approaches to study.

Eley (1992) further analyzed whether individual students showed variability in their study approaches between their compared course units. First, change scores were calculated by subtracting the second course unit from the first course unit, and then the obtained scores were classified into five categories based on the magnitude of change. According to the results, when students perceived the course unit greater compared to its comparison on Teaching Support, Structure and Cohesiveness, Metacognitive Focus, Independence of Learning, and Support for Higher Education Study, there were significant increases determined in their tendency to report the adoption of deeper study approaches. Similarly, increases in all of the learning environment subscales were associated with the significant increases in tendency to adopt achievement approaches to study. Also, increases in perceived ratings on Independence in Learning and Support for Higher Education Study sub scales resulted with the significant decreases in the report of surface approaches. Investigation of the relationship of achievement with study approaches and learning environment subscales showed that, tendency to report surface oriented approaches correlated with lower final grades of the course ($r = -.23$, $p < .01$), and tendency to report deep or achievement oriented approaches correlated positively and significantly with higher grades ($r = .22$ for deep and $r = .35$ for achievement approach, $p < .01$). When the relationship between learning environment subscales and final course grades were investigated, it was found that only Emphasis on Achievement was found to be correlated with grades ($r = -.25$, $p < .01$). Since there was a relationship found between learning environment subscales and study approaches, the researchers thought that learning environment was not seemed to be unrelated to academic performance; rather it seemed that there was an indirect effect on the environment on achievement. It can be said that learning approaches mediated the relationship between learning environment and academic achievement; learning environment influence the study approaches and accordingly the approaches influence the academic achievement.

Enwistle and Tait (1990) conducted a study to investigate 431 first year university students' perceptions of their academic environments and the relationships between their perceptions and study approaches. Students' study approaches were assessed in four sub dimensions namely, meaning orientation, achieving orientation, reproducing orientation, and non-academic orientation. The scale also includes additional items related to students' study methods and habits. Meaning orientation dimension includes items related to deep approach and intrinsic motivation, achieving orientation dimension includes items related to strategic approach and need for achievement, reproducing orientation approach includes items related to surface approach and fear of failure, non academic orientation approach includes items related to self confidence, distractibility and negative attitudes, and study habits and methods dimension focused on relative time spent in different aspects of studying. Scale used to measure students' perceptions of their academic environment includes five dimensions, namely experiences of the course, evaluation of lecture course, evaluation of staff advice, evaluation of tutorials, and evaluation of practicals. Correlation analysis showed that students having high scores in meaning orientation tended to perceive the content of the course particularly relevant, on the other hand, students having high scores in non academic orientation were found to be more likely to see the same content as irrelevant. Students having high scores in reproducing orientation perceived their course as demanding high workload which was also related to high anxiety related to the course. These students also found to blame themselves for their difficulties, whereas students with non academic orientation directed their difficulties away from themselves, and tended to see the content or lecturer to be responsible for their difficulties. The correlations were ranged between .12 and .50 ($p <.05$). In another study with 123 electrical engineering and 148 psychology students, Enwistle and Tait (1990) found statistically significant correlations between students study orientations and their perceptions related to their academic environment. Additionally, in this second study the researchers also investigated students' preferences for their academic environment. The statistically significant correlations in this second study were ranged between .15 and .39 ($p <. 05$). In this study, it was found that meaning and achieving orientations were associated with good teaching and openness to students. Similar to the first study, engineering students with high reproducing or non academic orientation scores perceived their courses as demanding high workload. Psychology students only with high reproducing orientations scores showed similar pattern of perception related to the course workload. The study also showed that students adopting deep approaches showed preference for a learning environment that promotes understanding, while those with rote learning prefer environments facilitating rote learning. It was seen that there was a parallelism between students' study approaches and their preferences for their learning environments utilizing different teaching methods and assessment procedures. Enwistle and Tait (1990) concluded that students' learning approaches can be seen as a reaction to their learning environment, at least in some part, and they added that good teaching causes utilization of deep approach, and vice versa. Also, their analysis at the department level showed that academic environment directly influenced students' learning approaches. For example, students from a department allowing for little freedom in learning or demanding high workload, are more likely to rely on rote learning.

In another study with university students, Ramsden (1979) examined students' perceptions of their courses and teachers in six departments at a British university, identified the characteristics of those environments and showed how contextual variables are related to students' way of learning. A total number of 285 students from the social science, applied science, natural science, and two arts departments enrolled in the study. A 47 item Course Perceptions Questionnaire was administered to students to assess their perceptions of the learning environments. There were eight dimensions in the questionnaire: Relationship with students (closeness of lecturer and students relationships; help and understanding shown to students), commitment to teaching (commitment of staff to improving teaching and to teaching students at a level appropriate to their level of understanding), workload (pressure placed on students in terms of demands of the syllabus and assessment tasks), formal teaching methods (formality or informality of teaching and learning, for example time spent for lectures and individual studies), vocational relevance (perceived relevance of courses to students' careers), social climate (frequency and quality of academic and social relationships between students), clear goals and standards (extent of the clearness of expectations from students), freedom of learning (amount of discretion possessed by students in choosing and organizing academic work). The results of the analysis of data obtained from the Course Perceptions Questionnaire showed that students from different departments perceived the process of learning and teaching in contrasting ways. Students from arts and social sciences departments perceived a fairly personalized approach of teaching and learning compared to students from other departments. The students from applied sciences and independent studies departments perceived the teacher control over the transmission of knowledge on opposite ends of a continuum. Knowledge in the applied sciences departments perceived by the students as strongly framed, clearly defined and systematically transmitted. On the other hand, students from independent studies department perceived the frame of knowledge extremely weak, found the expectations about satisfactory knowledge unclear, methods and goals of learning ambiguous, and felt that they were left to find their own ways through courses.

Ramsden (1990) conducted semi structured interviews to further clarify the students' perceptions about their learning environments and to see whether qualitatively different learning strategies are linked in students' minds with different context of learning. Interview results revealed that students put extreme importance to staff understanding of their learning needs as a part of the learning environments. A teacher without a commitment to teaching might put students off studying the subject. An enthusiastic teacher seemed to encourage the students to put more effort into the subject matter under study and make them enjoy it. Failure to reach the level of students in a lecture made the subject difficult to learn for students, and threatening learning environments make students anxious and consequently they seemed to learn nothing. The contextual variables mentioned above influenced students' level of interest in a topic. The perception of students of the task and the learning environment directly determines the students' approach of learning and studying meaning whether they tackle it in a superficial way or to strive for meaning.

2.3.3 Summary of the Literature on Learning Environments

There is an increasing recognition about the importance of the classroom environments in education research (Alridge, Fraser, & Huang, 1999). Classroom environments research revealed that classroom environments are important for students' affective performance and especially for their attitudes (Arısoy, 2007; Cheng, 1994; Kim, Fisher, & Fraser; 1999; Yılmaz-Tüzün, Çakıroğlu, & Boone, 2006). Classroom environments and instruction are the two important variables believed to contribute students' epistemological growth (Carey et al., 1989; Cavallo, Rozman, & Potter, 2004; Conley et al., 2004; Lederman & Druger, 1985; Tsai, 1996). Research revealed that constructivist classrooms developed a more sophisticated understanding of epistemological beliefs than do the students in more traditional classrooms, and epistemological beliefs of students can change, when students are given the opportunity to work collaboratively, reflect their thinking and evaluate their beliefs (Smith et al., 2000; Tsai, 1998a; 1998b; Valanides & Angeli, 2005).

There is another line of research in the classroom environment literature particularly focused the relationship between learning environment and students' learning approaches. It is stated that stated that students' perceptions of the learning environment that influence their learning approach, not necessarily the context itself (Enwistle, 1991). Results of some studies showed that when students perceived their course unit to be generally supportive and encouraging of their learning, clear in definition of unit goals, sensitive to students' mental processing in learning, concerned with their capacity to learn independently, and supportive of study practices expected for higher education, they tended to use deeper approaches to study. The perception of students related to the learning environment directly determines approach of learning; whether they tackle it in a superficial way or to strive for meaning (Dart et al., 2000; Eley, 1992; Enwistle & Tait, 1990; Ramsden, 1979; 1990; Trigwell & Prosser,1991).

In addition, learning approaches are said to mediate the relationship between learning environment and academic achievement; learning environment influence the study approaches and accordingly the approaches influence the academic achievement Eley, 1992; Trigwell & Prosser, 1991).

CHAPTER 3

METHOD

In the previous chapters, purpose and significance of the study were presented, related literature was reviewed and the essence of the study was justified. In this chapter, major characteristics of the sample, instruments used in the study, procedure, methods that were used to analyze data will be explained briefly.

3.1 Population and Sample

All sixth, seventh and eighth grade public elementary school students in Turkey were identified as the target population of this study. However, it is appropriate to define an accessible population, since it is not feasible to study with this target population. The accessible population was determined as all sixth, seventh and eighth grade students in public elementary schools in İstanbul, Ankara, İzmir, Diyarbakır, Van, Antalya, Afyon, Eskişehir, and Samsun. The total number of 6th, 7th, and 8th grade students in these ten cities was 1.655.659 according to 2006-2007 statistics of Ministry of Education (National Education Statistics Formal Education 2006-2007, n.d) as given in Table 3.1.

Table 3.1 Population of 6th, 7th, and 8th students in İstanbul, Ankara, İzmir, Diyarbakır, Van, Antalya, Afyon, Eskişehir, and Samsun

	Number of students			
	6th grade	7th grade	8th grade	Total
İstanbul	249519	237374	212816	699709
İzmir	65848	65388	61141	192377
Afyon	12946	12612	11827	37385
Eskişehir	11509	11874	11136	34519
Ankara	78594	78838	72632	230064
Antalya	34940	33519	31264	99723
Samsun	25969	25209	24128	75306
Van	27727	24196	19423	71346
Gaziantep	39482	35422	30710	105614
Diyarbakır	41366	37639	30611	109616
Total	587900	562071	505688	1655659

The sample of the study is determined as 6th, 7th, and 8th grade public elementary school students attending 11 Education Parks of TEGV (Educational Volunteers Foundation of Turkey) in 2006-2007 spring semester. Annually a total number of 150.000 students attend TEGV activity location in four activity terms. For one educational term, nearly 32.500 students attend TEGV activity locations throughout Turkey from all grade levels, namely from grade 1 to grade 8. Nearly one fourth of the students are from 6, 7 and 8th grade levels. Therefore, it can be said that for one activity term, the total number of students from 6, 7 and 8th grades is nearly 8.000 students.

The reason of the existence of TEGV foundation is to contribute to the basic education delivered by the state. To serve its mission, Educational Volunteers organizes volunteers to educate children between ages of 7-16, who come to these well equipped education facilities with their own will, and prepare them for the future (Educational Volunteers Foundation of Turkey, 2007).

The mission of Educational Volunteers is to create and implement extra curriculum programs which will contribute to children become reasonable, responsible, analytical minded, questioning, creative and peaceful individuals who are respectful of different ideas and beliefs, committed to the basic principles and values of the Turkish Republic and who do not consider gender, race, religion or language differences in human relations.

The foundation's mission is to provide non-formal educational opportunities for children and youth in need, currently serving the non-formal educational needs of over 150,000 children and young people (aged 6-16) throughout Turkey. It works with up to 2,780 volunteers annually. The Foundation provides a unique, non-formal educational environment for the personal and social development and practical skills enhancement, particularly of vulnerable children and youth, at 11 Education Parks, 58 centers and 17 mobile learning units (fireflies) in less-privileged urban and rural areas throughout Turkey's seven regions. And it aims to enhance personal potential, attitudes and community values in youth, by providing effective training programs for young volunteers working with less-privileged children and youth throughout Turkey, and the opportunity for young people to practice life skills by participating in non-formal mentored programs for children throughout Turkey (Educational Volunteers Foundation of Turkey, 2007).

Schools working with TEGV in abovementioned cities and the groups of students attending TEGV activity locations in those ten cities were chosen by convenience sampling. The sample of the study composed of 2702 students from 139 different schools and at the same time attending 15 different activity locations of TEGV across 10 cities. Among those students nearly half of them (53.2%) are girls and remaining half (46.8%) are boys. The ages of students are ranged between 11 and 16.

Demographic information namely age, gender, and socio economic status of the sample (SES) was collected as the major characteristics of the sample. The characteristics of the sample in terms of gender, grade level and age distributions were given in Table 3.2.

Table 3.2 Characteristics of the sample

	Frequency (*f*)	Percentage (%)
Gender		
Male	1265	46.8
Female	1437	53.2
Grade Level		
6	931	34.5
7	925	34.2
8	846	31.3
Age		
11	52	1.9
12	674	24.9
13	883	32.7
14	840	31.1
15	219	8.1
16	34	1.3

Number of books at home, pocket money opportunity, presence of a computer, separate study room, daily newspaper at home, number of books at home, educational level of mother and educational level of father were used as the indicators of SES of the sample of the study. It was seen that low-moderate SES level of children coming to TEGV activity locations was also represented by the sample of the study. Nearly two thirds of the participants indicated that they had pocket money opportunity (63.5%), nearly half of them had a computer at home (46.6%) and had separate study rooms (53.8%). Only one third of the participants indicated that they had daily newspaper at home (33.3%) and majority of them had 60 books at most (78.8%). Nearly half of the participants' mothers were primary school graduates (45.5%) and more than half of the participants' fathers were either primary or elementary school graduates (58.6%). Detailed information about the sample of the study in terms of mother's and father's educational level, number of books at home, pocket money opportunity, computer at home, daily newspaper, separate study room was given in Table 3.3.

Table 3.3 Socio-economic status of the sample

	f	%	*f*	%
Educational Level	Mother		Father	
Illiterate	557	20.6	148	5.5
Primary school	1230	45.5	962	35.6
Secondary school	356	13.2	622	23
High school	305	11.3	504	18.7
University	131	4.8	296	11
I don't know	123	4.6	170	6.3
Number of books at home				
0-25	1185	43.9		
26-60	673	24.9		
61- 100	465	17.2		
101-200	231	8.5		
More than 200	148	5.5		
Pocket Money Opportunity				
Yes	1716	63.5		
No	986	36.5		
Computer at Home				
Yes	1260	46.6		
No	1442	53.4		
Daily Newspaper				
Yes	900	33.3		
No	1802	66.7		
Separate Study Room				
Yes	1455	53.8		
No	1247	46.2		

3.2 Data Collection Instruments

In this study three instruments were used to collect data from the students. These instruments are the Turkish versions of the Scientific Epistemological Views Questionnaire (SEV), Constructivist Learning Environment Survey (CLES) and Learning Approach Questionnaire (LAQ). In addition to these questionnaires, a separate part was devoted to investigate students' demographic characteristics. In the following parts, each data collection instrument is explained in detail.

3.2.1 Demographic Characteristics

There were items for investigating the characteristics of the sample such as gender, age, SES and previous final report card grade (RCG) for science and technology course. SES was measured by asking six separate questions about number of books at home, pocket money opportunity, presence of a computer, separate study room, and daily newspaper at home, number of books at home and educational level of mother and educational level of father.

Previous year final report card grade for science and technology course was used as an indicator of science achievement level of students. A number of written and oral science examinations total of six written science examinations throughout the year contributed to a student’s yearly RCG. The RCG scores may range from 1 to 5, and high GPA indicates a high level of science achievement.

3.2.2 The Scientific Epistemological Views Questionnaire (SEV)

Scientific Epistemological Views Survey (SEV) was originally developed by Tsai and Liu (2005) in order to identify various dimensions of SEV held by high school students. Tsai and Liu used the conceptual framework of Tsai’s previous studies (1998a; 1998b; 1999a, 2002) and other existing instruments (e.g. Pomeroy, 1993) while developing the instrument. Construction process of the scale includes a pilot study and follow up interviews with students.

Initially the survey has 35 items, seven for five different dimensions. After conducting principle component analysis and reliability analysis, 16 items were omitted by the researchers. The final form of the original survey has 19 items. Tsai and Liu (2005) administered SEV to 613 Taiwanese high school students. In this administration, Cronbach alpha coefficients for the five dimensions were found to be ranging from .60 to .71, and for the entire instrument .67. Principal component analysis supports the five dimension factor structure with eigenvalues of (3.12, 2.22, 1.92, 1.49, 1.30) accounting for %53 of the variance.

The survey was adapted and translated into Turkish by the researcher. The inventory was controlled and retranslated into English by an instructor in the Department of Elementary Education at METU. After this process, for the face and content validity of the instruments, experts (two research assistants and two instructors from the Department of Elementary Education, and one instructor from Department of Secondary Science and Mathematics Education, METU) examined the inventory. Before giving the instrument, experts were explained about the instrument, and then they were required to evaluate appropriateness of the items to the students' characteristics, representativeness of each item for the related dimension, clarity of wordings, language, format and directions for the instrument. The Turkish version of the questionnaire was finally examined by a group of elementary level students attending a TEGV activity location in İstanbul in terms of clarity and the meanings of the items. Suggestions were taken into account and necessary changes were done accordingly and the final format of the instrument was obtained. The final format of the instrument is given in APPENDIX A.

Students are required to respond to the items on a five point Likert scale from "Strongly disagree" to "Strongly agree". Having higher score on a certain dimension refers to having a strong belief regarding constructivist view on that specific dimension. Four of the items (4, 8, 11, 19) on the scale were written in empiricist view. These items are scored in a reverse way.

The dimensions of the instrument are "The role of social negotiation (SON)", "Invented and Creative Nature of Science (IC)", "The theory laden exploration (TL)", "Cultural Impacts (CU)", and "The changing and tentative feature of science knowledge (CT)".

According to constructivist oriented view of science, development of science requires the communications and negotiations of scientists. On the other hand, according to the positivistic view, science is performed individually; it is a process of individual exploration. "The role of social negotiation (SON)" dimension includes 6 items based on these views.

The second dimension of the survey is "Invented and creative nature of science (IC)". This dimension is constructed to assess students' understanding of importance of human imagination and creativity in growth of scientific knowledge. Also, there are items to determine whether students think that scientific knowledge is invented instead of discovered. The dimension includes 4 items.

The third dimension, namely “The theory laden explorations (TL)” includes items about the idea that personal assumptions, values, research interests may have an influence on the scientific research according to constructivist view of science. On the same issue, empiricist view says that scientific knowledge is developed on totally objective observations. There are 3 items on this dimension; two of them are on the empiricist view.

“The cultural impacts (CU)” dimension is about the influence of culture on the nature of the development of scientific knowledge. It has 3 items; two of them are on the empiricist view and ignoring the effect of different ways of knowing in different cultures.

The last dimension, “The changing and tentative feature of scientific knowledge (CT)” has items about the conceptual change in the progress of scientific knowledge. According to constructivist view of science, scientific knowledge changes, therefore it is tentative. As opposed to the constructivist view, empiricist view says that scientific knowledge does not change; it provides absolute truths about nature. This dimension includes 3 items. Example items for each dimension are given in Table 3.4 below.

Table 3.4 Example SEV Items

Dimension	Example Item
The role of social negotiation (SON)	New scientific knowledge acquires its credibility through its acceptance by many scientists in the field.
Invented and Creative Nature of Science (IC)	Scientists' intuition plays an important role in the development of science.
The theory laden exploration (TL)	Scientist can make totally objective observations, which are not influenced by other factors.
Cultural Impacts (CU)	Different cultural groups have different ways of gaining knowledge about nature.
The changing and tentative feature of science knowledge (CT)	Contemporary scientific knowledge provides tentative explanations for natural phenomena.

The distribution of items on each dimension is given Table 3.5.

Table 3.5 Dimensions of SEV

Dimension	Item Numbers
The role of social negotiation (SON)	1, 6, 16, 10, 13, 9
The invented and creative nature of science (IC)	11, 2, 5, 17
The theory laden exploration (TL)	**4***, 7, **15**
The cultural impact (CU)	**19**, **8**, 12
The changing and tentative feature of science knowledge (CT)	3, 14, 18

*Bold numbers represent the items written in empiricist view.

Reliability and five factor structure of the Turkish version of the SEV instrument was checked. The total reliability of the SEV was found to be .72 in the main study. Three of the items (sev4, sev8 and sev12) in TL and CU sub-dimensions of the SEV questionnaire had negative item-total correlation. Detailed information about the reliability of the SEV is given in Table 3.6

Table 3.6 Item-total statistics for the SEV

Items	Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Alpha if item deleted
SEV1	60.6832	76.0669	.5175	.6906
SEV2	60.8497	77.3606	.4546	.6965
SEV3	60.7668	79.0274	.4063	.7017
SEV4*	61.6118	92.9647	-.2603	.7600
SEV5	60.4822	73.8988	.5668	.6836
SEV6	60.5048	75.5481	.5593	.6872
SEV7	60.7139	76.2769	.5058	.6916
SEV8*	61.3586	90.8736	-.1749	.7558
SEV9	60.5755	75.6742	.5266	.6893
SEV10	60.7802	78.5314	.3860	.7026
SEV11	60.6962	75.8429	.5191	.6901
SEV12*	61.7987	97.4559	-.4603	.7710
SEV13	60.6769	77.7034	.4668	.6963
SEV14	60.9004	79.9964	.3279	.7080
SEV15	61.0644	85.7981	.0413	.7330
SEV16	60.5699	75.9394	.5315	.6895
SEV17	60.4722	73.2660	.6039	.6800
SEV18	60.9500	80.8679	.2510	.7150
SEV19	61.2143	83.9626	.1208	.7265

SEV1-SEV19 are the items in the SEV Questionnaire.
* Items with negative item-total correlation.

The internal consistencies of the sub-dimensions of the SEV were found to be very low for two sub-dimensions; Cronbach alpha values for TL and CU sub-dimensions were found to be .06 and .14 respectively. Cronbach alpha values for all sub-dimensions of the SEV are given in Table 3.7.

Table 3.7 Internal consistencies of the sub-dimensions of the SEV

Dimension	Cronbach alpha
The role of social negotiation (SON)	.77
The invented and creative nature of science (IC)	.75
The theory laden exploration (TL)	.06
The cultural impact (CU)	.14
The changing and tentative feature of science knowledge (CT)	.47

The factor structure of Turkish version of SEV was examined with the confirmatory factor analysis (CFA) by using structural equation modeling (SEM) technique. In order to evaluate the appropriateness of the proposed model root mean square error of approximation (RMSEA), standardized root mean square residuals (SRMR), goodness of fit index (GFI) and adjusted goodness of fit index (AGFI) were used. For RMSEA, values below .05 indicate a very good fit to the data (Kelloway, 1998; Schumacker & Lomax, 2004). Similarly, Browne and Cudeck (1993) suggest the value of .05 as an indicator of good model data fit, and they accepted the values up to .08 as acceptable values as well. Schreiber, Stage, King, Nora, and Barlow (2006) accepted values of .08 or less in RMSEA and SRMR as a good model data fit.

RMR is the root mean squared discrepancies between the implied and observed covariance matrices. SRMR is the standardized version of RMR. Generally for SRMR, values less than .05 are interpreted as goof fit to the data (Kelloway, 1998).

GFI is based on a sum of the squared discrepancies to the observed variances. For GFI, values greater than .90 indicates a good fit to the data. AGFI is the adjusted version of GFI for the degrees of freedom in the model. Similar to GFI, for AGFI values greater than .90 indicates a good fit to the data (Jöreskog & Sörbom, 1993; Kelloway, 1998).

Since their internal consistencies were found to be very low in the analysis, the two sub-dimensions; namely TL and CU were totally excluded from the SEV. Three factor structure of the SEV was examined with the confirmatory factor analysis (CFA) by using structural equation modeling (SEM) technique. The fit indices for evaluating the proposed model, RMSEA = .04, SRMR = .02, GFI = .98 and AGFI = .97 indicated good model data fit. Consequently, it can be said that five factor model proposed by Tsai and Liu (2005) was not completely replicated with Turkish sample. Instead, three factor model of the SEV was obtained and used in order to represent students' scientific epistemological views.

3.2.3 Constructivist Learning Environment Survey (CLES)

Constructivist Learning Environment Survey (CLES) was originally developed by, Taylor and Fraser (1991) in order to assess a degree to which a particular classroom environment is consistent with a constructivist epistemology. And also, it was designed to guide teachers to reflect on their teaching practices in terms of their epistemological beliefs and accordingly reshape their teaching practice.

The instrument originally has 28 items, seven items in four scales namely Autonomy, Prior Knowledge, Negotiation, and Student Centeredness. Taylor (1996) revised the instrument. This revised version of the instrument has five dimensions: Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation. In 2002, Johnson and McClure revised this new format of the instrument and shortened to 20 items. The five dimensions were kept but the number of items in each dimension was decreased.

Personal Relevance dimension is designed to assess students' perception of the classroom environment regarding the degree of relevance in their studies, in Shared Control dimension, there are items to assess whether students feel that they have shared control over their learning, in Critical Voice dimension, there are items to assess perception of the degree to which they feel free to express their thoughts about their learning, in Student Negotiation dimension, there are items to assess their perception of the degree whether they are able to interact with each other for better learning, and in Uncertainty dimension there are items to assess the degree of students' perception about tentative nature of science. The distribution of items according to each dimension is given in Table 3.8.

Table 3.8 Dimensions of CLES

Dimension	Item Numbers
Personal relevance (PR)	1, 7, 11, 16
Student Negotiation (SN)	5, 10, 14, 17
Shared Control (SC)	4, 6, 12, 20
Critical Voice (CV)	3, 8, 15, 18
Uncertainty (UN)	2, 9, 13,19

The final format of the instrument was adapted and translated into Turkish by Yılmaz-Tüzün, Çakıroğlu and Boone (2006). For the validity of the instrument, the researchers conducted principal component analysis and according to their findings, all of the items loaded on their hypothesized dimensions. Reliability estimates of the each sub-scale of the instruments ranged from .72 to .86.

In this study, the adapted Turkish version of the instrument was used as given in APPENDIX B. Reliability analyses were done. And confirmatory factor (CFA) analysis was conducted in order to get evidence for the construct validity of the instrument. The total reliability of the CLES was found to be .90. Detailed information about the reliability of the CLES is given in Table 3.9.

Table 3.9 Item-total statistics for the CLES

Items	Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Alpha if item deleted
CLES1	65.0807	182.2571	.5730	.8937
CLES2	65.5155	191.2524	.2548	.9029
CLES3	64.9778	182.7067	.5656	.8939
CLES4	65.5100	182.7661	.5218	.8951
CLES5	65.0255	183.3400	.5401	.8946
CLES6	65.4463	182.1724	.5540	.8942
CLES7	64.9049	182.4460	.5721	.8937
CLES8	64.8220	183.6162	.5432	.8945
CLES9	64.9978	185.5150	.4938	.8958
CLES10	65.4064	184.3228	.4808	.8962
CLES11	64.7435	184.1922	.5277	.8949
CLES12	65.3372	183.1077	.5208	.8951
CLES13	65.0433	183.7652	.5440	.8945
CLES14	65.0774	181.6264	.5952	.8931
CLES15	65.0855	182.3285	.5640	.8939
CLES16	64.8349	183.7654	.5342	.8947
CLES17	64.9075	184.7793	.4987	.8957
CLES18	65.1199	182.1878	.5573	.8941
CLES19	64.9363	182.5631	.5940	.8932
CLES20	65.2128	181.8270	.5366	.8947

CLES 1-CLES 20 are the items in the CLES.

The internal consistencies of the sub-dimensions of the CLES were found to be ranging between .57 and .75. Cronbach alpha values for all sub-dimensions of the CLES are given in Table 3.10.

Table 3.10 Internal consistencies of the sub-dimensions of the CLES

Dimension	Cronbach alpha
Personal relevance (PR)	.73
Student Negotiation (SN)	.68
Shared Control (SC)	.75
Critical Voice (CV)	.69
Uncertainty (UN)	.57

In order to provide evidence for the construct validity of the instrument, confirmatory factor analysis was done whether the expected five dimensions of the instrument are confirmed or not with the data provided by the study by using structural equation modeling (SEM) technique. The fit indices for evaluating the proposed model, RMSEA = .05, SRMR = .03, GFI = .96 and AGFI = .94 indicated good model data fit. When cles2 was removed from the analysis AGFI took the value of .95; a slight increase was observed. Consequently, it can be said that five factor model proposed by the researchers (Yılmaz-Tüzün, Çakıroğlu & Boone, 2006) was replicated with the sample of this study.

3.2.4 Learning Approach Questionnaire (LAQ)

The Learning Approach Questionnaire (LAQ) is a 24 item Likert type instrument, originally developed by Cavallo (1996) to assess students' perceptions about how they learn. The instrument has two sub-scales; namely Meaningful Learning and Rote Learning. A high score on the meaningful learning sub-scale means students learn by meaningful learning approach and a high score on the rote learning means students learn by rote learning.

Meaningful learning sub-dimension measures the degree to which the learner has intention to understand the learning material by constructing the meaning of the content. On the other hand, rote learning sub-dimension measures the degree to which the learner has the intention to learn by memorizing for the recall of facts.

The instrument was adapted and translated into Turkish by Özkan (2008). After she adapted the questionnaire, it was examined by a group of elementary level students in terms of clarity and the meanings of the items. Then, a back translation of the Turkish version into English by a qualified, bilingual Turkish instructor was done. The adapted version of LAQ was initially pilot tested with 156 seventh graders from three elementary schools in the Çankaya district. Özkan (2008) found the total reliability of the LAQ with its 24 items was found to be .67 as measured by the Cronbach alpha coefficient. In this study the 24 item Turkish version of the instrument was used to collect data. The distribution of items according to two dimensions is given in Table 3.11. The LAQ instrument is presented in APPENDIX C.

Table 3.11 Dimension of items on LAQ

Dimension	Item Numbers
Meaningful Learning	1, 2 ,3 6, 8, 9, 10, 11, 13, 15, 17, 23, 24
Rote Learning	4, 5, 7, 12, 14, 16, 18, 19, 20, 21, 22

In this study, the total reliability of the LAQ was found to be .89. The internal consistencies of the two sub-dimensions were found as .90 and .73 for ML and RL respectively. Detailed information about the reliability of the LAQ given in Table 3.12.

Table 3.12 Item-total statistics for the LAQ

Items	Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Alpha if item deleted
LAQ1	80.4130	216.9882	.5962	.8883
LAQ2	80.4819	219.7529	.6208	.8883
LAQ3	80.4837	218.6741	.6274	.8879
LAQ4	80.4123	220.0862	.5811	.8890
LAQ5	80.7283	221.7255	.4743	.8913
LAQ6	80.3967	219.2783	.5952	.8886
LAQ7	81.0707	231.8739	.1608	.8998
LAQ8	80.5115	219.6191	.5718	.8891
LAQ9	80.6292	219.7573	.5735	.8891
LAQ10	80.4722	219.7340	.5890	.8888
LAQ11	80.5722	218.5048	.5976	.8884
LAQ12	80.5829	220.7430	.5393	.8898
LAQ13	80.5096	218.5395	.5990	.8884
LAQ14	80.4900	221.2918	.5308	.8901
LAQ15	80.5559	219.0393	.6142	.8882
LAQ16	80.5289	219.9168	.5574	.8894
LAQ17	80.3990	219.6734	.5488	.8896
LAQ18	81.3490	229.6682	.2150	.8984
LAQ19	80.4497	219.9899	.5552	.8895
LAQ20	81.4275	230.7395	.1849	.8993
LAQ21	81.2006	228.4877	.2583	.8969
LAQ22	81.2402	228.7120	.2443	.8975
LAQ23	80.5507	219.3967	.5922	.8887
LAQ24	80.5707	221.1018	.5064	.8906

LAQ1-LAQ24 are the items in the LAQ.

In order to provide evidence for the construct validity of the instrument, two factor structure of the LAQ was examined with the CFA by SEM technique. The fit indices for evaluating the proposed model, RMSEA = .05, SRMR = .04, GFI = .94 and AGFI = .92 indicated good model data fit. Consequently, it can be said that two factor model proposed theoretically by researchers of the previous studies (Cavallo, 1996; Özkan, 2008) was replicated with the sample of this study.

3.3 Procedure

The study was started with defining the research problem and forming the keyword list accordingly. Then, the related literature was reviewed in detail. Previous studies related to the study was systematically searched from Educational Resources Information Center (ERIC), International Dissertations Abstracts, Social Science Citation Index (SSCI), Ebscohost, Science Direct, Kluwer Online databases, Internet (e.g., Google), and studies done in Turkey (from YÖK, Hacettepe Eğitim Dergisi, Eğitim ve Bilim Dergisi (TED), Çağdaş Eğitim Dergisi, MEB Dergisi, and studies presented in National Congress on Science And Mathematics Education. The photocopies of the available documents were obtained from METU library, Hacettepe University Library, Tübitak-Ulakbim library, Gazi University Library, Boğaziçi University Library and Internet. Some of the documents which could not be reached were obtained from abroad. First, all of the obtained documents were organized, read, and the results of the studies were compared.

After completing the literature review, the hypothesized structural model of the study was proposed. According to the variables of the proposed model, a detailed research was made in order to find the most appropriate measurement instruments for the purpose and sample of the study. Selection of the measurement instruments was followed by the adaptation and preparation process.

Then, the researcher decided on the cities and activity locations of TEGV to be included in the study and the necessary permission was taken from the TEGV executive for the administration of the measurement instruments. Fifteen activity locations from different cities were selected so that the various geographical regions of Turkey were represented. The selected activity locations were from ten different cities namely; İstanbul, Ankara, İzmir, Afyon, Antalya, Samsun, Eskişehir, Gaziantep, Van and Diyarbakır.

Before the administration, all TEGV personnel participated in the study were informed first by face to face explanation in a meeting, then by e-mail and lastly telephone conversations about the purpose of the study, instrument and administration, and the necessary directions were given. Then, the questionnaires were packed and posted to the selected activity locations. Then, the study was conducted by administering the instruments to the selected sixth, seventh and eighth grade students. The data were collected by the personnel who were working in the selected TEGV activity locations. The data collection procedure was lasted in 10 weeks. In order to eliminate potentially confounding variables, data related to the subject characteristics, such as gender, age and SES were also obtained with the inventory, and taken into consideration.

After the data collection procedure, all questionnaires were posted back from the administration cities to the researcher. Data entry was made by the researcher. Then the researcher coded all the categories of the variables in the data.

Possibility of harm to the participants was not appeared to be a problem for this study. Deception was not required. All students were assured that any data collected will be held in confidence and names of the schools and subjects will not be used in any kind of publication. Also, the participants were informed that the results of the study would not affect any of their grades in the school. In order to ensure confidentiality of the research data, the participant students were required to write their TEGV member numbers instead of their names. Before the data entry, the researcher was assigned a number to each of the questionnaire. The participants were also given the guarantee that the study will not give any physical and psychological harm or discomfort to them and they were informed about the actual purposes and procedures of the study.

3.4 Analysis of Data

The data analysis consists of three main parts; preliminary data analysis, descriptive statistics and Structural Equation Modeling (SEM). In preliminary analysis part, first the data were screened out for outliers and influential data points. Then missing data analysis was done and assumptions of SEM were checked. In the final part, SEM was conducted to test if hypothesized model fitted the sample data. Preliminary analysis and assumptions are presented in the Results chapter.

In order to conduct data analysis, SPSS 10.0 (Statistical Package for Social Sciences) and LISREL 8.3 were utilized. Analysis related to outlier and influential data points, missing data, descriptive statistics and assumptions were done by using SPSS. Confirmatory factor analysis and SEM were conducted by using LISREL.

3.4.1 Descriptive Statistics

After completing the preliminary data analysis; namely, missing data and outlier analysis, normality and multicollinearity checks, CFAs were conducted by using LISREL 8.3 separately for each of the scales in order to confirm their theoretical structures.

In order to formulate latent variables to be included in SEM, observed variables with high R^2 values were determined. Then, final data file was formed including the selected items constituting the latent variables to be imported to PRELIS from SPSS.

Descriptive statistics including mean, mode, minimum and maximum values standard deviation of the variables were obtained in order to summarize students' profiles in terms of scientific epistemological views, perceptions related to classroom environment, learning approaches, science achievement and their socio economic status. Descriptive statistics are presented in the Results chapter.

3.4.2 Effect Size

Effect size is the measure of proportion of variance in the dependent variable accounted by the independent variables (Green, Salkind, & Akey, 2000). It is the indicator of practical significance of findings (Stevens, 2002). There are different measures for effect size depending on the statistical technique utilized and the type of interpretation made. According to Kline (1998), in SEM analysis, standardized path coefficients can be interpreted as effect size. Standardized path coefficients below the value of .10 indicates small effects that of around .30 indicates medium effects and that of .50 and above indicates large effects.

On the other hand, since SEM is related to multiple regression. R^2 values which assess how well the linear combination of predictor variables in the regression analysis predicts the criterion variable (Green, Salkind, & Akey, 2000) may be used as an indicator of effect size in SEM analysis.

In multiple regression analysis, R value is Pearson product-moment correlation coefficient between the predicted criterion scores and the actual criterion scores and it ranges from 0 to 1. In order to interpret R values as effect size, it may be squared and multiplied by 100 making the interpretation of a percent of variance accounted for a specific variable (Green, Salkind, & Akey, 2000). According to Cohen (1983) effect sizes in terms of R^2, .01, .09, and .25 represents small, medium, and large effect sizes respectively.

3.4.3 Structural Equation Modeling (SEM)

Structural Equation Modeling (SEM) is a statistical methodology providing a hypothesis testing approach to the multivariate analysis of a structural theory hypothesized by a researcher (Byrne, 1998). More specifically, a theoretical model, hypothesizing how a set of variables define constructs and how these constructs are related to each other can be tested with SEM (Schumacker & Lomax, 2004).

SEM studies are divided into three in terms of the modeling approach (Jöreskog & Sörbom, 1993). These are:

1. Strictly confirmatory strategy: In this approach the researcher formulates a model and tests this model with empirical data. The model is either accepted or rejected (Jöreskog & Sörbom, 1993).
2. Alternative models or competing models strategy: In this approach, the researcher proposes alternative models, and based on the analysis of the empirical data, one of the models, which provides best model data fit, is selected (Jöreskog & Sörbom, 1993).
3. Model generating strategy: In this approach, the researcher specifies a tentative, hypothetical model. If this model does not fit the data, then it is modified and tested again. The aim is to reach a model not only

fitting to the data well statistically, but also having meaningful interpretations of the relationships between the variables (Jöreskog & Sörbom, 1993).

In this study, data were analyzed utilizing the model generating strategy and LISREL 8.3 for Windows with SIMPLIS command language was used in order to obtain the best model describing the factors contributing to the science achievement of sixth, seventh and eighth grade students.

3.4.4 Definition of Terms

In this section important terms related to SEM analysis are briefly described.

1. Observed, Measured, or Indicator Variables: Observed variables are directly measured or observed variables (Schumacker & Lomax, 2004). Observed variables are presumed to measure latent variables (Kline, 1998).

2. Latent variables: Latent variables are the variables which cannot be directly observed or measured, but presumed to be measured by a set of observed variables (Schumacker & Lomax, 2004).

3. Path Diagram: Path diagram is the schematic representation of a structural equation model in which observed variables are represented by rectangular boxes and latent variables are represented by ellipses (Byrne, 1998). In path diagrams, unidirectional arrows represent the casual relationships, on the other hand bi-directional arrows represent the correlational relationships (Kelloway, 1998).

4. Endogenous latent variables: An endogenous latent variable is a variable that is predicted by other latent variables in a structural equation model and therefore an endogenous latent variable must have at least one arrow leading into it (Schumacker & Lomax, 2004). The term endogenous is

used as dependent or criterion variable but they can be causes of other endogenous variables (Kline, 1998).

5. Exogenous latent variables: Exogenous latent variable is a variable that does not have an arrow leading to it (Schumacker & Lomax, 2004). The term exogenous is often used instead of predictor or independent variable and they are assumed to affect other variables (Kline, 1998).

6. The measurement model: The measurement model is a model which focuses on the link between latent variables and their observed variables (Byrne, 1998). The measurement coefficients determining the relationship between observed variables and the latent variable represents factor loadings. A factor loading gives information about a given observed variable's measurement extent of a specific latent variable. The measurement models also give information about the reliability and validity of the latent variables (Schumacker & Lomax, 2004).

7. The structural model: The structural model is a model which depicts the relationships between latent variables. The relationships between latent variables are represented by arrows. A model that specifies the direction of cause from one direction only is called a recursive model, and a model allowing for reciprocal or feedback effects is called non-recursive models (Byrne, 1998). A structural model holds information about the amount of variance explained and unexplained (Schumacker & Lomax, 2004).

8. The measurement coefficients: Measurement coefficients are the values determining the relationship between the latent variable and observed variables. These are factor loadings and used as validity coefficients as well. There are two types of measurement coefficients; λ_y and λ_x (Schumacker & Lomax, 2004). The former represents the relationship between an endogenous latent variable and its observed variable, and the

latter represents the relationship between an exogenous latent variable and its observed variable (Jöreskog & Sörbom, 1993).

9. The structure coefficients: The structure coefficients represent the strength and direction of relationships between latent variables. The coefficient representing the relationship between the latent dependent variables (latent endogenous variables) are denoted by β and the coefficient representing the relationship between a latent independent variable (latent exogenous variable) and latent dependent variable (latent endogenous variable) is denoted by γ (Schumacker & Lomax, 2004).

10. The measurement errors: Measurement errors refer to the unmeasured portion of the variance of an observed variable (Schumacker & Lomax, 2004). According to Kline (1998), measurement error terms reflects two kinds of variance: 1) random error, 2) systematic error due to measuring other things than what the latent variable presumed to measure.

11. Direct effect: Direct effect is the effect between two latent variables represented by a unidirectional arrow (Schumacker & Lomax, 2004).

12. Indirect effect: In indirect effects, there is no line appears between two latent variables but this effect involves one or more intervening variables which are responsible for transmitting the casual effects of prior variables to subsequent ones (Kline, 1998).

3.4.5 Steps in Structural Equation Modeling

Although SEM composed of a number of different techniques, there is a common basic sequence for all of the techniques, in which analysis is conducted (Kline, 1998). The steps listed below were followed in this study.

1. Specify the model: In this step, the researcher's hypotheses are expressed in the form of a theoretical structural equation model. This model defines the presumed relations among observed or latent variables (Kline, 1998). In order to formulate a theoretical model, all research, relevant theories and other information are used (Schumacher & Lomax, 2004). In this study, the researcher used the relevant literature to build a theoretical structural model.

2. Determine whether the model is identified: A model is said to be identified if it is theoretically possible to derive a unique estimate of every parameter in the model. The model should be met the criteria for identification in order to have successful estimates (Kline, 1998). In this step, each parameter in the model are specified as free, fixed or a constrained parameter. A free parameter is the unknown one and it need to be estimated. A fixed parameter, as its name implies is fixed to a specific value, either 0 or 1. A constrained parameter is another type of unknown parameter that is constrained to be equal one or more other parameters (Schumacher & Lomax, 2004).

   Schumacker and Lomax (2004) suggested various possible methods for avoiding identification problems. In one of the methods, they suggest that in the measurement model for each latent variable, each observed variable have to be constrained to load only one latent variable. In another method, they suggest researchers to begin with a simple model including a minimum number of parameters which are thought to be crucial. Once this simple model is identified, one may add other parameters in subsequent more complicated models.

3. Select measures: In this step, Kline (1998) suggests to select measures of the variables included in the theoretical model and collecting the data.

4. Analyze the model: In this step, one of the different methods is used in order to derive the estimates of the model's parameter with the data. The maximum likelihood (ML) estimation is the most widely used methods in many model fitting programs (Kline, 1998). Schumacker and Lomax (2004) suggest using ML estimates when the observed variables are normally distributed. In other cases, for example when the data is nonnormal, a distribution free or weighted procedures are suggested to be used.

5. Evaluate the model fit: It involves determining how adequately the model accounts for the data (Kline, 1998). In order to interpret the data model fit, a number of goodness of fit criteria has been proposed (Schumacker & Lomax, 2004).

6. Respecify the model: If the initial model does not fit the data very well, then the next step is modify the model and evaluate this respecified model (Kline, 1998; Schumacker & Lomax, 2004). In this step, the researcher may add new paths to the model, remove some of the existing paths or modify the existing paths based on the empirical evidence and modification suggestions provided by the LISREL output (Şimşek, 2007).

3.4.6 One Step or Two Step Approach of Modeling

Jöreskog and Sörbom (1993) stated that the testing of a structural model may be meaningless unless if it is initially established that the measurement model holds. If the selected indicators for each of the construct do not measure that constructs, the initially specified theory needs to be modified or changed before tested. Therefore, before the structural model, the measurement model should be tested. Similarly, James, Mulaik and Brett (as cited in Schumacker & Lomax, 2004) proposed two step approach the analysis of two conceptually separate latent variable models; measurement models and structural models.

Schumacker and Lomax (2004) stated that, examining latent variable relationships in a structural model will be meaningful if first all the latent variables are adequately defined. In one step model, parameters for both the measurement model and the structural model are estimated at the same time. However, if the model is proposed for the first time, one step approach is not suggested (Şimşek, 2007). Therefore, in this study, the two step approach was utilized; first the measurement model and then the structural model depicting the relationships among latent variables were tested.

3.4.7 The Assessment of Fit and Goodness-of-Fit Criteria for Structural Equation Modeling

Schumacker and Lomax (2004) suggested using following three criteria for judging the statistical significance and meaning of a theoretical model. These are:

1. The chi square test and the root-mean square error of approximation (RMSEA) values: These two values are global fit measures. A non-significant chi-square value means that the sample covariance matrix and the reproduced model implied matrix are similar (Schumacker and Lomax., 2004). A RMSEA value of .08 or below is considered as acceptable (Şimşek, 2007). According to Kelloway (1998) RMSEA value is an important indicator of model fit both because it provides ease of interpretation and it is independent of sample size.

2. The statistical significance of individual parameter estimates: The statistical significance of a parameter estimate is found by simply comparing the t value or critical value with a tabled t value of 1.96 at the .05 level of significance. The critical value is computed by dividing the parameter estimates by their respective standard errors (Schumacker and Lomax, 2004).

3. The magnitude and direction of the parameter estimates: In assessing the model fit of a particular model, it is important to pay attention to the sign and magnitude of the parameter estimates (Schumacker and Lomax, 2004). Parameter estimates should be examined to see if there are any unreasonable values or anomalies (Jöreskog & Sörbom, 1993).

Besides the three criteria mentioned above, both Jöreskog and Sörbom (1993) and Kline (1998) suggested to examine the squared multiple correlation (R^2) for each relationship in the model. R^2 value indicates the strength of the linear relationship and a small R^2 value indicates a weak relationship and suggests that the model is not effective (Jöreskog & Sörbom, 1993).

Schumacker and Lomax (2004) indicate that the model fit determines the degree to which the sample variance-covariance data fit the structural model. In order to determine the model fit commonly chi-square (χ^2), the goodness of fit index (GFI), the adjusted goodness of fit index (AGFI) and the root mean square residual (RMR) are used. The model fit criteria and their respective acceptable fit values are given in Table 3.13. The detailed information about each model fit criteria is given after the Table 3.13 below.

Table 3.13 Model fit criteria and acceptable fit interpretation (Schumacker & Lomax, 2004, p. 82)

Model fit criterion	Acceptable level	Interpretation
Chi-square	Tabled χ^2 value	Compares obtained χ^2 value with tabled value for given df
Goodness-of-fit index (GFI)	0 (no fit) to 1 (perfect fit)	Value close to .95 reflects a good fit
Adjusted Goodness-of-fit index (AGFI)	0 (no fit) to 1 (perfect fit)	Value adjusted for *df*, .95 a good model fit
Root-mean-square residual (RMR)	< .05	Value less than .05 indicates a good model fit
Standardized-root-mean-square residual (S-RMR)	< .05	Value less than .05 indicates a good model fit
Root-mean-square error of approximation (RMSEA)	< .05	Value less than .05 indicates a good model fit

1. Chi-square (χ^2): A significant χ^2 value relative to the degrees of freedom means that the observed and estimated variance-covariance matrices differ. On the other hand, if the χ^2 is non-significant, it means that the two matrices are similar, in other words; the implied theoretical model significantly reproduces the sample variance-covariance relationship in the matrix. However, the χ^2 criterion is sensitive to sample size and it tends to indicate a significant probability level as the sample size increases (generally above N = 200) (Schumacker & Lomax, 2004). Because of its sensibility to sample size, it is not suggested to be used as a goodness of fit index especially when the sample size is large (Şimşek, 2007).

2. Goodness of Fit Index (GFI) and Adjusted Goodness of Fit Index: GFI is based on the ratio of the sum of the squared differences between the observed and the reproduced matrices to the observed variances. It measures the amount of variance and covariance in sample variance-covariance matrix that is predicted by the reproduced variance-covariance matrix (Schumacker & Lomax, 2004). AGFI is the adjusted version of the GFI for degrees of freedom of a model relative to the number of variables (Byrne, 1998; Schumacker & Lomax, 2004). Both GFI and AGFI indices range between 0 (no fit) and 1 (perfect fit). GFI and AGFI values above .95 indicated good data fit (Schumacker & Lomax, 2004). According to Byrne (1998) and Kline (1998), GFI and AGFI are less sensitive to sample size compared to χ^2, and therefore they are more standardized criteria for model fit.

3. Root mean square residual (RMR): The RMR index uses the square root of the mean-squared differences between the estimated and observed covariance matrices and it ranges between 0 and 1. A RMR value of 0 indicates a perfect fit, therefore the less the RMR value, the better the model data fit (Schumacker & Lomax, 2004). The S-RMR represents the average value across all standardized residuals, and in a well fitting model this value should be .05 or less (Byrne, 1998).

CHAPTER 4

RESULTS

The results of the study are presented in three main parts; preliminary data analysis, descriptive statistics and inferential statistics. In preliminary analysis part, first result of the missing data analysis is given. Then, the results of the outlier analysis and analysis related to the assumptions of SEM are presented. The second section is descriptive statistics in which dependent variables of the study are explored. In the final part of inferential statistics results of the SEM are given.

4.1 Preliminary Data Analysis

4.1.1 Missing Data Analysis

The first step of data analysis was missing data analysis. Missing data in the variables have the potential of affecting statistical analysis. There are different options for handling missing data. Listwise and pairwise deletions are the two options but they are not recommended due to possibility of loss of large number subjects. Mean substitution is suggested when there is a small number of missing values (Schumacker & Lomax, 2004). According to Cohen (1983) less than 5% or even 10% missing data on a variable is not large, and in this study all the missing values were less than 1%. Therefore, missing data of students in any of the items in any of the scales were replaced by the series mean or mode of the item depending on the measurement scale of the item (i.e, continuous or categorical).

During the data entering procedure, some of the participants were completely excluded from the study, since 20% or more of the answers to one or more of the scales were missing. Then, all items in the data collection instruments were analyzed in order to determine the missing data percentages.

Missing values in science grade, number of books at home, pocket money opportunity, presence of a computer, separate study room, and daily newspaper at home, number of books at home and educational level of mother and educational level of father constituted less than 1% of the whole sample, and those missing values were replaced with the mode instead of the mean of the related variable, since they were categorical variables.

All the missing values in items of SEV, CLES and LAQ scales were constituted less than 1%. It was thought that leaving an item without indicating an answer most closely meant being not sure about the item. For this reason, missing data in SEV and LAQ items were replaced by “Undecided” (3). In CLES items, since the scale was based on frequency of observations missing values were replaced with each item’s mode.

Finally, missing data in students’ age (AGE) was replaced with the series mean of the variable. The replaced missing values were constituted less than 1% of the whole sample.

4.1.2 Outlier Analysis

Stevens (2002) defined outliers as the data values that are different from the rest of the points in the data set. On the other hand, an influential data point is the one that when deleted from the data set, substantial change in at least one of the regression coefficients is produced. The data were also screened out for outliers and influential data points. In this analysis, first unusual values were determined. By using the numbers assigned to each participant, each extreme value was checked on the questionnaires and replaced with the original responses.

For measuring outliers on endogenous variables, the standardized residuals were used. Stevens (2002) indicated that any standardized residual greater than 3, in absolute value, is unusual and should be examined carefully. For measuring outliers on exogenous variables, the hat elements (leverage values) were used. The leverage values lie between 0 and 1, and values greater than 3p/n, where “p” is the number of independent variables and “n” is the sample size, were accepted as unusual (Stevens, 2002). According to these standardized residuals and leverage values, some outliers were detected in the data. To determine which outliers were influential, Cook’s distances were examined. A Cook’s distance greater than 1 would generally be considered as large (Stevens, 2002). None of the points in the data were found to be influential; Cook’s distance values were ranged between .000 and .015. Therefore, all cases were kept for the analysis.

4.1.3 Normality

SEM requires certain assumptions of data especially about distributional characteristics such as normality (Kline, 1998). Multivariate normality is the common assumptions of all SEM analysis. Multivariate normality requires 1) univariate normal distributions for all variables; 2) the joint normal distribution of all variable combinations; and 3) linearity and homosedacticity of all bivariate combinations of the variables (Kline, 1998).

Kline (1998) indicated that since it is difficult to examine joint distributions of three or more variables, it is difficult to assess the all requirements of multivariate normality (Kline, 1998; Stevens, 2002). He added that multivariate non-normality is detectable through the inspection of univariate normalities. Therefore, in this study univariate normality of all variables were assessed by using skewness and kurtosis values. Generally, skewness and kurtosis values can be considered as acceptable between -2 and +2 range (George & Mallery, 2003). In this study, as given in Table 4.1, skewness and kurtosis values for all variables were found to be between -1 and +1 range, and therefore all variables fulfilled the normality assumption.

Table 4.1 Univariate normality statistics of the variables

	Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Std. Error
SON	-.700	.047	.234	.094
IC	-.748	.047	-.750	.094
CT	.023	.047	-.045	.094
CLES	-.540	.047	-.388	.094
ML	-.614	.047	.234	.094
RL	-.012	.047	.422	.094
SCIACH	-.478	.047	-.629	.094

4.1.4 Multicollinearity

When the intercorrelations between some of the variables are high, a problem occurs. Multicollinearity makes certain mathematical operations either impossible or unstable. The problem sometimes occurs because some separate variables actually measure the same thing. It's suggested that when the correlation between two variables exceed .85, one has to deal with the multicollinearity problem (Kline, 1998).

In order to solve the multicollinearity problem, Kline (1998) suggested either eliminating one of the highly correlating variables or combining the highly correlating variables as a composite variable. It was added that the latter strategy has the advantage of preserving more information by keeping more variables (Kline, 1998).

In this study, the correlations among latent variables which are sub-dimensions of variables and constituting a variable together (e.g SON, IC, TL, CT, CU as sub dimensions of SEV) were examined for multicollinearity problem. Sub-dimensions of CLES variable namely the latent variables PR, SC, SN, CV, UN were found to be highly correlated. In both groups of latent variables, the correlation was generally around .60. In order to prevent any potential problem of multicollinearity PR, SC, SN, CV and UN were combined as a composite variable called CLES. In the rest of the analysis, CLES latent variable were used instead of previously defined sub-dimensions.

4.2 Descriptive Statistics

In descriptive statistics part confirmatory factor analysis were conducted to identify the factor structure of the epistemological beliefs, learning approaches and views about classroom environment. Also, descriptive statistics such as mean, mode and range were obtained in order to summarize the profile of the sample in terms of students' epistemological beliefs, learning approaches, views about classroom environment and science achievement.

4.2.1 Factor Structure of SEV

Research Question 1: What are the nature and the number of factors that comprise the scientific epistemological views of Turkish elementary school students?

As discussed in Chapter 3, different factor structure was obtained with the sample of this study when compared to Tsai and Liu's (2005). Five factor model proposed by Tsai and Liu (2005) was not completely replicated with Turkish sample. Instead, three factor model of the SEV was obtained and used in order to represent students' scientific epistemological views. As a result, it can be concluded that, this study revealed three factor structure constituting the scientific epistemological views of Turkish elementary school students. These factors are the role of social negotiation (SON), the invented and creative nature of science (IC) and the changing and tentative feature of science knowledge (CT).

4.2.2 Descriptive Statistics for Scientific Epistemological Views

Research Question 2: What is the scientific epistemological view profile of Turkish elementary school students?

In order to analyze the scientific epistemological views of the sample, mean scores of the subscales, standard deviations, minimum and maximum values were used.

Descriptive statistics showed that elementary school students generally had scientific epistemological views more near to constructivist view. For the SON dimension minimum score was 6 and maximum score was 30, and the mean for this dimension was found as 21.8 (SD = .4.82). When the scale is thought as a continuum, the mean score of SON is close to the highest end of the scale. In other words, students had a more constructivist view of science in terms of the role of social negotiations among scientists. Therefore, it can be said that students more believe that development of science requires the communications and negotiations of scientists rather than viewing science as a process of individual exploration.

For the IC dimension, the minimum score was 4, the maximum score was 20 and the mean for this dimension was found as 14.5 (SD = 3.75). It can be said that like the SON dimension, in IC dimension, generally students had scientific epistemological views near to constructivist view. Students believe the importance of imagination and creativity in growth of scientific knowledge.

The third dimension was the CT. For this dimension, the minimum score was 3 and the maximum score was 15. The mean of the CT sub-dimension was to be 10.2 (SD = 2.46). Since the higher scores indicate belief in the tentative feature of science, the results showed that students were more likely to view scientific knowledge as a tentative and changing entity. As opposed to the empiricist view, the mean score indicated that students had a more constructivist view.

The descriptive statistics results with respect to gender and grade level were presented in Table 4.2 and 4.3 respectively. According to Table 4.2, girls' mean score for all of the scientific epistemological view sub-dimensions' were slightly higher than that of boys.

Table 4.2 Descriptive statistics for the scientific epistemological view dimensions across gender

	Dimension	N	*M*	*SD*	Min.	Max.
Girls	SON	1437	22.18	4.78	6.00	30.00
	IC	1437	14.88	3.68	4.00	20.00
	CT	1437	10.22	2.46	3.00	15.00
Boys	SON	1265	21.30	4.82	6.00	30.00
	IC	1265	14.15	3.79	4.00	20.00
	CT	1265	10.09	2.46	3.00	15.00
Total	SON	2702	21.77	4.82	6.00	30.00
	IC	2702	14.54	3.75	4.00	20.00
	CT	2702	10.16	2.46	3.00	15.00

The results of the descriptive statistics as shown in Table 4.3 indicated that as the grade level increases, the mean scores of students for the SON and CT sub-dimensions slightly increases. In IC sub-dimension, 7th grade students' means was higher than 6th graders, but 8th grade students' mean was lower than both 6th and 7th grade students' mean. However, the differences between scores were very low. When the minimum and maximum scores are taken into account, it can be said that 6th, 7th, and 8th grade students' views for the SON, IC and CT dimensions were near to constructivist view.

Table 4.3 Descriptive statistics for the scientific epistemological view dimensions across grade level

	Dimension	N	*M*	*SD*	Min.	Max.
6th grade	SON	931	21.43	4.95	6	30
	IC	931	14.58	3.78	4	20
	CT	931	10.14	2.59	3	15
7th grade	SON	925	21.79	4.85	6	30
	IC	925	14.63	3.69	4	20
	CT	925	10.08	2.52	3	15
8th grade	SON	846	22.11	4.60	6	30
	IC	846	14.39	3.78	4	20
	CT	846	10.27	2.24	3	15

Descriptive statistics namely mean and standard deviations were also computed at the item level. The means and standard deviations for the items in SON, IC and CT sub-dimensions were given in Table 4.4. The items with the highest mean scores were the items with numbers 17 (Creativity is important for the growth of scientific knowledge) and 5 (The development of scientific theories requires scientists' imagination and creativity). Both of the items were in the IC sub-dimension. The items with the lowest mean scores were the items with the numbers 18 (Currently accepted science knowledge may be changed or totally discarded in the future) and 14 (Contemporary scientific knowledge provides tentative explanations for natural phenomena). These two items were in the CT sub-dimension.

Table 4.4 Item descriptive summary for the SON, IC and CT sub-dimensions of SEV

	Dimension	M	*SD*
SON	1	3.58	1.19
	6	3.75	1.16
	9	3.68	1.21
	10	3.48	1.20
	13	3.58	1.12
	16	3.69	1.17
IC	2	3.41	1.18
	5	3.78	1.29
	11	3.56	1.20
	17	3.79	1.28
CT	3	3.49	1.10
	14	3.36	1.16
	18	3.31	1.27

In Table 4.5 percentages of the responses to the each category of the scale were given. In general, about 60% of the students tended to agree with the statements given in the three sub-dimensions of the SEV. Above 65% of the students either agree or strongly agree with the statements given Items 6 (Scientists share some agreed perspectives and ways of conducting research), 5 (The development of scientific theories requires scientists' imagination and creativity) and 17 (Creativity is important for the growth of scientific knowledge). From these items, Item 6 was from the SON sub-dimension, and Items 5 and 17 were from IC sub-dimension. Generally, percentages of agreements for the statements from SON and IC dimensions were higher than that of CT sub-dimension. Nearly half of the students did not think that culture has an influence on the development of scientific knowledge. For some of the items above 20% students remained undecided about the given statement. Specifically, percentages of undecided students were higher for the items in the CT dimension. It may indicate that students' had no idea about the given statement or the implied meaning of the statement may be complicated for the selected sample of students.

Table 4.5 Percentages of responses to the items in the SON, IC and CT sub-dimensions of SEV

Dimensions	Item number	SD (%)	D (%)	U (%)	A (%)	SA (%)
SON	1	8.1	8.5	26.3	31.8	25.3
	6	7.0	7.5	17.9	38.0	29.5
	9	8.0	8.2	20.8	33.3	29.7
	10	8.4	11.7	26.3	30.9	22.8
	13	6.6	8.7	27.0	35.4	22.3
	16	6.6	8.7	23.2	31.9	29.5
IC	2	7.6	15.1	25.7	32.0	19.6
	5	8.5	10.3	15.3	26.7	39.2
	11	7.5	12.4	21.9	32.8	25.4
	17	8.3	9.8	16.5	26.0	39.5
CT	3	6.6	9.2	31.7	33.4	19.1
	14	8.7	12.7	30.1	31.0	17.5
	18	11.6	13.8	27.5	26.2	20.9

Note. SD = strongly disagree, D = disagree, U = undecided, A = agree, SA = strongly agree

4.2.3 Descriptive Statistics for Learning Approaches

Research question 3: What is the learning approach profile of Turkish elementary school students?

The mean sub-dimension scores, standard deviations, minimum and maximum scores were used to describe the learning approach profile of the sample of the study. Descriptive statistics showed that the meaningful learning (ML) approach mean scores of the participants were higher than their rote learning (RL) approach mean score. According to the results, it can be said that students tended to utilize meaningful learning approach more than rote learning approach. In other words, students more prefer to understand a learning material by constructing its meaning, rather than just memorizing it. In Table 4.6, descriptive statistics results for the learning approaches according to gender were given. As seen from the table, meaningful learning mean scores of the girls (*M* = 22.49, SD = 4.94) was slightly higher than that of boys (*M* = 21.60, SD = 5.17), and also when the minimum and maximum scores were taken into account it was apparent that meaning girls were more likely to learn by constructing the meaning of the content. The difference between rote learning mean scores of girls (*M* = 18.73, SD = 3.89) and boys (*M* = 18.04= 4.05) were not much, but girls seemed to be likely to use memorization for learning than boys.

Table 4.6 Descriptive statistics for the learning approach dimensions across gender

	Dimension	N	*M*	*SD*	Min.	Max.
Girls	ML	1437	22.49	4.94	6	30
	RL	1437	18.73	3.89	5	25
Boys	ML	1265	21.60	5.17	6	30
	RL	1265	18.04	4.05	5	25
Total	ML	2702	22.07	5.06	6	30
	RL	2702	18.41	3.98	5	25

As seen in Table 4.7, a slight decrease was observed both on students' ML and their RL mean scores as they grow older. However, the differences between scores are small, especially the difference between ML scores of 6th and 7th graders. It is interesting to note that the although little changes observed in the mean scores of students in different grade levels, the difference between ML and RL mean scores nearly stated constant; at each of the grade level, students preferred to utilize ML a little more than RL in their learning.

Table 4.7 Descriptive statistics for the learning approach dimensions across grade level

	Dimension	N	*M*	*SD*	Min.	Max.
6th grade	ML	931	22.34	5.44	6	30
	RL	931	18.82	4.13	5	25
7th grade	ML	925	22.22	5.04	6	30
	RL	925	18.47	4.05	5	25
8th grade	ML	846	21.61	4.62	6	30
	RL	846	17.90	3.66	5	25

Descriptive statistics for learning approach scores of students were also computed at the item level. The means and standard deviations for the items in ML and RL were given in Table 4.8. Generally the mean scores of the all items were near to each other, they ranged from 3.55 to 3.78. The items with the highest mean scores were Items 1 (*M* = 3.76, SD = 1.25), 4 (*M* = 3.76, SD = 1.11), and 6 (*M* = 3.78, SD = 1.13). Items 1 (I generally put a lot of effort into trying to understand things that initially seem difficult) and 6 (I go over important topics until I understand them completely) were from the ML dimension and Item 4 (I tend to remember things best if I concentrate on the order in which they were presented by the instructor) was from the RL dimension. The item with the lowest mean score was Item 9 (*M* = 3.55, SD = 1.14). Item 9 (I often find myself questioning things that I hear in lectures or read in books) was from the ML dimension.

Table 4.8 Item descriptive summary for the ML and RL sub-dimensions of LAQ

Dimension	Item number	M	*SD*
ML	1	3.76	1.25
	2	3.69	1.06
	3	3.69	1.11
	6	3.78	1.13
	9	3.55	1.14
	11	3.60	1.16
RL	4	3.76	1.11
	12	3.59	1.15
	14	3.69	1.13
	16	3.65	1.16
	19	3.73	1.16

Percentages of the responses to the each category of the ML and RL sub-dimensions of LAQ scale were given in Table 4.9.

In general, about 60% or above of the students tended to agree with the statements given in the both ML and RL sub-dimensions 67.6% and 65.3% of the students either agree or strongly agree with the statement given Item 1 (I generally put a lot of effort into trying to understand things that initially seem difficult) and Item 6 (I go over important topics until I understand them completely), respectively. Both of the items were from the ML dimension. Generally, percentages of agreements for the statements from ML dimension were higher than that of RL dimension. And on average more than 20% of the students were undecided with all of the selected items both from ML and RL dimensions. The reason for high undecided percentages may be the implied meaning of the items; some of the statements might not be perceived as an indicator of rote or meaningful learning. Students might not understand some of the items or their daily life practices did not match with some of the items, and therefore they preferred to be remained undecided.

Table 4.9 Percentages of responses to the items in the ML and RL sub-dimensions of LAQ

Dimensions	Item number	SD (%)	D (%)	U (%)	A (%)	SA (%)
ML	1	8.7	8.2	15.5	33.4	34.2
	2	4.6	8.6	23.2	40.3	23.4
	3	5.7	7.6	24.4	36.6	25.8
	6	5.1	8.5	21.2	34.2	31.1
	9	6.3	11.3	26.0	34.3	22.1
	11	6.7	10.2	24.8	32.8	25.5
IC	4	4.7	8.1	23.4	33.8	30.0
	12	6.2	10.5	25.8	33.0	24.5
	14	5.2	8.6	27.4	30.1	28.8
	16	6.1	10.4	22.9	33.8	26.8
	19	6.1	8.5	22.3	32.8	30.3

Note. SD = strongly disagree, D = disagree, U = undecided, A = agree, SA = strongly agree

4.2.4 Descriptive Statistics for Students' Perceptions of Constructivist Classroom Environment

Research question 4: What is the view of Turkish elementary school students about their classroom environment?

Descriptive statistics indicated that mean score of the CLES was above the half point and close to the highest end of the continuum. For Constructivist Classroom Environment Survey (CLES) scale with the exclusion of the one item, the minimum score was 19 and the maximum score was 95, and the mean for the scale was found as 65.52 (SD = 13.83). Therefore, it can be said that students viewed their classroom environment somewhat constructivist.

The descriptive statistics results with respect to gender were presented in Table 4.10. According to Table 4.10, girls' and boys' mean scores were nearly the same. Therefore, it can be concluded that girls and boys had similar views about their classroom environment.

Table 4.10 Descriptive statistics for the CLES across gender

Gender	N	*M*	*SD*	Min.	Max.
Girls	1437	65.47	13.92	19	95
Boys	1265	65.57	13.73	19	95
Total	2702	65.52	13.83	19	95

The descriptive statistics results with respect to grade level were presented in Table 4.11. According to Table 4.11, a decrease was observed going from 6th grade to 8th grade on mean CLES scores. It can be concluded that as they grow older, students think that their classroom environment became less constructivist. According to the minimum and maximum scores for the scales, students' views were more like to constructivist classroom environment.

Table 4.11 Descriptive statistics for the CLES across grade level

Grade Level	N	*M*	*SD*	Min.	Max.
6th Grade	931	68.21	13.57	19	95
7th grade	925	66.47	13.96	19	95
8th grade	846	61.49	13.04	19	95

Descriptive statistics namely mean and standard deviations were also computed for CLES at the item level. The means and standard deviations for the items were given in Table 4.12. The items with the highest mean scores were the items with numbers 11 (In science and technology course, I learn that science is a part of the life inside and outside school), 8 (In science and technology course, I learn better when I am allowed to question what is taught and how is taught) and 16 (In science and technology course, I learn interesting things about world inside and outside school). The items with the lowest mean scores were the items with the numbers 4 (In science and technology course, I help teacher about planning what I'm going to learn) and 6 (In science and technology course, I help teacher about measurement and evaluation of what and how much I've learned).

Table 4.12 Item descriptive summary for CLES

CLES	Item number	M	*SD*
	1	3.44	1.20
	3	3.55	1.19
	4	3.02	1.27
	5	3.50	1.20
	6	3.08	1.24
	7	3.62	1.19
	8	3.70	1.17
	9	3.53	1.15
	10	3.12	1.26
	11	3.78	1.17
	12	3.19	1.25
	13	3.48	1.16
	14	3.45	1.20
	15	3.44	1.21
	16	3.69	1.18
	17	3.62	1.19
	18	3.41	1.23
	19	3.59	1.15
	20	3.31	1.30

In Table 4.13 percentages of the responses to the each category of the CLES scale were given. In general, more than 75% of the students reported that they viewed the given situation in their classrooms at least sometimes. 63% of the students responded Item 11 (In science and technology course, I learn that science is a part of the life inside and outside school) either “frequently” or “mostly, and 59% of the students responded Item 16 (In science and technology course, I learn interesting things about world inside and outside school) in a similar way. On the other hand, 33% of the students responded Item 4 (In science and technology course, I help teacher about planning what I'm going to learn) as either “never” or “seldom”.

Table 4.13 Percentages of responses to the items in the CLES

Item number	N (%)	SL (%)	SM (%)	F (%)	M (%)
1	7.7	11.1	35.6	20.1	25.5
3	6.6	11.3	29.9	25.1	27.1
4	15.0	18.9	31.4	18.9	15.8
5	7.5	12.3	27.3	28.5	24.4
6	12.8	18.6	32.8	19.4	16.4
7	5.7	12.5	25.8	26.4	29.8
8	5.3	10.4	25.3	26.7	32.3
9	6.0	11.3	30.5	28.1	24.1
10	14.0	14.9	32.7	21.9	16.5
11	4.7	10.4	21.8	28.0	35.0
12	11.6	17.3	30.2	22.5	18.4
13	5.8	14.0	30.1	26.4	23.7
14	7.3	14.2	28.3	26.9	23.4
15	7.0	15.4	29.3	23.3	25.0
16	5.1	11.8	24.2	26.9	32.1
17	6.2	11.4	25.6	28.1	28.7
18	9.0	13.9	28.2	25.6	23.4
19	5.4	10.9	29.5	27.6	26.5
20	11.3	16.1	26.4	22.7	23.6

Note. N: Never (1), SL: Seldom (2), SM: Sometimes (3), F: Frequently (4), M: Mostly (5)

4.2.5 Descriptive Statistics for Science Achievement

In order to measure students' science achievement, their self-report of previous semester grades over 5 for science and technology course were used. The frequency analyses showed that students enrolled in this study had generally medium and high achievers. Among the students 81.1% had previous science and technology course grade of 3 or above. Only 6.4% of the students had course grade of 1 in previous year's science and technology course (see Table 4.14).

Table 4.14 Distribution of science and technology course grades

Grade	(%)
1	6.4
2	12.5
3	25.9
4	29.3
5	25.9

The mean science and technology course grades of students *M* = 3.56 (SD = 1.18). The mean scores of girls (*M* = 3.66, *SD* = 1.14) were higher than that of boys (*M* = 3.44, *SD* = 1.22.) as given in Table 4.15. When the minimum and maximum scores were thought for the course grades, students' enrolled in the study were generally above average achievers.

Table 4.15 Descriptive statistics for the science achievement scores across gender

Gender	N	Min.	Max.	*M*	*SD*
Girls	1437	1	5	3.66	1.14
Boys	1265	1	5	3.44	1.22
Total	2702	1	5	3.56	1.18

There were slight differences in mean science and technology course grades of students from different grade levels. Sixth graders had the highest mean grades (*M= 3.84* , *SD* = 1.17) among the all students. Following the 6th graders, 8th graders had the second highest mean grade (*M= 3.46*, *SD* = 1.15) and the 7th grade students had the lowest mean grade (*M= 3.37*, *SD* = 1.17), but all groups of students had scores above average achievers according to minimum and maximum values for the science and technology course grade as given in Table 4.16.

Table 4.16 Descriptive statistics for the science achievement scores across grade level

Grade level	N	Min.	Max.	*M*	*SD*
6th grade	931	1	5	3.84	1.17
7th grade	925	1	5	3.37	1.17
8th grade	846	1	5	3.46	1.15

4.3 Inferential Statistics

In the inferential statistics part, first the final science achievement model for the total sample was introduced. Then, the science achievement model for boys and girls were presented separately for cross validation as suggested by Özkan (2008). Schumacker and Lomax (2004) suggested splitting the original sample and running SEM analysis for each sample for cross validation, when the replication of the study with a second set of data is not available.

4.3.1 The Final Science Achievement Model for the Whole Sample

First the latent variables were determined through confirmatory factor analysis and then their indicators were selected according to their R^2 values. The actual model given in Chapter 1 was tested with the data of the study. Some of the paths given in the initial model; namely the paths between IC and SCIACH, CT and SCIACH, SON and ML, IC and ML, IC and RL, and CT and RL were found to have non significant t values and in the following analysis, those paths were removed from the model. The final SIMPLIS syntax used in the analysis was presented in APPENDIX D. The final structural model with estimates was given in Figure 4.1 and model with significant t values was presented in Figure 4.2.

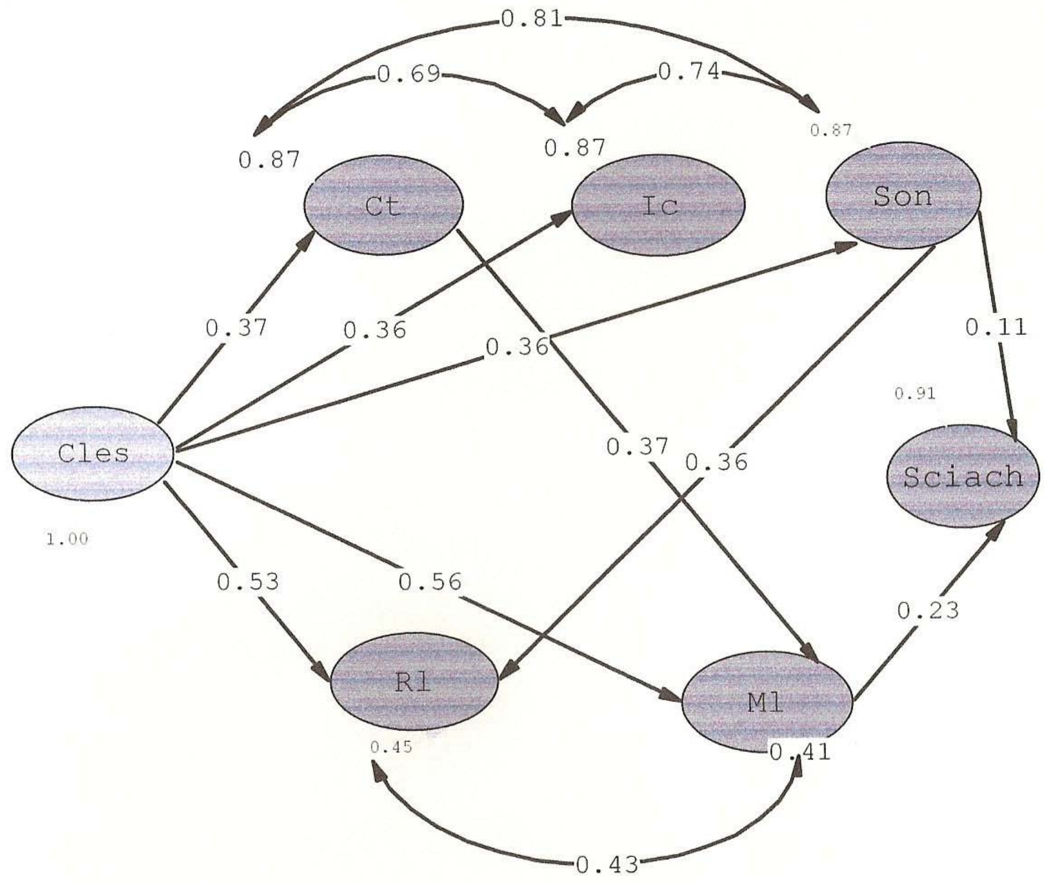

Figure 4.1 Science achievement model with standardized estimates (Whole sample)

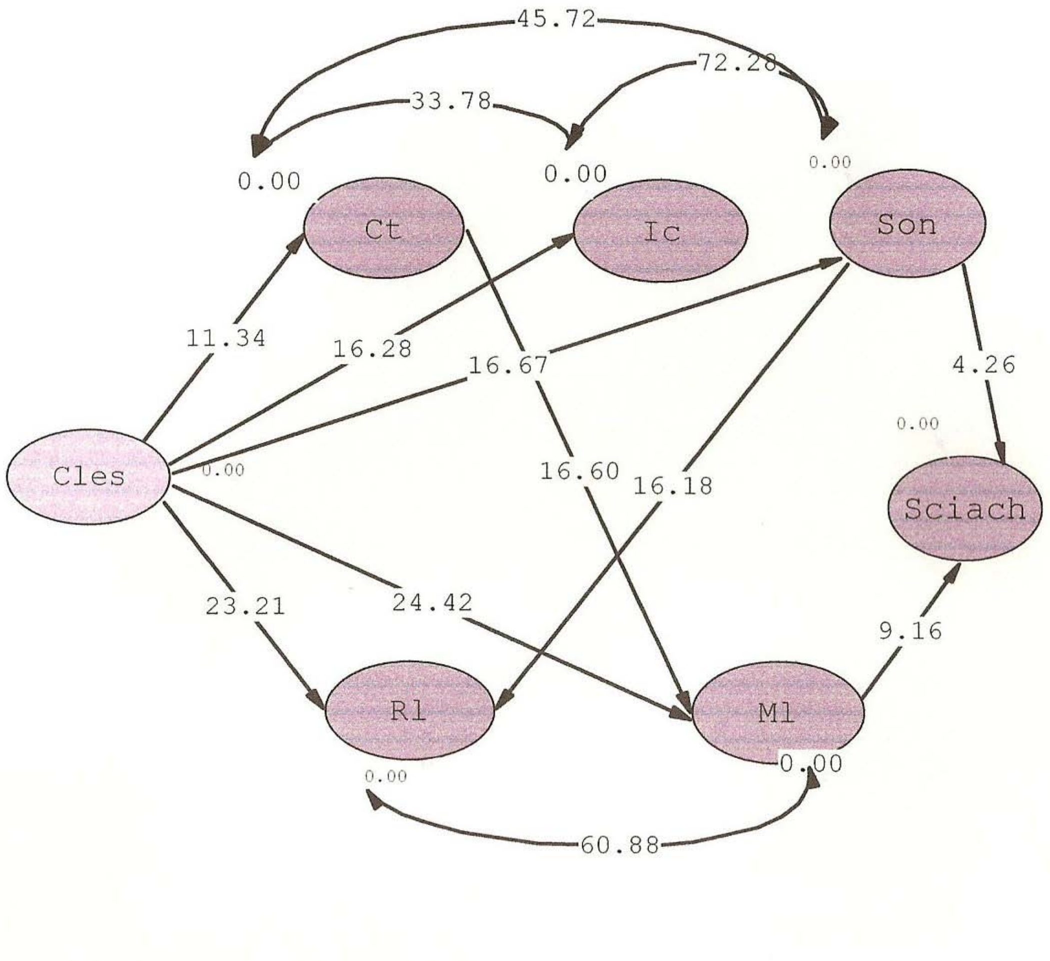

Figure 4.2 Science achievement model with t- values (Whole sample)

The measurement coefficients (λ) and measurement errors of the final model were listed in Table 4.17. Measurement coefficients (λ) points out the relationships between latent variables and observed variables. The relationships between the exogenous variable (CLES) and observed variables (X-variables) were shown by λ_x (lowercase lambda sub x). The relationships between endogenous variables (SON, CT, IC, ML, RL and SCIACH) and the observed variables (Y-variables) were presented by λ_y (lowercase lambda sub y) in Table 4.17. The measurement errors were also listed for X-variables and Y-variables in Table 4.17. The δ (lowercase delta) and ε (lowercase epsilon) were the measurement errors for X and Y variables, respectively.

Table 4.17 Measurement coefficients (λ) and measurement errors of the science achievement model

Latent Variables	λ	Observed Variables	Measurement Errors
CLES	13.83(λ_x)	Clestot*	.00(δ)
SON	.66(λ_y)	Sev1	.56(ε)
	.70(λ_y)	Sev6	.51(ε)
	.67(λ_y)	Sev9	.55(ε)
	.50(λ_y)	Sev10	.75(ε)
	.59(λ_y)	Sev13	.66(ε)
	.67(λ_y)	Sev16	.55(ε)
IC	.57(λ_y)	Sev2	.68(ε)
	.75(λ_y)	Sev5	.44(ε)
	.65(λ_y)	Sev11	.58(ε)
	.77(λ_y)	Sev17	.40(ε)
CT	.53(λ_y)	Sev3	.72(ε)
	.42(λ_y)	Sev14	.82(ε)
	.36(λ_y)	Sev18	.87(ε)
ML	.73(λ_y)	Laq1	.47(ε)
	.75(λ_y)	Laq2	.44(ε)
	.73(λ_y)	Laq3	.47(ε)
	.73(λ_y)	Laq6	.46(ε)
	.63(λ_y)	Laq9	.60(ε)
	.68(λ_y)	Laq11	.53(ε)
RL	.71(λ_y)	Laq4	.49(ε)
	.59(λ_y)	Laq12	.65(ε)
	.60(λ_y)	Laq14	.64(ε)
	.61(λ_y)	Laq16	.63(ε)
	.66(λ_y)	Laq19	.57(ε)
SCIACH	1.18(λ_y)	Scitot**	.00(ε)

*Clestot is the total score obtained from CLES.
**Scitot is the students' grade point average for science and technology course.

The strength and direction of the relationships among exogenous and endogenous variables are indicated by the structure coefficients (β and γ). The strength and direction of the relationships among endogenous variables were identified by β (lowercase beta) and the strength and direction of the relationships among exogenous and endogenous variables were identified by γ (lowercase gamma) values. The β and γ value in the model were given in Table 4.18 and Table 4.19 respectively.

Table 4.18 β (lowercase beta) values of the science achievement model

Endogenous Variables	β	Endogenous Variables
ML	.37	CT
RL	.36	SON
SCIACH	.11	SON
SCIACH	.23	ML

Table 4.19 γ (lowercase gamma) values of the science achievement model

Exogenous Variables	γ	Endogenous Variables
CLES	.36	SON
CLES	.37	CT
CLES	.37	IC
CLES	.56	ML
CLES	.53	RL

The significant paths in the final model with their structure coefficients and t-values were presented in Table 4.24. Some of the paths given in the initial model; namely the paths between IC and SCIACH, CT and SCIACH, SON and ML, IC and ML, IC and RL, and CT and RL were found to have non significant t-values, therefore they were all excluded from the model as indicated before. The all paths given in Table 20 had significant t-values.

Table 4.20 Structure coefficients and t-values of the paths in the science achievement model

Paths			
From	To	Structure coefficients	t-values
CLES	SON	.36	16.67
	IC	.37	16.28
	CT	.37	11.34
	ML	.56	24.42
	RL	.53	23.21
SON	RL	.36	16.18
	SCIACH	.11	4.26
CT	ML	.37	16.60
ML	SCIACH	.23	9.16

All the fit indices, namely; Goodness of fit index (GFI), adjusted GFI (AGFI), standardized RMR (SRMR), and root mean square error of approximation (RMSEA) indicated a good model fit. The goodness-of-fit indices used to evaluate the model were given in Table 4.21. The Chi-Square, χ^2 = 1034.33 was significant with degrees of freedom of, df = 285, and the significance level, p = .00. χ^2 criterion tends to result with a significant probability level with large sample sizes, generally with sample size above 200 (Schumacker & Lomax, 2004). The model in the current study was tested with N= 2702 students; therefore, as expected significant χ^2 was obtained. When χ^2 is divided by df, the Normed Chi-Square (NC) is obtained. A NC value less than five can be accepted as an additional evidence for the good model fit (Schumacker & Lomax, 2004). For this model the NC was found as 3.63 indicating a good fit to the data. The values for the whole goodness-of-fit statistics were provided in Appendix F.

Table 4.21 Goodness-of-fit indices of the science achievement model

Index	Value	Criterion
GFI	.970	≥.95
AGFI	.964	≥.95
SRMR	.0228	<.05
RMSEA	.0319	<.05

As an additional fit statistics, R^2 values (squared multiple correlations) for each observed variable were presented in Table 4.22. R^2 values give the indicator's explained variance. Therefore, R^2 value less than .50 mean that more than half of an indicator's variance is unexplained by the factors it is specified to measure (Kline, 1998).

Table 4.22 Squared multiple correlations (R^2) for the science achievement model

Variable	R^2	Variable	R^2
Sev1	.44	Laq1	.53
Sev6	.49	Laq2	.56
Sev9	.45	Laq3	.53
Sev10	.25	Laq6	.54
Sev13	.34	Laq9	.40
Sev16	.45	Laq11	.47
Sev2	.32	Laq4	.51
Sev5	.56	Laq12	.35
Sev11	.42	Laq14	.36
Sev17	.60	Laq16	.37
Sev3	.28	Laq19	.43
Sev14	.18	Clestot	1.00
Sev18	.13	Scientot	1.00

The null hypothesis introduced in Chapter 1 was evaluated according to the final model obtained. As explained before, in order to prevent any potential problem of multicollinearity, sub-dimensions of CLES were combined to form a composite variable called CLES. A significant model between CLES, SON, IC, CT, ML, RL and SCIACH was obtained. According to the model:

1. As expected, constructivist classroom environment is significantly and positively related to the role of social negotiation ($\gamma = .36$, $t = 16.67$, $p < .05$).

2. As expected, constructivist classroom environment is significantly and positively related to the invented and creative nature of science ($\gamma = .37$, $t = 16.28$, $p < .05$).

3. As expected, constructivist classroom environment is significantly and positively related to the changing and tentative feature of science knowledge ($\gamma = .37$, $t = 11.34$, $p < .05$).

4. As expected, constructivist classroom environment is significantly and positively related to the meaningful learning ($\gamma = .56$, $t = 24.42$, $p < .05$).

5. Surprisingly, constructivist classroom environment is significantly and positively related to the rote learning ($\gamma = .53$, $t = 23.21$, $p < .05$).

6. Surprisingly, the role of social negotiation is not significantly related to the meaningful learning.

7. Surprisingly, the invented and creative nature of science is not significantly related to the meaningful learning.

8. As expected, the changing and tentative feature of science knowledge is significantly and positively related to the meaningful learning ($\beta = .37$, $t = 16.60$, $p < .05$).

9. Surprisingly, the role of social negotiation is significantly and positively related to the rote learning ($\beta = .36$, $t = 16.18$, $p < .05$).

10. Surprisingly, the invented and creative nature of science is not significantly related to the rote learning.

11. Surprisingly, the changing and tentative feature of science knowledge is not significantly related to the rote learning.

12. As expected, the meaningful learning is significantly and positively related to the science achievement (β = .23, t = 9.16, $p < .05$).

13. Surprisingly, the rote learning is not significantly related to the science achievement.

14. As expected, the role of social negotiation is significantly and positively related to the science achievement (β = .11, t = 4.26, $p < .05$).

15. Surprisingly, the invented and creative nature of science is not significantly related to the science achievement.

16. Surprisingly, the changing and tentative feature of science knowledge is not significantly related to the science achievement.

4.3.2 The Final Science Achievement Model for Girls

The final science achievement models with estimates and t-values for girls are presented in Figure 4.3 and Figure 4.4, respectively.

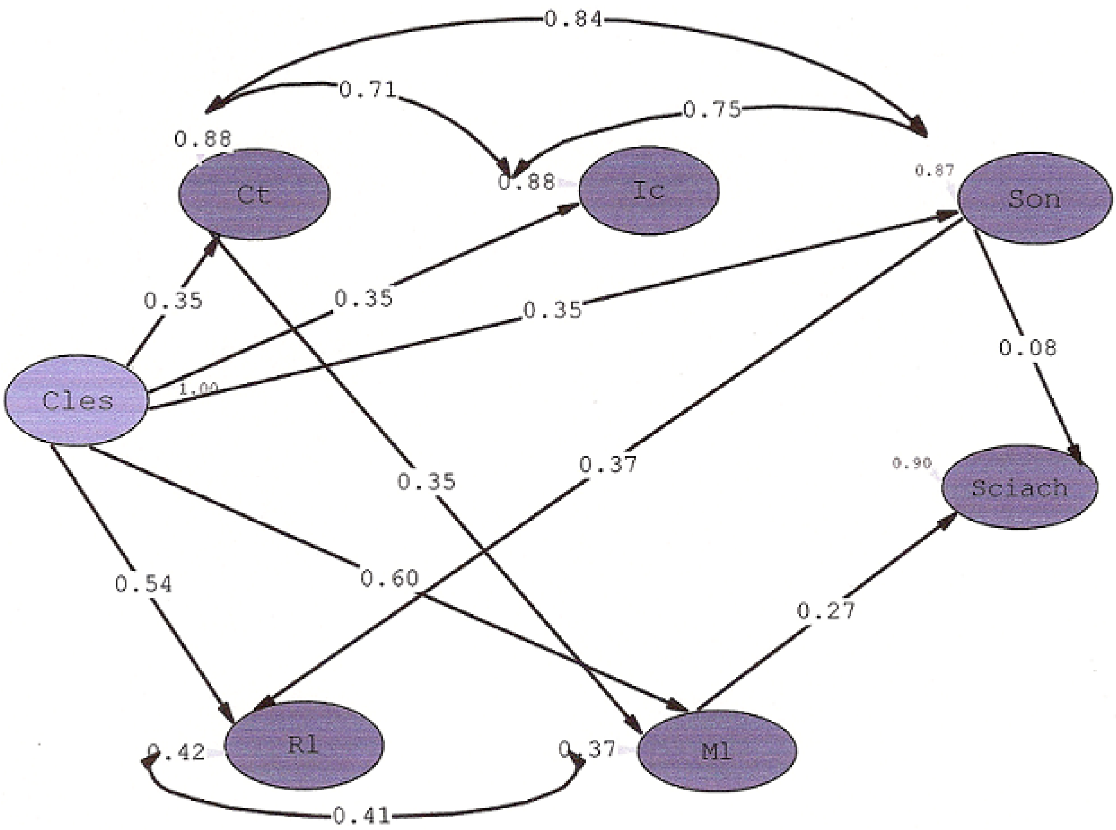

Figure 4.3 Science achievement model with standardized estimates (Girls)

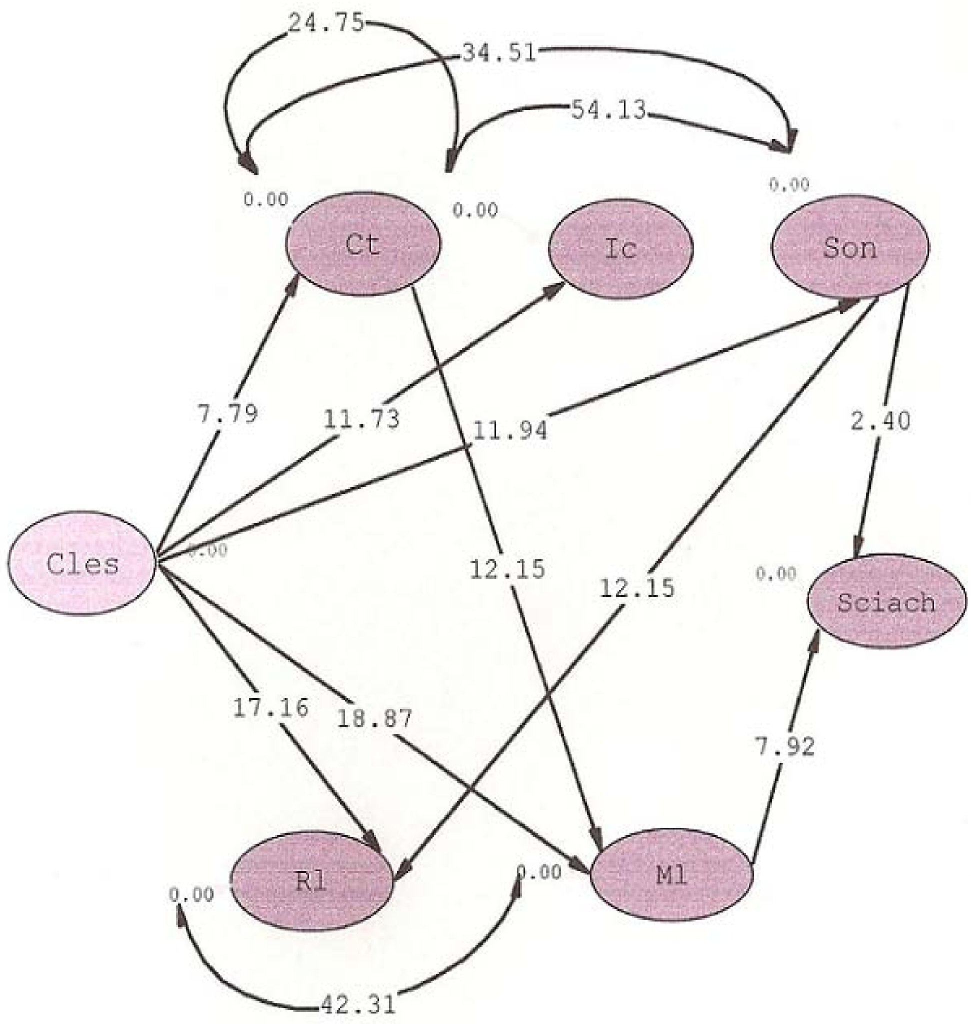

Figure 4.4 Science achievement model with t-values (Girls)

The measurement coefficients (λ) and measurement errors of the science achievement model for girls were listed in Table 4.23.

Table 4.23 Measurement coefficients (λ) and measurement errors of the science achievement model (Girls)

Latent Variables	λ	Observed Variables	Measurement Errors
CLES	13.92(λ_x)	Clestot	.00(δ)
SON	.65(λ_y)	Sev1	.57(ε)
	.70(λ_y)	Sev6	.49(ε)
	.70(λ_y)	Sev9	.51(ε)
	.51(λ_y)	Sev10	.73(ε)
	.59(λ_y)	Sev13	.64(ε)
	.77(λ_y)	Sev16	.39(ε)
IC	.57(λ_y)	Sev2	.66(ε)
	.75(λ_y)	Sev5	.43(ε)
	.62(λ_y)	Sev11	.60(ε)
	.77(λ_y)	Sev17	.39(ε)
CT	.51(λ_y)	Sev3	.73(ε)
	.43(λ_y)	Sev14	.81(ε)
	.34(λ_y)	Sev18	.88(ε)
ML	.71(λ_y)	Laq1	.49(ε)
	.77(λ_y)	Laq2	.40(ε)
	.71(λ_y)	Laq3	.49(ε)
	.72(λ_y)	Laq6	.47(ε)
	.62(λ_y)	Laq9	.60(ε)
	.68(λ_y)	Laq11	.53(ε)
RL	.69(λ_y)	Laq4	.51(ε)
	.60(λ_y)	Laq12	.63(ε)
	.59(λ_y)	Laq14	.65(ε)
	.58(λ_y)	Laq16	.66(ε)
	.67(λ_y)	Laq19	.54(ε)
SCIACH	1.00(λ_y)	Scitot	.00(ε)

The strength and direction of the relationships among latent variables in the model indicated by structure coefficients (β and γ) with their associated t-values were presented in Table 4.24. All paths in the model were significant and there was no difference between the model for the whole sample and the model for girls.

Table 4.24 Structure coefficients and t-values of the paths in the science achievement model (Girls)

Paths			
From	To	Structure coefficients	t-values
CLES	SON	.35	11.93
	IC	.35	11.73
	CT	.35	11.34
	ML	.60	18.86
	RL	.54	17.15
SON	RL	.37	12.15
	SCIACH	.08	2.40
CT	ML	.35	12.15
ML	SCIACH	.27	7.91

The goodness-of-fit indices used to evaluate the model for girls were given in Table 4.25. All the fit indices, namely; GFI, AGFI, SRMR, and RMSEA indicated a good model fit.

The Chi-Square, χ^2 = 952.158, was significant with degrees of freedom, df = 258, and p = .00. When χ^2 is divided by df, the Normed Chi-Square (NC) value of 3.34 is obtained. Since, a NC value of less than five is an indicator of a good model fit, the value obtained for girls data can be regarded as an additional evidence of good model fit.

Table 4.25 Goodness-of-fit indices of the science achievement model (Girls)

Index	Value	Criterion
GFI	.951	$\geq$.95
AGFI	.940	$\geq$.95
SRMR	.0292	<.05
RMSEA	.0407	<.05

As an additional fit statistics, R^2 values (squared multiple correlations) for each observed variable were presented Table 4.26.

Table 4.26 Squared multiple correlations for the science achievement model (Girls)

Variable	R^2	Variable	R^2
Sev1	.42	Laq1	.50
Sev6	.50	Laq2	.60
Sev9	.49	Laq3	.51
Sev10	.26	Laq6	.53
Sev13	.36	Laq9	.40
Sev16	.46	Laq11	.47
Sev2	.33	Laq4	.49
Sev5	.56	Laq12	.36
Sev11	.39	Laq14	.35
Sev17	.60	Laq16	.34
Sev3	.27	Laq19	.46
Sev14	.19	Clestot	1.00
Sev18	.12	Scientot	1.00

4.3.3 The Final Science Achievement Model for Boys

The final science achievement models with estimates and t-values for boys were presented in Figure 4.5 and Figure 4.6, respectively.

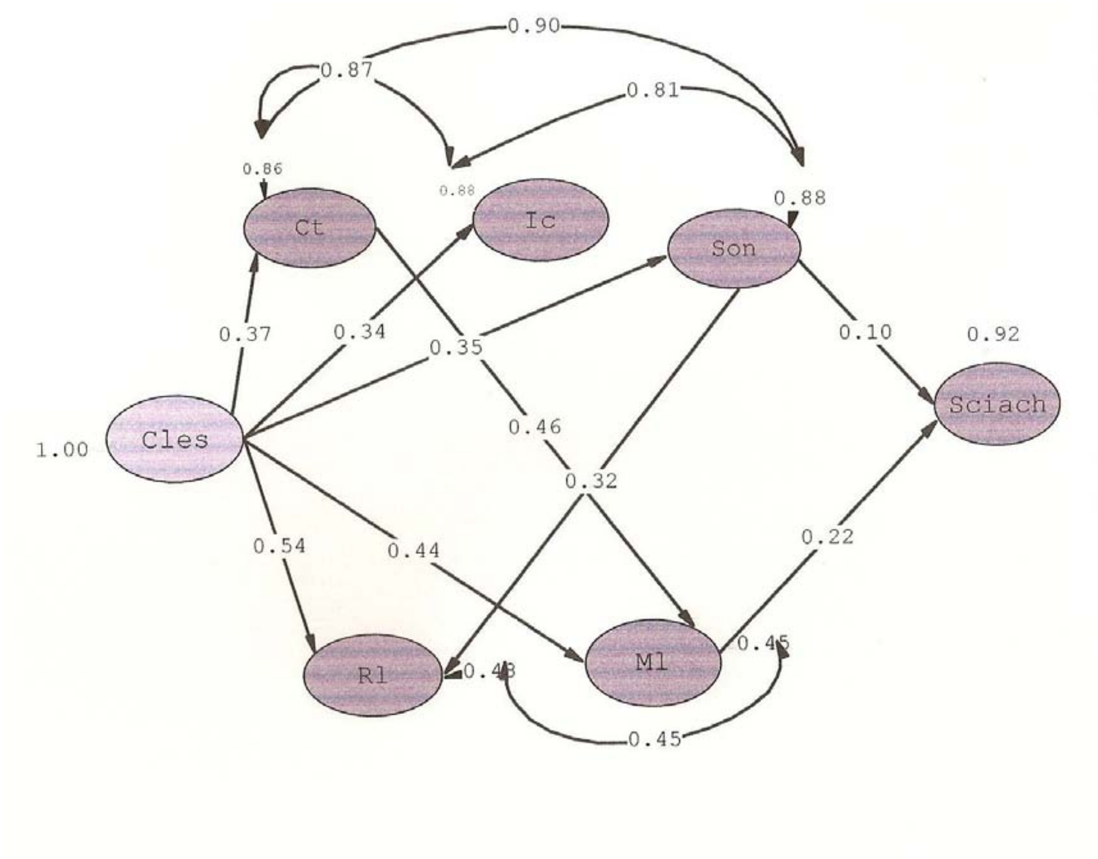

Figure 4.5 Science achievement model with standardized estimates (Boys)

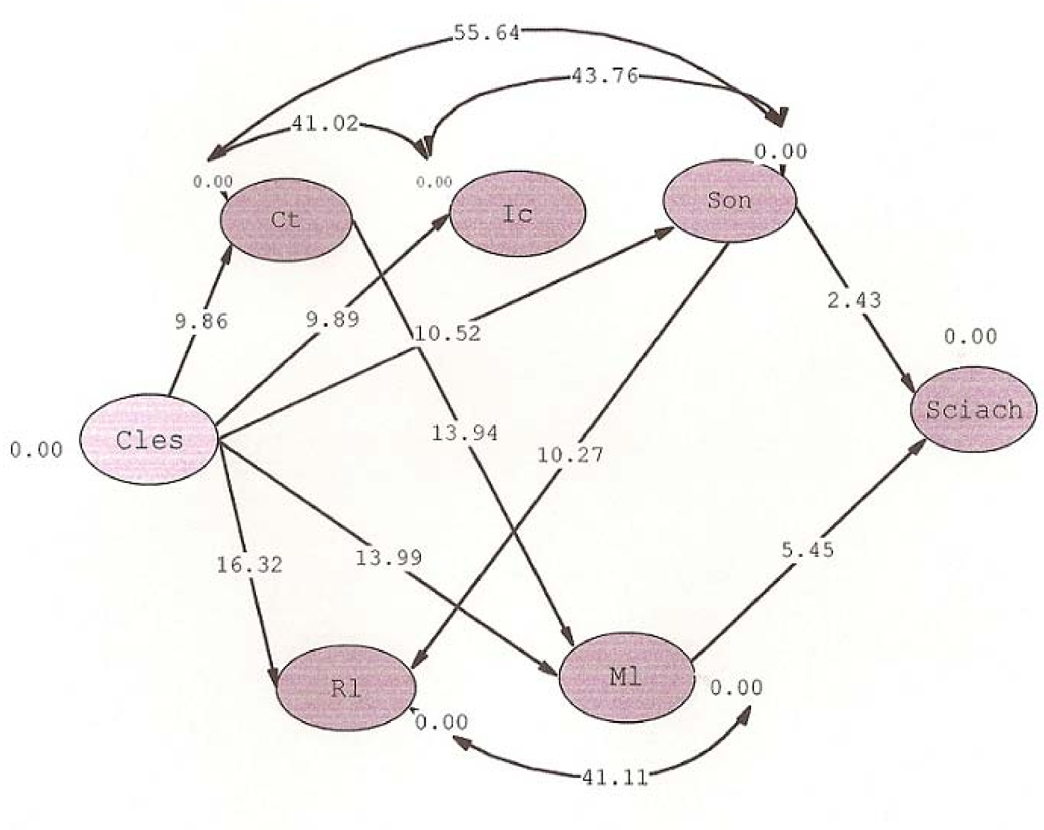

Figure 4.6 Science achievement model with t-values (Boys)

The measurement coefficients (λ) and measurement errors of the science achievement model for boys were listed in Table 4.27.

Table 4.27 Measurement coefficients (λ) and measurement errors of the science achievement model (Boys)

Latent Variables	λ	Observed Variables	Measurement Errors
CLES	1.00(λ_x)	Clestot	.00(δ)
SON	.65(λ_y)	Sev1	.53(ε)
	.68(λ_y)	Sev6	.49(ε)
	.56(λ_y)	Sev9	.68(ε)
	-.21(λ_y)	Sev10	.95(ε)
	.47(λ_y)	Sev13	.77(ε)
	.56(λ_y)	Sev16	.68(ε)
IC	.52(λ_y)	Sev2	.72(ε)
	.70(λ_y)	Sev5	.50(ε)
	.64(λ_y)	Sev11	.59(ε)
	.41(λ_y)	Sev17	.83(ε)
CT	.50(λ_y)	Sev3	.74(ε)
	.62(λ_y)	Sev14	.62(ε)
	.62(λ_y)	Sev18	.62(ε)
ML	.44(λ_y)	Laq1	.81(ε)
	.23(λ_y)	Laq2	.94(ε)
	.76(λ_y)	Laq3	.43(ε)
	.74(λ_y)	Laq6	.45(ε)
	.71(λ_y)	Laq9	.50(ε)
	.71(λ_y)	Laq11	.49(ε)
RL	.74(λ_y)	Laq4	.45(ε)
	.65(λ_y)	Laq12	.57(ε)
	.68(λ_y)	Laq14	.53(ε)
	.57(λ_y)	Laq16	.67(ε)
	.61(λ_y)	Laq19	.63(ε)
SCIACH	1.00(λ_y)	Scitot	.00(ε)

The strength and direction of the relationships among latent variables in the model indicated by structure coefficients (β and γ) with their associated t-values were presented in Table 4.28. All paths in the model were significant and similar to the model for the whole sample.

Table 4.28 Structure coefficients and t-values of the paths in the science achievement model (Boys)

Paths			
From	To	Structure coefficients	t-values
CLES	SON	.35	10.52
	IC	.34	9.89
	CT	.37	9.85
	ML	.44	13.99
	RL	.54	16.32
SON	RL	.32	10.27
	SCIACH	.10	2.43
CT	ML	.46	13.94
ML	SCIACH	.22	5.45

The goodness-of-fit indices used to evaluate the model for boys were given in Table 4.29. All the fit indices, namely; GFI, AGFI, SRMR, and RMSEA indicated nearly a good model fit of the data.

The Chi-Square, χ^2 = 1518.077, was significant with degrees of freedom, df = 258, and the significance level, p = .00. When χ^2 is divided by df, the Normed Chi-Square (NC) value of 5.32 is obtained. Since, it is greater than 5, a NC value of 5.32 indicates a fair model fit to the data.

Table 4.29 Goodness-of-fit indices of the science achievement model (Boys)

Index	Value	Criterion
GFI	.920	≥.95
AGFI	.902	≥.95
SRMR	.066	<.05
RMSEA	.056	<.05

As an additional fit statistics, R^2 values (squared multiple correlations) for each observed variable were presented in Table 4.30.

Table 4.30 Squared multiple correlations for the science achievement model (Boys)

Variable	R^2	Variable	R^2
Sev1	.43	Laq1	.19
Sev6	.47	Laq2	.05
Sev9	.32	Laq3	.57
Sev10	.04	Laq6	.55
Sev13	.22	Laq9	.50
Sev16	.31	Laq11	.51
Sev2	.27	Laq4	.55
Sev5	.50	Laq12	.43
Sev11	.41	Laq14	.46
Sev17	.17	Laq16	.33
Sev3	.26	Laq19	.37
Sev14	.38	Clestot	1.00
Sev18	.38	Scientot	1.00

The relationships among the variables for whole sample (WS), girls (G) and boys (B) were compared in terms of the strength and direction. The structure coefficients and t-values were presented in Table 4.31. All of the paths had significant t-values.

When the structure coefficients of the groups were compared, it was seen that generally all of the coefficients had similar values in three groups, namely in whole sample, girls and boys groups. When girls and boys were compared, girls were found to have greater structure coefficients for four paths, namely the paths from CLES to IC ($\gamma = .35$, $p < .05$), from CLES to ML ($\gamma = .60$, $p < .05$), from SON to RL ($\beta = .37$, $p < .05$) and from ML to SCIACH ($\beta = .27$, $p < .05$). For two of the paths, namely the path from CLES to SON ($\gamma = .35$, $p < .05$), and the path from CLES to RL ($\gamma = .54$, $p < .05$), the structure coefficients had approximately the same value for girls and boys groups. For the remaining three paths in the model, the boys had the greater coefficients than girls; these were the path from CLES to CT ($\gamma = .37$, $p < .05$), the path from SON to SCIACH ($\beta = .10$, $p < .05$), and the path from CT to ML ($\beta = .46$, $p < .05$).

Table 4.31 Structure coefficients and t-values for the three groups (WS, G, B)

Paths							
From	To	Structure coefficients			t-values		
CLES	SON	.36(WS)	.35(G)	.35(B)	16.67(WS)	11.93(G)	10.52(B)
	IC	.37(WS)	.35(G)	.34(B)	16.28(WS)	11.73(G)	9.89(B)
	CT	.37(WS)	.35(G)	.37(B)	11.3(WS)	11.34(WS)	9.85(B)
	ML	.56(WS)	.60(G)	.44(B)	24.42(WS)	18.86(G)	13.99(B)
	RL	.53(WS)	.54(G)	.54(B)	23.21(WS)	17.15(G)	16.32(B)
SON	RL	.36(WS)	.37(G)	.32(B)	16.18(WS)	12.15(G)	10.27(B)
	SCIACH	.11(WS)	.08(G)	.10(B)	4.26(WS)	2.40(G)	2.43(B)
CT	ML	.37(WS)	.35(G)	.46(B)	16.60(WS)	12.15(G)	13.94(B)
ML	SCIACH	.23(WS)	.27(G)	.22(B)	9.16(WS)	7.91(G)	5.45(B)

(WS): Whole sample
(G): Girls
(B): Boys

4.4 Summary of Results

After preliminary data analysis, namely missing data analysis, outlier analysis, normality and multicollinearity checks, descriptive analysis were done. In this study, instead originally proposed five factor structure for SEV (Tsai & Liu, 2005), a three factor structure underlying Turkish elementary schools epistemological views of science was obtained. According to the model obtained in this study, Turkish elementary school students' epistemological views of science composed of their views related to SON, IC and CT dimensions.

According to the descriptive statistics results, elementary school students generally had scientific epistemological views more near to constructivist view. In terms of sub dimensions constituting the students epistemological views of science, it can be said that students more believe that development of science requires the communications and negotiations of scientists rather than viewing science as a process of individual exploration. They believe the importance of imagination and creativity in growth of scientific knowledge, and they were more likely to view scientific knowledge as a tentative and changing entity. Generally, girls' and boys' mean scores for SON, IC and CT dimensions were near to each other. On the other hand, it was seen that as the grade level increases, the mean scores of students for the SON and CT sub-dimensions slightly increases.

The descriptive results for the LAQ showed that According to the results, it can be said that students tended to utilize meaningful learning approach more than rote learning approach. Girls were shown to be more meaningful learners than boys. A slight decrease was observed for the students' ML and RL scores as they grow older.

Descriptive statistics results for CLES indicated that students' perceived their classroom somewhat constructivist, the mean score for CLES was above the half point and more near to maximum score for the survey. Girls' and boys' perceptions related to their classroom environment was nearly the same; their mean score for CLES was found to be close to each other. Whereas, students from different grade levels perceived their classroom different; as the students grow older, they perceived their classroom less constructivist. Students from eight grade had the lowest mean score for CLES.

When the students' RCGs were examined as an indicator of their science achievement, it was seen that students were generally above average achievers; the mean score for all three grade levels were found to be somewhere between 3 and 4.

In the inferential statistics part, when the insignificant paths; namely the paths between IC and SCIACH, CT and SCIACH, SON and ML, IC and ML, IC and RL, and CT and RL were excluded from the model and some of the suggestions given by the LISREL were done, a good data model fit was obtained. According to the model, CLES is significantly and positively related to the students' epistemological views of science namely, SON, IC and CT. CLES is also related with ML significantly and positively and RL significantly and negatively. CT is related with ML, and SON is related with RL significantly and positively. ML and SON are related with SCIACH significantly and positively. The obtained model was also validated by splitting the sample as girls and boys. The results showed that generally all the structure coefficients had similar values in three groups; namely in whole sample, girls and boys groups.

CHAPTER 5

DISCUSSION, CONCLUSIONS AND IMPLICATIONS

This study was designed to test the hypothetical model based on the review of the related literature and proposed in the first chapter. In this chapter, the results obtained through the study are summarized and discussed by comparing and contrasting with the previous studies found in the literature. Then, the conclusions drawn from the study are presented together with the limitations, implications, and recommendations for future studies.

5.1 Discussion of the Results

In this study, the interrelationships among Turkish elementary school students' epistemological views of science, learning approaches, perceptions of science classroom environments, and their science achievement were investigated. The results obtained from the study were discussed below.

5.1.1 Results of the Factor Structure of the Epistemological Views of Science Questionnaire

The instrument used for assessing epistemological views of students revealed a different factor structure in Turkish context compared to the five factor structure proposed by Tsai and Liu (2005) with Taiwanese students. For Turkish elementary school students, the three factor model was obtained instead of five as representing their epistemological views of science. The obtained and validated three factor structure of SEV included SON, IC, and CT dimensions. Because of their low reliabilities of the two dimensions, TL and CU dimensions were totally excluded from the SEV.

Although, the originally proposed factor structure proposed for SEV could not be obtained in this study, the multidimensionality of epistemological beliefs proposed by several researchers (Cano, 2005; Hofer & Pintrich, 1991; Schommer, 1990; Pintrich, 2002; Schraw, Bendixen, & Dunkle, 2002; Tsai; 2002) was replicated for the Turkish students. Therefore, through the findings of this study, it was revealed that Turkish elementary school students' epistemological views of science could be identified with the more or less independent three factor structure.

As Chan and Elliot (2004) indicated there is no universally valid instrument to assess the complicated nature of epistemological beliefs, since those beliefs may be culture dependent. Having low reliabilities regarding the above mentioned two dimensions may be explained as follows: There might be differences in terms of students' perceptions of the items' meanings compared to the scale's original language. The differences might be caused from the translation of items; the Turkish version of the items might not reflect the complete and literal meaning of the original items. Actually, this is a limitation of all translated scales. Supporting this argument, Chan and Elliot (2000) found that socio-cultural factors were important in shaping the epistemological beliefs of individual. The differences obtained between studies conducted with Turkish students and with students from other cultures might be reasoned from the different interpretation of adapted items in the scales used to survey students' views.

Another potential reason for having different factor structure for SEV with the Turkish students is the age, maturation and amount of education issue discussed in the epistemological beliefs literature. Schommer (1990; 1998) suggested that amount of education and age are influential factors in epistemological beliefs structure. Based on these view, it can be said that for the younger students, it could be difficult to understand some of the complicated dimensions of epistemological beliefs, and accordingly as Qian and Alvermann (1995) stated some of the beliefs might be overlapped on each other and arose as combined dimensions.

Supporting this age, maturation, and amount of education argument, Schommer and her colloquies (2000) obtained three factor structure for epistemological beliefs of middle school students, while original factor structure for high school and college students suggested four factor structure for the same instrument. Similarly, Qian and Alvermann (1995) used Schommer's instrument in order to assess secondary school students' epistemological beliefs and ended up with three factor structure instead of originally proposed four factor structure.

Similar to the findings obtained from this study regarding epistemological beliefs structure of Turkish elementary grade students, in a recent study Özkan (2008) found a different factor structure compared to the originally proposed four factor structure for Turkish 7th graders with another instrument developed by Conley et al. (2004). In Özkan's (2008) study, similar to the current study, Turkish elementary grade students' epistemological belief structure was explained in a three factor model, consisting Development, Justification, and Source/Certainty dimensions. The latter was formed as the combination of two originally proposed dimensions called Source of Knowledge and Certainty of Knowledge.

Eley (1999) stated that students' understanding of the purpose of science and the changing nature of science constituted two important and central constructs of their beliefs about the nature of science knowledge. These two dimensions serve as anchor to the complete system of epistemological beliefs and these are fundamental ideas about the nature of scientific knowledge, and they are found to have a priority in developmental perspective. In this regard, the current study partly validated Eley's (1999) argument by the instrument used to assess students' epistemological views of science and revealed that Turkish elementary grade students' epistemological beliefs profile consisting a dimension called the changing and tentative feature of science knowledge. Therefore, in the developmental perspective, it can be said that elementary level students' epistemological belief structure consisting a separate element related to the tentative nature of science.

5.1.2 Results of the Model Testing

First of all, the results of the descriptive analysis showed that students generally had constructivist views related to epistemology of science in terms of their views about the role of social negotiations, the invented and creative nature of science, and the changing and tentative nature of science knowledge. They generally seemed to adopt meaningful learning approach instead of rote learning approach. The students perceived their science classroom environments somewhat constructivist.

When the model tested was compared to the hypothesized model in the beginning of the study, it was seen that some of the hypothesis related to the relationships among the variables included in the study were validated and some of them surprisingly did not. Therefore, some of the findings obtained from the model testing were parallel to the findings of the previous studies in the literature, and some of them were contradicted.

First of all, although the five factor model proposed for Turkish context (Yılmaz-Tüzün, Çakıroğlu & Boone, 2006) was validated with the data of this study, in order to prevent any potential problem related to multicollinearity, sub-dimensions of CLES were combined as a composite variable called CLES. Therefore, in the model tested, CLES latent variable was used instead of previously defined sub-dimensions called Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation.

The final model obtained in the study revealed that students' perceptions of the classroom environments directly predicted students' epistemological views of science and learning approaches. Students' perceptions of the classroom environment were hypothesized to be positively related with the role of social negotiation, the invented and creative nature of science and the changing and tentative feature of science knowledge, meaningful learning and negatively related with rote learning approach. The results supported in most of the proposed hypothesis, but contradicted with one of the hypothesis. Specifically, students' perceptions of the classroom environment positively predicted the role of social negotiation of SEV, as expected. Since the higher points in the perceptions of classroom environments indicate perceptions related to more constructivist classroom environments, it means that the more constructivist the students’ perceptions of their science classroom environments are, the more sophisticated their views related to the role of social negotiation or more they believe the role of communications and negotiations of scientists in the development of science. Similarly, students’ perceptions of the classroom environments significantly and positively predicted the invented and creative nature of science of SEV, as predicted. That is, the more the students perceive their science classroom environment close to a constructivist environment, the more they understand the importance of human imagination and creativity in growth of scientific knowledge. And, finally the students’ perceptions of classroom environment positively predicted the changing and tentative feature of science knowledge, as expected. It means that the more the students perceive their science classroom environment close to a constructivist environment, the more sophisticated their beliefs regarding the change in the progress of scientific knowledge; the more they believe that the scientific knowledge is tentative. Smith, Maclin, Hougton and Hennesey (2000) similarly concluded that elementary school students in a constructivist classroom develop more sophisticated epistemological beliefs of science. Lederman and Druger (1985) also showed that inquiry oriented instruction and a supportive classroom environment help students to develop better understanding of nature of science. The researchers similar to this study found that, classroom characteristics such as a supportive environment, openness to students’ thoughts and questions, students-teacher interaction, an environment relating school science subjects to everyday life, using a variety of instructional media and use of inquiry-oriented questions during instruction affected positively students’ epistemological view development, specifically their beliefs about developing nature of science. Carey et al. (1989) also reported that students’ epistemological beliefs were better developed in a constructivist classroom environment. Moreover, Tsai (2000b) found positive correlations among students’ epistemological views of science and some sub dimensions of CLES; the more constructivist the students’ perceptions, the more sophisticated their views related to the epistemology of science. In a more recent study, Ozkal, Tekkaya, Çakıroğlu, and Sungur (2009) found that students' perceptions of constructivist learning environment influence their scientific epistemological beliefs. More specifically, students' perceptions related to Personal Relevance, Uncertainty, Critical Voice, Shared Control, and Student Negotiation affect their epistemological beliefs in terms of its fixed/tentative nature. Therefore, based on the literature and findings of this study, it can be said that constructivist classroom environments provide students an opportunity to develop more sophisticated epistemological views of science.

The model also revealed that the students' perceptions of the classroom environment positively predicted meaningful learning approach, as expected. That is, the more the students perceive their classroom environment as constructive, the more they adopt meaningful learning approach. If students found their classroom environment relevant in their studies, feel that they have shared control over their learning, feel free to express their thoughts about their learning, believe that they are able to interact with their peers for better learning, and perceive that science knowledge may change in the progress, they will more likely to adopt meaningful learning in their science learning and therefore intend to learn the science material by constructing the meaning of the content. On the other hand, contrary to the expectations, students' perceptions of their science classroom environment positively predicted rote learning approach. Supporting the relationship found for perceptions of more constructivist classroom environment and meaningful learning, Dart et al. (2000) found that a providing a classroom environment in which personalized and investigative skills are used, the students tended to use deep approaches of learning. Similarly, Özkal, Tekkaya, Çakıroğlu, and Sungur (2009) found that students perceptions of constructivist learning environments, specifically Personal Relevance, Critical Voice, and Student Negotiation dimensions influenced students' learning approaches positively. Eley (2002) also found that when students perceived their course unit to be generally supportive and encouraging of their learning, clear in definition of unit goals, sensitive to students' mental processing in learning, concerned with their capacity to learn independently, and supportive of study practices expected for higher education, they tended to use deeper approaches to study. As a result of the interviews, Ramsden (1990) found that the perception of students of the task and the learning environment directly influence the students' approach of learning; whether they tackle it in a superficial way or to strive for meaning. Although parallel results with the related literature obtained for perceptions of constructivist classroom environment and meaningful learning relationship, the same could not be said for the direction of the relationship with the rote learning approach. Since the expected relationship based on the related literature for the perceptions of constructivist classroom environment and rote learning approach was negative, the results obtained in this study somehow contradicted with the literature.

Same unexpected result was encountered about rote learning approach, when the path between the role of social negotiation and rote learning approach was examined. Contrary to the expectation, students' views related to the role of social negotiation positively predicted the rote learning approach. It means, the more sophisticated the students' views related to the role of social negotiation, the more likely they tend to adopt the rote learning approach. In other words, the more students believe the role of communications and negotiations among scientists in the development of science knowledge, the more likely they have the intention to learn the science material memorizing for recall of facts. Özkan (2008) found similar inconsistencies related to the relationship among epistemological beliefs dimensions and learning approaches. It gave rise to thought that there is something typical to Turkish context. It is all known that, although the curriculum has changed, in our education system students are generally accustomed to learn by memorization the presented knowledge. And generally, the success of students are assessed by their performance on the in-class or nationwide examinations. In these examinations multiple choice type of questions are asked to students, mostly including knowledge or comprehension level questions. For this level of questions, generally recalling of information is enough to be successful. Therefore, by performing well on this type of exams students may think that they learn meaningfully. That is, they think themselves as meaningful learners; however they just use rote learning to meet the demands of those exams. That's why some of the items in the Learning Approach Questionnaire might be perceived differently, and consequently the two types of learning approaches might be overlapped and unexpected results were obtained regarding epistemological views of science and rote learning relationship. This explanation is supported by some of the findings in the literature. A variety of studies revealed that the nature of the assessment type affect students' learning approaches. Students change their approaches in learning according to the demand of the assessment and the type of the assessment procedures may make students retreat to use meaningful learning strategies (Enwistle & Tait, 1990; Scouller, 1998; Scouller & Prosser, 1994; Trigwell & Prosser, 1991). For example students perceive multiple choice examinations as requiring lower level cognitive processes and accordingly tend to adopt surface or rote learning approaches. Whereas they perceive essay type exams as requiring higher level cognitive processes and tend to adopt deep or meaningful learning approaches. Diseth and Martinsen (2003) explained the missing relationship between deep approach and academic achievement of students in their study as follows: the pressure to achieve on students may prevent them being deeply interested in the subject matter.

For the other epistemological views of science constructs, some of the expected relationships were not obtained. The creative and invented nature of science and the changing and tentative feature of science knowledge did not predict rote learning. Similarly, the invented and creative nature of science and the role of social negotiations did not predict meaningful learning approach. Saunders (1998) found a similar result, in her study epistemological beliefs did not predict meaningful learning approach, while predicting rote learning approach. However, the changing and tentative feature of science knowledge directly and positively predicted the meaningful learning approach, as predicted. That is, the more sophisticated the students' beliefs regarding the change in the progress of scientific knowledge, the more they likely to have the intention to understand the learning material by constructing the meaning of the content.

The research on epistemological beliefs and learning approaches generally stated that students' sophisticated views of epistemology of science generally resulted with the adopting meaningful learning approach, whereas unsophisticated or naive beliefs related to epistemological views of science accompanied with the rote or surface approaches to learning (Cavallo, Rozman, & Potter, 2004; Davis, 1997;

Edmondson, 1989, Hammer, 1995, Tsai, 1996; 1998a; 1999a; 2000a). Tsai (1996) found that students having epistemological views more oriented to the constructivist oriented instructional activities, employ a more active mode of learning, utilize more meaningful strategies to enhance their learning and assess their understanding, and have more pragmatic and socially contextualized ideas about learning science and applying scientific knowledge when compared to the students who were more oriented to the empiricist epistemology of science. Also, Chan (2003) found that the Innate/Fixed ability dimension was found to be positively related to Surface Approach, Learning/Effort Process was positively related to Deep Approach, Authority/Expert knowledge positively related to Surface Approach. Certainty of knowledge was found to be positively related to Surface Approach. The results obtained from the study suggested that the students with the naïve belief believing that ability is fixed and innate tended to use the Surface Approach. Students believing that learning require effort and a process of understanding tended to use the Deep Approach when learning. Kızılgüneş (2007) also found similar results about the relationships between epistemological beliefs and learning approaches of students. Moreover, Tsai (1996; 1998a; 1999a; 2000a) revealed that As the students develop more sophisticated views of epistemology of science, they more likely to use meaningful learning strategies in their science learning, and their attitude toward science become more positive. In this respect, some of the findings of the current study supported the results of those studies.

Concerning the relationship between students' epistemological views of science and science achievement relationship, only the role of social negotiation dimension directly and positively predicted their science achievement, as hypothesized. It means that the more students believe the role of communications and negotiations among scientists in the development of science knowledge, the more successful they are in science and technology course. In the literature, there are a number of studies suggesting that sophisticated epistemological beliefs are associated with the higher achievement (Cavallo et al., 2003; Conley et al., 2004; Elder, 1999; Driver, Leach, Millar, & Scott, 1996; Hammer, 1994; Schommer, 1993; Songer & Linn, 1991; Qian & Alvermann, 1995; Tsai, 1998b; 2000a). However, the other two dimensions assumed to predict students' science achievement did not do so. Similar to the result obtained in this study, there are different studies in the literature reporting epistemological belief dimensions in relationship with achievement differing in number and nature. For example Schommer (1993) showed that all four epistemological factors predicted GPA. According to her results, the less students believed in quick learning, simple knowledge, certain knowledge, and fixed ability the better were their GPA scores. Similarly, in the study of Conley et al. (2004) all four epistemological beliefs sub dimensions namely source, certainty, development, and justification were found to be correlated with the students' achievement. However, there are other studies in the literature found different results in terms of number of epistemological beliefs dimensions relating to the students' achievement. Schommer et al. (2000) found that only two of the epistemological belief dimensions namely belief in fixed ability and belief in quick learning predicted students' GPA scores. In another study, Schommer et al. (1997) found that only beliefs in quick learning predicted students' achievement. Similarly, Özkan (2008) found that only Source/Certainty of Knowledge dimension of epistemological beliefs predicted students' science achievement. Trautwein and Ludtke (2007) found that certainty beliefs were found to influence students' cognitive abilities and final school grades in a negative manner. Moreover, Cano (2005) showed that both epistemological beliefs and learning approaches influenced students' achievement directly. Epistemological beliefs also influence achievement indirectly by effecting learning approaches of students. Songer and Linn (1991) stated that the relationship between students' epistemological beliefs and science achievement or learning become more obvious beginning from the middle school years. For this reason, before middle school the relationship may not be clear as in the case of studies with middle school, high school or college students. This might be a developmental issue, as the students grow older the potential effect of epistemological beliefs on their learning and achievement may be more apparent. In sum, regardless of the number and nature of the epistemological belief dimensions, there are evidences in the literature that students' epistemological views of science are related to their achievement. Therefore, the results of this study supported this claim.

The effect of epistemological beliefs on students' academic performance of science may also be indirect besides having direct effects. If for example students see scientific knowledge as a collection facts, they may choose learning approaches that are consistent with this belief and tend to memorize those facts. Accordingly, if they successfully memorize the facts they may think that they understood or learned. Therefore, epistemological beliefs may affect students' learning approaches and the approaches affect their science achievement. Schommer, Crouse and Rhodes (1992) indicated evidences for this indirect relationship among students' epistemological beliefs and their academic performance.

Finally, when the relationships concerning the students' learning approaches and science achievement were examined, it was seen that students' meaningful learning approach predicted positively their science achievement, as hypothesized. It means that the more the students have the intention of understanding the science material by constructing its meaning, the better their learning outcomes are. On the other hand, contrary to the expectations rote learning did not predict science achievement. There are various of results in the related literature supporting the results obtained from this study. Cavallo et al. (2004), Snelgrove and Slater (2003), Waters and Waters (2007) reported that there is a relationship between meaningful learning of students and their academic achievement. Snelgrove and Slater (2003) indicated that deep learning was found to be correlated significantly and positively with grade performance average and sociology examination results. Similarly, Hazel and Proser (2002) showed that the deep approach correlated positively with all of the three learning outcomes. Bernardo (2003) found deep and achieving learning approaches were positively related to academic achievement even when the school ability and prior academic achievement was controlled. Similarly, Sadler-Smith (1996) found relationship between overall academic performance and deep approach. In another study, Williams and Cavallo (1995) found that students' reasoning ability and meaningful learning were found to be correlated to physics understanding. Boujaoude (1992) showed that meaningful learners performed significantly better than the rote learners on the misunderstanding posttest. In a longitudinal study, Zeegers (2001) found that deep approach showed a consistent positive correlation with assessment outcomes. Similarly, Boujaoude and Giuliano (1994) found that meaning orientation together with the prior knowledge and logical thinking ability were found as the predictors of students' achievement. Rote learning was not appeared as a predictor of achievement neither in negative nor in positive direction. Also, Bernardo (2003) obtained no relationship between surface approach to learning and academic achievement while revealing a positive relationship between deep approach and academic achievement. Therefore, the current study presented a parallel result with the related literature.

As a sum, the current study suggested some direct and also indirect relationships for the selected variables. There are both expected and unexpected results obtained. Although, some of the relationships revealed through the study were different from the results obtained in other studies in the literature, generally the obtained relationships in the model were supported and found parallel with the related literature. According to the tested model, students' perceptions of the classroom environment contributed to their epistemological views of science and learning approaches. Students' epistemological views of science had an influence on their learning approaches and their science achievement, and finally students' meaningful learning approach influenced their science achievement.

5.2 Conclusions

The following conclusions can be drawn according to the results of the present study:

1. The epistemological views of science of Turkish elementary school students can be identified with the three factor structure. These factors are the role social negotiation, the invented and creative nature of science, and the changing and tentative feature of science knowledge.

2. Students' perceptions of science classroom environment predict their epistemological views of science. Constructivist perceptions of science classroom environments are related positively to students' views about the role of social

negotiation, the invented and creative nature of science, and the changing and tentative feature of science knowledge. That is, more constructivist the students' perceptions of their science classroom environments are, more they believe the role of communications and negotiations of scientists in the development of science, the more they understand the importance of human imagination and creativity in growth of scientific knowledge, and the more they believe that the scientific knowledge is tentative.

3. Students' epistemological views of science predict their learning approaches directly. The changing and tentative feature of science knowledge is the only epistemological views of science dimension predicting students' meaningful learning approach significantly. Sophisticated views about tentativeness of scientific knowledge related with the intention to understand the material under study by constructing its meaning. The role of social negotiation is the only dimension predicting rote learning approach. According to this relationship, the sophisticated beliefs related to the role of communications and negotiations among scientists in the development of science are associated with the tendency to adopt rote learning approach.

4. Students' epistemological views of science directly predict their science achievement. The role of social negotiation is the only dimension predicting science achievement significantly. The more students believe the role of communications and negotiations among scientists in the development of science, the better science achievers they are.

5. Students' learning approaches directly predict their science achievement. Only the meaningful learning approach predicts science achievement. The higher intention of understanding the science material by constructing its meaning is associated with the higher grades in science and technology course.

5.3 Implications

Based on both the findings of this study and the related studies in the literature some implications can be drawn. First of all, it should be clarified that by epistemological beliefs or views, only students' views related to the three dimensions; namely the role of social negotiations, the invented and creative nature of science, and the changing and tentative feature of science knowledge dimensions were implied in the conclusions and implications of this study.

Similar to the results in the literature, the findings of this study imply that epistemological beliefs influenced students' academic achievement directly and also indirectly via learning approaches. Therefore, epistemological beliefs of students are important constructs in terms of students' science understanding and achievement and should be taken into account.

In Turkish educational system, many teachers still use traditional teacher centered approaches in science instruction. Since it's known that science classroom environment including classroom atmosphere, type of instruction and assessment affect students' epistemological views of science, teacher centered instruction may led students to think that science is a collection of facts and should be given by an authority like a teacher. Therefore, that type of instruction may have an effect on students' perceptions related to their science classes and resulted with students holding unsophisticated or naïve views of epistemology of science. Supporting this argument, it is accepted in the literature that school science experiences can dramatically affect students' development of scientific thinking about science in elementary school years. Therefore, it is important to implement student-centered; constructivist based instructional methods in order to develop proper epistemological beliefs of students beginning from the elementary school years. Parallel to this view regarding the importance of science classroom environments, it can be said that students' epistemological views of science may reflect their reality in science classrooms. Generally, students in science classes do teacher directed science activities even if they actively involved in the teaching-learning process. However, scientists do their own investigations directed by previous works, their own curiosity and interest. Therefore, from this point of view it is again seen that science lessons should be planned in a way that students can be more active in constructing their knowledge, create ideas, discuss with each other and with teacher, plan their own learning instead of only passively accumulating the given information and following the teacher's directions. Science teachers should encourage students to use reasoning and critical thinking skills when learning instead of reinforcing the belief that the teacher is the authority of the knowledge in the class.

Attempts to develop students' epistemological views of science from the elementary grades are also important to make their subsequent science educational experiences more exciting and understandable. Developing positive attitudes toward science also contribute students' scientific literacy as well.

Researches also showed that students differentiate between "school science" and "real science". Generally, students' image of science and scientists come from the sources what they read, discussed, see at schools, and some out of school sources like televisions, cartoons. Therefore, what they experience in science classes contradicts with what they see and hear at outside the school. For this reason, it is important to relate school science activities to real life and make them to see there is no differentiation between school science and real science. Explicit discussions at science classes related to epistemology of science may help to provide this vision. Also, it should be remembered that science is not an isolated activity from society, culture and technology, thus Science Technology Society (STS) instruction providing a learning environment in which students have the opportunity for divergent thinking, discussion of everyday scientific issues and the concepts in the context of human experiences, and cooperative learning facilitates students' development of epistemological views of science toward a more constructivist perspective. In addition, research also showed that a supportive classroom environment implementing inquiry oriented instruction can help students to develop better understanding of epistemology of science. Classroom environments providing opportunities for students to discuss, negotiate, comment on each other's and teacher's views and ideas may help them to understand the epistemology of science better.

In another point of view, students' differentiation of real science and school science may influence their epistemological views of science negatively in another way. Since generally the media presents findings of the scientific studies as facts, it makes harder for students to understand the changing and uncertain nature of science knowledge. Looking at this point, it becomes important for teachers to make their students being aware of that science is a human product and the scientific information and findings are not certain, they always have the potential of change in the light of the new research and findings or making inferences with the different perspectives.

Research showed that developmentally as the students grow older, their cartoon image of science move toward a more realistic view, and this change largely attributed to the science teaching. How teacher links the work they experience in class to theory affect students' understanding of epistemology of science. Therefore, the choice of good activities, specifically experiments and linking what they obtained from the experiments to theory may affect largely what students understand from the scientific investigation. Experiments as a way to collect evidences to test some predictions can be used to model scientific investigations. Since studies showed that students generally have naïve views related to purpose of science, instruction beginning on this dimension may be also useful to develop other epistemological beliefs effectively.

Taking students' epistemological views of science is also important for meaningful learning of science. It is stated in the literature that meaningful learning of science requires generally adopting meaningful approach to learning. Also, the results of this current study showed that meaningful learning directly contributes to students' science achievement. Since students having empiricist or naïve views of science generally think that science is a collection of facts. This view about science may push them to use rote memorization in order to make themselves be familiar with the topic under study. Therefore, developing sophisticated views of science is also important for meaningful learning of science via making students use meaningful learning approach. Another important point to keep in mind that learning approaches are not simply innate characteristics of students; these are characteristics influenced by the learning environment, teachers' and students' own epistemological beliefs of science.

Teachers may also be unconsciously influenced by their students' learning approaches directly or indirectly through the use type of assessment strategies they used in the classroom. If a teacher uses test items assessing memorization of facts instead of understanding of concepts or if the test items have only involve one right answer instead of requiring making interpretations and allowing for several different answers, he or she may unconsciously oriented the students to adopt rote learning approach.

The effect of epistemological beliefs on science achievement is apparent both from the literature and from the findings of this study. Thus, science curriculums should be designed to emphasize learning about science besides learning science. In Turkey, by 2004 curriculum science curriculum release, this change has been tried to be accomplished. However, in practice there have been lots of obstacles in order to implement the new curriculum in an appropriate way; one may the teachers' lack of knowledge about philosophy of science and inadequacy of in-service trainings for teachers.

Overall it can be seen that it is useful for teachers to know their students' epistemological views of science. By this information they may be able to implement appropriate instructional strategies to develop necessary or undeveloped/unsophisticated dimensions and therefore contribute students' science learning. However, before utilizing this approach teachers themselves should be aware of the importance of epistemological views of science. Teachers' awareness of epistemological views of science is twofold: First it is important to decide on the appropriate instructional activities for better teaching of science, and second teachers' own epistemological beliefs affect the way they teach and consequently influence their students' epistemological beliefs indirectly. For this reason, it is necessary to explore science teacher candidates' epistemological beliefs and design interventions to develop their beliefs before they start to teach. Several courses such as philosophy of science, history of science, and methods of science teaching may help to develop their beliefs. Therefore, it seems vital to encourage science teacher candidates to take these courses during their education at faculties. Moreover, it is worth to plan trainings, workshops, seminars on epistemology of science for both pre service and in service science teachers, since it will be useless to change curriculums or suggesting constructivist practices if teachers do not have appropriate epistemological views of science.

Besides being aware of the students' epistemological views of science, teachers also make use of students' perceptions about classroom environment. These perceptions may be used as a guide to improve the quality of teaching and learning in science classrooms. Literature showed that students' attitude toward science classes was influenced by their perceptions related to their science classes. Also, students' perceptions of classroom environment is found to be important for epistemological views of science, learning approaches, and consequently science learning and achievement. It is possible to improve students' attitudes toward science lessons by providing sharing the decision process in planning the classroom activities and assessment procedures, opportunities for negotiation with their peers, making instruction and learning process more relevant to daily life. Hence, it can be said that as we increase our attention to the issue that how students' see their classroom environments; we may get some clues to improve the effectiveness of teaching and learning in science classes. It is also important to assess students' perception is classroom environments and explore specific components of the environment in order to decide which can be used to promote meaningful learning approaches to promote deeper understanding.

5.4 Internal and External Validity

The possible threats to the internal validity in this study are (Fraenkel & Wallen, 1996): Subject characteristics, location, instrumentation, and mortality threats. Subject characteristics threat is accepted as an important issue in correlational studies, since there might be another factor explaining the obtained relationship. In order to eliminate potentially confounding variables, data related to the subject characteristics, such as gender, age and SES were also obtained with the inventory, and taken into consideration. This was help to control for a subject characteristics threat to the internal validity and for a possible loss of subjects.

The location in which the data were collected might have affected the students' responses to the questionnaires. In this study, location threat was possible since different activity locations of TEGV from different cities were involved in the study. However, all selected locations belong to TEGV and their standards are nearly the same. This minimized this threat, and also the personnel who were responsible for the administration were informed about the standardization of the administration process.

Also, the attitude of the subjects and instrumentation might affect the results of this study, to prevent this factor same written directions and necessary explanations about the instrument were given to all of the participants, and the instrumentation process was tried to be standardized. In order to control data collector characteristics threat, the same directions and information were given the participant TEGV personnel and they were trained in a meeting for the administration. Before the administration, all TEGV personnel participated in the study were informed first by face to face explanation in a meeting, then by e-mail and lastly telephone conversations about the purpose of the study, instrument and administration, and the necessary directions were given.

Loss of subjects is an important threat for internal validity. The students should have scores for each variable being measured. If a student one of those scores is missing, this participant directly excluded from the study. In order to prevent possible big decreases in the sample, the predetermined sample size was kept as large as possible. Missing data analyses were conducted; the replaced missing values were constituted less than 1% of the whole sample.

External validity is the generalizability of research results (Fraenkel & Wallen, 1996). It cannot be possible to generalize the results to the 6th, 7th, and 8th grade students attending elementary school across cities, namely İstanbul, Ankara, İzmir, Van, Diyarbakır, Eskişehir, Afyon, Antalya, Samsun and Gaziantep, since the sample of the students in this study only constituted a very small portion (less than 1%) of the whole population of students in these ten cities. Therefore, the external validity of the study is limited and the results of this study can only be generalized to the 6, 7, 8th grade students attending TEGV activity locations throughout Turkey.

5.5 Limitations and Suggestions for Future Research

There are some limitations of the study that are important when the findings of the study are interpreted. Recognizing the limits and weaknesses of the study will avoid any interpretation beyond the scope of this investigation. In this section, specific limitations and suggestions for future research are given together.

The work done in this dissertation provides some information about the elementary grade students' epistemological views of science and the relationships among those beliefs and some important variables like perceptions of classroom environments, learning approaches and science achievement. This study is based on the data obtained by the written questionnaires via students' self reports and perceptions. It is an important fact that using written questionnaires are the most efficient and useful way to gather information from a large sample of students. However, there are some limitations. First of all, written questionnaires may limit the students' responses; there may be some thoughts, beliefs or perceptions of students that cannot captured by the use of questionnaires. Interviews may provide more in depth information about students' epistemological views. Also, observations during science classroom performances like doing experiments or other activities may provide information about students' way of thinking, reasoning and viewing science activities. Relying only on the questionnaire results is the major weakness of this study. Future studies may be more clearly identify the epistemological views of science on learning by using above mentioned data gathering procedures.

The above mentioned limitation of the study is a general problem regarding the epistemology studies. Chan and Elliot (2004) stated that epistemology studies are problematic since there is a possibility that individuals' epistemological beliefs might change or fluctuate. The situation implies that there is no universally valid instrument to assess the complicated nature of epistemological beliefs. Therefore, it may be more useful to conduct epistemology studies by utilizing mixed methodologies.

Quantitative measures like questionnaires together with the qualitative means like interviews would be useful to reveal the complex structure of epistemological beliefs. Since in this study only a quantitative measure was used to assess students' epistemological beliefs, this is a limitation of the study. Independent from the specific measurement of epistemological beliefs, self-reported questionnaires may be problematic. In measuring constructs relying only on the self reports of respondents also raise some issues related to the validity and reliability of the obtained data.

As stated before students may differentiate between school science and real science. When responding to the questionnaire items if they rely on school science, their ideas about science come from passive sources like teachers and books. On the other hand, scientists' ideas in real life come from some active endeavors; these ideas arise from scientists' thinking. Therefore, it is important to examine, what the sources that students rely upon while responding to the questionnaire items are. Did they responses base on their school science experiences or scientists' work on real life? Depending on their thinking mode interpretation of results may totally change. Students might feel limited to think about their school science experiences when responding the items. Therefore, this might limit the findings of this study. Investigating students' sources when responding the items through interviews may extend the interpretations based on the results. Since in this study only a questionnaire was used to collect data, this may be accepted as a limitation. Future studies should also give attention to this issue in order to make more sound interpretations.

Another issue is the results of the study might be affected by the fact that students' understandings of science may be dependent on the domain when they think about science. Some students may think biology when asked about science, on the other hand some may think physics or any other science related domain. Some may think school science as mentioned above, some may think science outside school. Therefore, their responses on the scientific epistemological views questionnaire may change depending on the domain or context they think when they are asked about science. Domains have their own characteristics; for example, in physics, one may believe knowledge is certain when think about the law of gravitation or Newton's laws of motion. On the other hand, in biology, every day we hear about new developments about genes, knowledge about nutrition is changing; everyday new medicines are announced for once known as incurable diseases or new viruses. When one thinks about the school context, the teacher generally is the only authority in science lessons, students generally do experiments to confirm what they have already learned. Whereas, when they think science as an out of school activity, media; movies, cartoons, television commercials play an important role on their views, and accordingly they may view scientists as mad, lonely, crazy men with white hairs and thick eye glasses. Overall, all of these domains or contexts may affect the thinking mode in responses and results may change. Future studies should give attention to the domain or contexts that students think about when they asked about science. Again interviews may be useful to collect information about these domains and contexts. Items that are independent from domain or context may be prepared or domain specific epistemological belief items may be asked and the results may be compared for different domains to get more fruitful results.

The sample size of the study limits the generalizability of the research results. Since the sample of the study is only a very small portion of the population, the results obtained from the study may not be reliable if generalized to a group of students in conditions different from the conditions of students enrolled in this study. Therefore, the generalizations based on the findings of this study should be made with caution.

Another limitation is related to the specific data analysis technique used in this study. Structural equation modeling similar to other correlational methods of analysis does not give information about causation. The constructs found to be related to each other cannot say a casual relationship. In order to make inferences about casual relationships, further studies, more specifically experimental research is needed.

In terms of perceptions of classroom environment research, future studies may include the assessment of teachers' perceptions of the science classes, and comparison of teachers and their students' perceptions may provide a valuable data for learning environment research. Also, qualitative data through for example classroom observations may be used to enhance our understanding of the dynamics of classroom environment by providing deeper information.

Epistemological beliefs are developmentally change as the students grow older and learning approaches are influenced by the learning environment. Since these constructs are known to be dynamic, longitudinal studies should be conducted over time in order to investigate the relationship between the two.

Future studies may investigate the teachers' epistemological beliefs besides their students. This type of research may enlighten our knowledge about the influence of teachers' epistemological beliefs effect on classroom practices and students' beliefs. In addition, pre service teachers' epistemological may be investigated. This information about teacher candidates will also be valuable for teacher educators to develop or reshape the student teachers' beliefs before they practice in real classes. Future studies conducted to investigate both in service and pre service teachers' epistemological beliefs will be valuable for science education research.

In order to understand the relationship between epistemological views of science and science learning, future studies should assess students' science learning by also performance based assessments which will provide more and deeper information about students' thinking and learning in science compared to paper and pencil measurement tools.

Future experimental studies investigating the effect of implementing inquiry based, constructivist instructional environments on students' epistemological views will provide rich information about students' epistemological development and be useful for specifying the kinds of practices, curricula and environment which are helpful to improve students' epistemological understanding of science. There are a small number of such intervention studies in the literature investigating elementary school students' epistemological views of science development under specific instructional strategies. Therefore, more studies are needed to get evidence and further information about the appropriate instruction to provide improvements on students' epistemological views of science.

In investigating the students' perceptions of classroom environment, future studies may ask for previous experiences and perceptions of students related their science classroom environment. Results may be affected by the specific events that are experienced by the students at the time of measurement. It will be more reliable to assess students' perceptions regarding their science classrooms at different times.

As mentioned in the discussion part, different studies found diverging results regarding the dimensions of epistemological beliefs and their relationships with different aspects of academic performance. Future research should investigate the relationship of specific epistemological beliefs dimensions and specific aspects of academic performance to provide richer insights about the beliefs' effect on students' achievement.

Finally, since student learning is a very complex variable to investigate, the current study can be improved and more fruitful inferences can be obtained by including other variables which may provide more light to the complex nature of student learning.

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APPENDIX A

THE SCIENTIFIC EPISTEMOLOGICAL VIEWS QUESTIONNAIRE

	KESİNLİKLE KATILMIYORUM	KATILMIYORUM	KARARSIZIM	KATILIYORUM	KESİNLİKLE KATILIYORUM
1. Yeni bilimsel bilgiler, o alanda çalışan bilim insanlarının onaylamasıyla güvenirlik kazanır.	☐	☐	☐	☐	☐
2. Bazı kabul görmüş bilimsel bilgiler insanların hayallerinin ve sezgilerinin ürünüdür.	☐	☐	☐	☐	☐
3. Bilimsel bilginin gelişimi çoğu zaman o bilgiyi oluşturan bilimsel kavramların değişimini de kapsar.	☐	☐	☐	☐	☐
4. Bilim insanları, başka etkenlerden etkilenmeden, tamamen tarafsız gözlemler yapabilir.	☐	☐	☐	☐	☐
5. Bilimsel teorilerin gelişmesi için bilim insanlarının hayal güçlerine ve yaratıcılıklarına ihtiyaç vardır.	☐	☐	☐	☐	☐
6. Bilim insanlarının hemfikir oldukları bazı bakış açıları ve araştırma yapma yolları vardır.	☐	☐	☐	☐	☐
7. Bilim insanlarının yaptıkları bilimsel çalışmalar, sahip oldukları ön bilgi ve düşüncelerden etkilenir.	☐	☐	☐	☐	☐
8. Bilimsel bilgi dünyanın her yerinde aynıdır, kültürden kültüre farklılık göstermez.	☐	☐	☐	☐	☐
9. Bilim insanlarının yaptıkları tartışmalar ve görüş alış verişleri sayesinde, bilimsel teoriler gelişir.	☐	☐	☐	☐	☐
10. Bilimsel bilginin geçerli olması için o alanda çalışan bilim insanları tarafından kabul edilmesi gerekir.	☐	☐	☐	☐	☐
11. Bilimin gelişmesinde bilim insanlarının sezgileri önemli bir rol oynar.	☐	☐	☐	☐	☐
12. Farklı kültürlerden gelen insanlar doğa hakkında bilgi edinmek için farklı yöntemler kullanırlar.	☐	☐	☐	☐	☐
13. Günümüz bilim insanları, bilimsel araştırma sonuçlarının değerlendirilmesi için bir takım kurallar üzerinde fikir birliğine varmışlardır.	☐	☐	☐	☐	☐
14. Günümüz biliminin doğa olaylarına getirdiği açıklamalar değişebilir.	☐	☐	☐	☐	☐
15. Bilim insanlarının inandıkları teorilerin bilimsel araştırma süreçlerine etkisi yoktur.	☐	☐	☐	☐	☐
16. Bilim insanlarının kendi aralarında yaptıkları tartışmalar, görüşmeler ve bunların sonuçlarının paylaşılması bilimsel bilginin	☐	☐	☐	☐	☐

gelişmesini kolaylaştıran en önemli etkenlerden biridir.					
17. Yaratıcılık, bilimsel bilginin gelişmesi için önemlidir.	☐	☐	☐	☐	☐
18. Şu anda kabul edilen bilimsel bilgiler, gelecekte değişebilir ya da tamamen terk edilebilir.	☐	☐	☐	☐	☐
19. Farklı kültürlerden gelen insanlar doğa olaylarını aynı yöntemleri kullanarak yorumlarlar.	☐	☐	☐	☐	☐

APPENDIX B

CONSTRUCTIVIST LEARNING ENVIRONMENT SURVEY

OKULDA …	HİÇBİR ZAMAN	NADİREN	BAZEN	SIK SIK	ÇOĞUNLUKLA
1. Fen ve Teknoloji dersimizde okul içindeki ve dışındaki dünya hakkında bilgi ediniyorum.	☐	☐	☐	☐	☐
2. Fen ve Teknoloji dersimizde bilimin problemlere her zaman bir çözüm getiremediğini öğreniyorum.	☐	☐	☐	☐	☐
3. Fen ve Teknoloji dersimizde neyin, nasıl öğretildiğini rahatlıkla sorguluyorum.	☐	☐	☐	☐	☐
4. Fen ve Teknoloji dersimizde ne öğreneceğimin planlamasında öğretmene yardımcı oluyorum.	☐	☐	☐	☐	☐
5. Fen ve Teknoloji dersimizde problemleri nasıl çözeceğimi diğer öğrenciler ile tartışıyorum.	☐	☐	☐	☐	☐
6. Fen ve Teknoloji dersimizde ne kadar iyi öğrendiğimin değerlendirilmesinde/ölçülmesinde öğretmene yardımcı oluyorum.	☐	☐	☐	☐	☐
7. Fen ve Teknoloji dersimizde öğrendiğim yeni bilgilerin okul içinde ve dışında edindiğim deneyimler ile ilişkili olduğunun farkındayım.	☐	☐	☐	☐	☐
8. Fen ve Teknoloji dersimizde neyin, nasıl öğretildiğini rahatlıkla sorgulamama izin verildiğinde daha iyi öğreniyorum.	☐	☐	☐	☐	☐
9. Fen ve Teknoloji dersimizde bilimsel açıklamaların zaman içinde değiştiğini öğreniyorum.	☐	☐	☐	☐	☐
10. Fen ve Teknoloji dersimizde diğer öğrenciler benim fikrimi açıklamamı istiyorlar.	☐	☐	☐	☐	☐
11. Fen ve Teknoloji dersimizde bilimin okul içindeki ve dışındaki hayatın bir parçası olduğunu öğreniyorum.	☐	☐	☐	☐	☐
12. Fen ve Teknoloji dersimizde hangi etkinliklerin benim için daha yararlı olacağına karar vermede öğretmene yardımcı oluyorum.	☐	☐	☐	☐	☐
13. Fen ve Teknoloji dersimizde bilimin, insanların kültürel değerlerinden ve fikirlerinden etkilendiğini öğreniyorum.	☐	☐	☐	☐	☐
14. Fen ve Teknoloji dersimizde fikirlerimi diğer öğrencilere açıklıyorum.	☐	☐	☐	☐	☐
15. Fen ve Teknoloji dersimizde karmaşık olan etkinlikler için açıklayıcı bilgi isteyebiliyorum.	☐	☐	☐	☐	☐
16. Fen ve Teknoloji dersimizde okul içindeki ve dışındaki dünya hakkında ilginç şeyler öğreniyorum.	☐	☐	☐	☐	☐

17. Fen ve Teknoloji dersimizde diğer öğrencilerin fikirlerini açıklamalarını istiyorum.	☐	☐	☐	☐	☐
18. Fen ve Teknoloji dersimizde öğrenmeme engel olabilecek durumlar için düşüncelerimi dile getirebiliyorum.	☐	☐	☐	☐	☐
19. Fen ve Teknoloji dersimizde bilimin, soruların ortaya konması ve çözüm yollarının oluşturulmasında bir yol olduğunu öğreniyorum.	☐	☐	☐	☐	☐
20. Fen ve Teknoloji dersimizde herhangi bir etkinlik/aktivite için ne kadar zamana ihtiyacım olduğunu öğretmene bildiriyorum.	☐	☐	☐	☐	☐

APPENDIX C

LEARNING APPROACH QUESTIONNAIRE

	KESİNLİKLE KATILMIYORUM	KATILMIYORUM	KARARSIZIM	KATILIYORUM	KESİNLİKLE KATILIYORUM
1. Fen ve Teknoloji dersinde ilk bakışta zor gibi görünen konuları anlamak için genellikle çok çaba sarf ederim.	☐	☐	☐	☐	☐
2. Fen ve Teknoloji dersi ile ilgili bir konuya çalışırken öğrendiğim yeni bilgileri o konuyla ilgili eski bilgilerimle ilişkilendirmeye çalışırım.	☐	☐	☐	☐	☐
3. Fen ve Teknoloji dersine çalışırken, öğrendiğim konuları günlük hayatta nasıl kullanabileceğimi düşünürüm.	☐	☐	☐	☐	☐
4. Fen ve Teknoloji dersinde öğretmenin anlattığı sırayı takip ettiğimde konuları en iyi şekilde hatırlarım.	☐	☐	☐	☐	☐
5. Fen ve Teknoloji dersinde öğrenmek zorunda olduğum konuların büyük bir kısmını ezberlerim.	☐	☐	☐	☐	☐
6. Fen ve Teknoloji dersinde önemli konuları tam olarak anlayana kadar gözden geçiririm.	☐	☐	☐	☐	☐
7. Fen ve Teknoloji dersinde öğretmenler, sınavda çıkmayacak konulara öğrencilerin çok fazla zaman harcamalarını **beklememelidirler.**	☐	☐	☐	☐	☐
8. Fen ve Teknoloji dersine tam anlamıyla çalışmaya başladığımda, her konunun benim için ilgi çekici olacağını düşünürüm.	☐	☐	☐	☐	☐
9. Fen ve Teknoloji dersinde edindiğim veya kitaplardan okuduğum bilgiler hakkında sık sık kendime sorular sorarım.	☐	☐	☐	☐	☐
10. Fen ve Teknoloji dersinde, yeni konu hakkında genel bir fikir vermesi bakımından, konuları birbirleri ile ilişkilendirmenin faydalı olduğunu düşünürüm.	☐	☐	☐	☐	☐
11. Fen ve Teknoloji dersinde, anladığımdan iyice emin olana kadar ders ya da laboratuar notlarımı tekrar tekrar okurum.	☐	☐	☐	☐	☐
12. Fen ve Teknoloji dersi ile ilgili bir konuyu ana hatlarıyla çalışmanın zaman kaybı olduğunu düşündüğümden, sınıfta ya da ders notlarında anlatılanları detaylı bir şekilde çalışırım.	☐	☐	☐	☐	☐
13. Fen ve Teknoloji dersiyle ilgili okunacak materyalleri (kitap, dergi vb.), iyice anlayıncaya kadar okurum.	☐	☐	☐	☐	☐
14. Fen ve Teknoloji dersinde gerçek olaylara dayanan konuları, varsayıma dayanan konulardan daha çok severim.	☐	☐	☐	☐	☐

15. Fen ve Teknoloji ile ilgili bir konu hakkındaki bilgimi başka bir konu hakkındaki bilgilerimle ilişkilendirmeye çalışırım.	☐	☐	☐	☐	☐
16. Fen ve Teknoloji dersinde benim için teknik terimlerin anlamlarını öğrenmenin en iyi yolu, ders kitabındaki tanımları hatırlamaktır.	☐	☐	☐	☐	☐
17. Fen ve Teknoloji dersinde bulmaca ve problemler çözerek mantıksal sonuçlara ulaşmak beni heyecanlandırır.	☐	☐	☐	☐	☐
18. Fen ve Teknoloji dersiyle ilgili okumam gereken materyalin (kitap, dergi vb.) ne işime yarayacağını genellikle düşünmem.	☐	☐	☐	☐	☐
19. Fen ve Teknoloji dersinde konuları iyice öğrenene kadar tekrar tekrar gözden geçiririm.	☐	☐	☐	☐	☐
20. Fen ve Teknoloji dersinde çoğunlukla, konuları gerçekten anlamadan okurum.	☐	☐	☐	☐	☐
21. Fen ve Teknoloji dersiyle ilgili fazladan okumalar, kafa karıştırıcı olduğundan, derste önerilen okumaların sadece bir kısmına bakarım.	☐	☐	☐	☐	☐
22. Fen ve Teknoloji dersi için fazladan çalışmanın gereksiz olduğunu düşündüğümden, çalışmamı genellikle derste verilen bilgiyle sınırlarım.	☐	☐	☐	☐	☐
23. Fen ve Teknoloji dersinde yeni bir konuya başlarken kendime yeni edindiğim bilginin cevaplaması gereken sorular sorarım.	☐	☐	☐	☐	☐
24. Boş zamanlarımda, Fen ve Teknoloji dersinde gördüğüm ilginç konular hakkında araştırma yaparım.	☐	☐	☐	☐	☐

APPENDIX D

THE FINAL SIMPLIS SYNTAX FOR THE STRUCTURAL MODEL

```
Model structural - A path analysis
 Observed Variables
 FENNOTU SEV1 SEV2 SEV3 SEV5 SEV6 SEV9 SEV10
 SEV11 SEV13 SEV14 SEV16 SEV17 SEV18 LAQ1 LAQ2
 LAQ3 LAQ4 LAQ6 LAQ9 LAQ11 LAQ12 LAQ14 LAQ16
 LAQ19 CLESTOT
 Covariance Matrix From File EX12.COV
 Sample Size: 2702
 Latent Variables: Son Ic Ct Cles Sciach Ml Rl
 Relationships:
 SEV1 SEV6 SEV9 SEV10 SEV13 SEV16 = Son
 SEV2 SEV5 SEV11 SEV17 = Ic
 SEV3 SEV14 SEV18 = Ct
 CLESTOT = Cles
 FENNOTU = Sciach
 LAQ1 LAQ2 LAQ3 LAQ6 LAQ9 LAQ11 = Ml
 LAQ4 LAQ12 LAQ14 LAQ16 LAQ19 = Rl
 Son = Cles
 Ic = Cles
 Ct = Cles
 Ml = Cles Ct
 Rl = Cles Son
 Sciach = Son Ml
 Let the Error Variance of  FENNOTU be 0
 Let the Error Variance of  CLESTOT be 0
 Let the Error Covariances of  SEV14 and SEV18 correlate
 Let the Error Covariances of  LAQ1 and LAQ2 correlate
 Let the Error Covariances of  LAQ11 and LAQ9 correlate
 Let the Error Covariances of Son and Ic correlate
 Let the Error Covariances of Son and Ct correlate
 Let the Error Covariances of Ic and Ct correlate
 Let the Error Covariances of Ml and Rl correlate
 Admissibility Check = OFF
 Iterations = 25000
 Path Diagram
```

Number of Decimals = 3
Wide Print
Print Residuals
End of Problem

APPENDIX E

THE BASIC MODEL WITH STANDARDIZED ESTIMATES AND t-VALUES

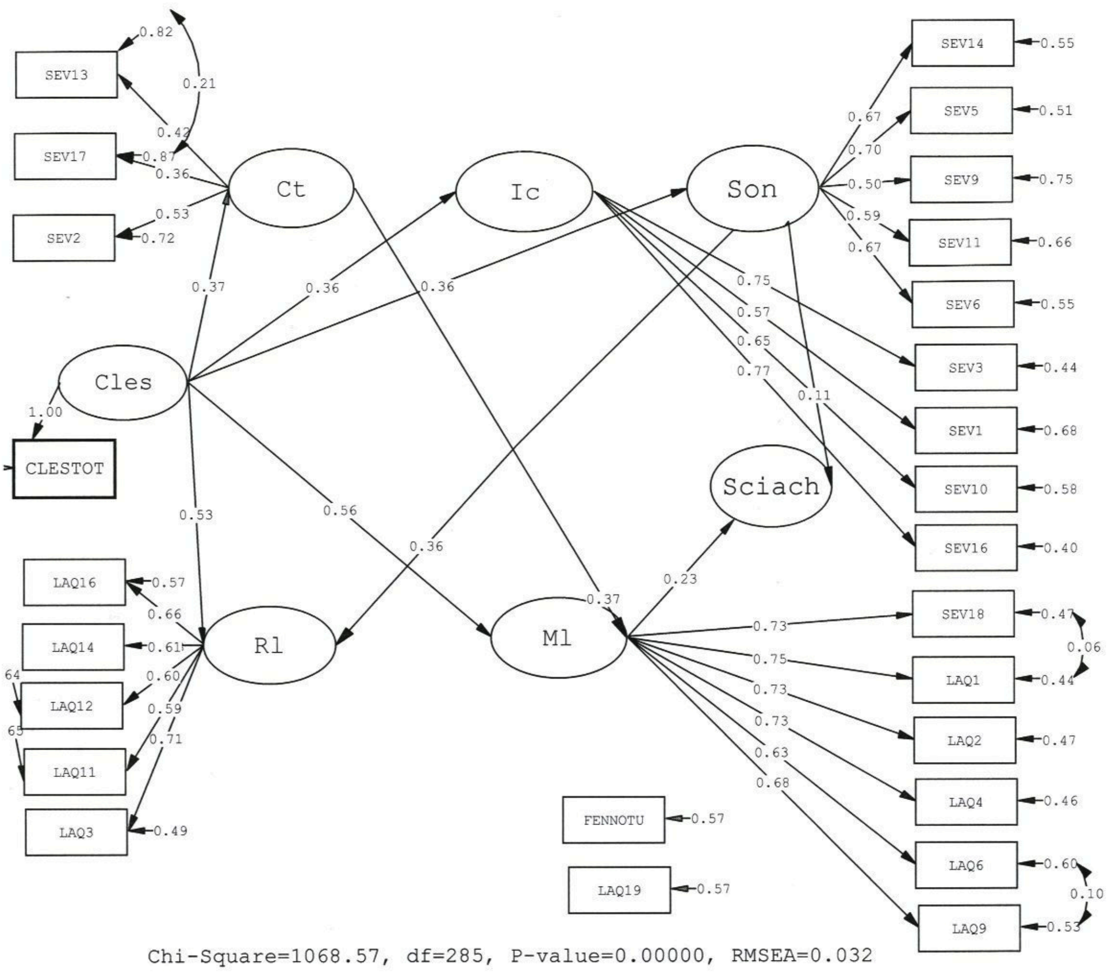

Figure A.1 The basic model with standardized estimates

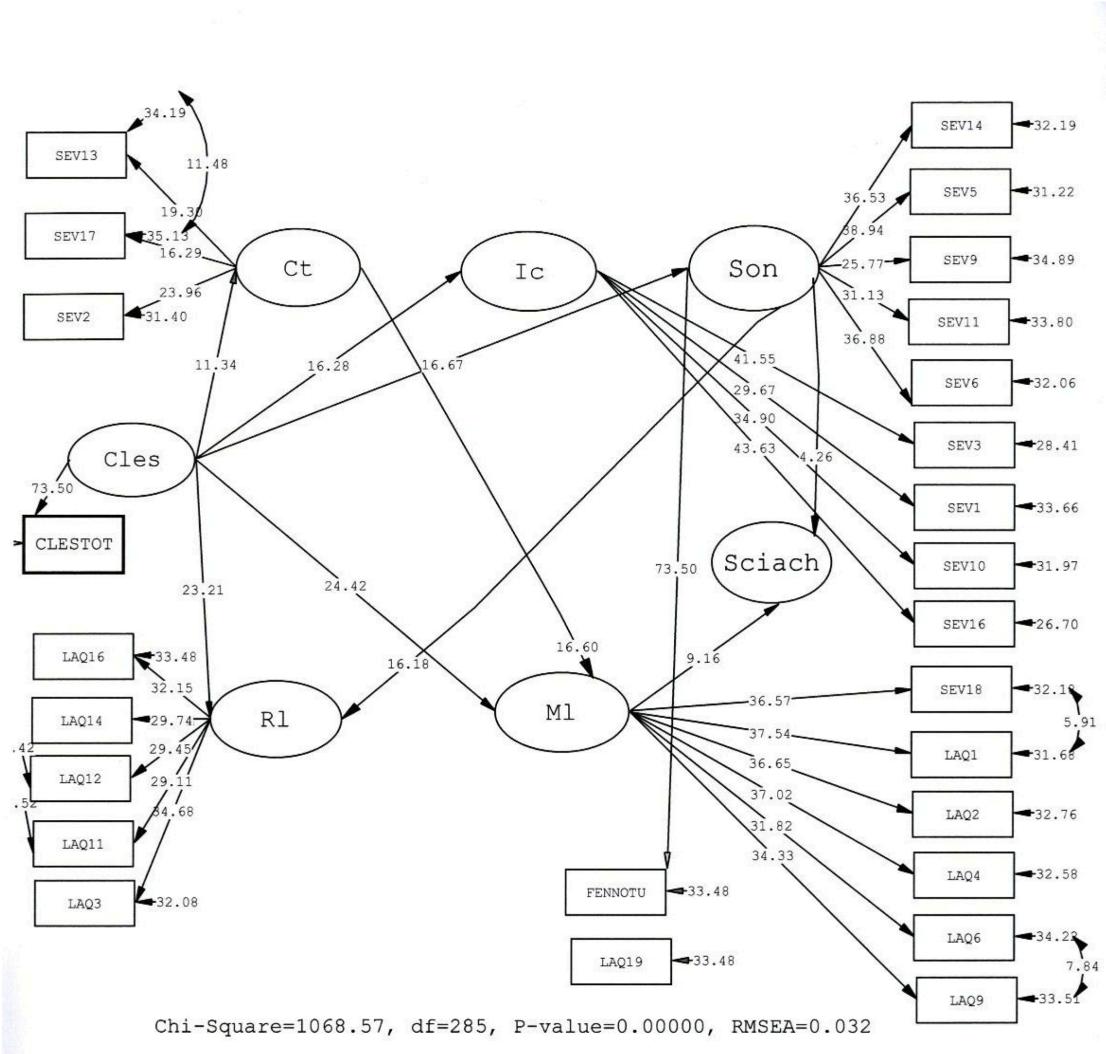

Figure A.2 The basic model with t-values

APPENDIX F

GOODNESS-OF-FIT STATISTICS

Degrees of Freedom = 285
Minimum Fit Function Chi-Square = 1034.327 (P = 0.0)
Normal Theory Weighted Least Squares Chi-Square = 1068.567 (P = 0.0)
Estimated Non-centrality Parameter (NCP) = 783.567
90 Percent Confidence Interval for NCP = (687.200 ; 887.493)

Minimum Fit Function Value = 0.383
Population Discrepancy Function Value (F0) = 0.290
90 Percent Confidence Interval for F0 = (0.254 ; 0.329)
Root Mean Square Error of Approximation (RMSEA) = 0.0319
90 Percent Confidence Interval for RMSEA = (0.0299 ; 0.0340)
P-Value for Test of Close Fit (RMSEA < 0.05) = 1.000

Expected Cross-Validation Index (ECVI) = 0.444
90 Percent Confidence Interval for ECVI = (0.409 ; 0.483)
ECVI for Saturated Model = 0.260
ECVI for Independence Model = 9.703

Chi-Square for Independence Model with 325 Degrees of Freedom = 26155.193
Independence AIC = 26207.193
Model AIC = 1200.567
Saturated AIC = 702.000
Independence CAIC = 26386.638
Model CAIC = 1656.083
Saturated CAIC = 3124.513

Root Mean Square Residual (RMR) = 0.0886
Standardized RMR = 0.0228
Goodness of Fit Index (GFI) = 0.970
Adjusted Goodness of Fit Index (AGFI) = 0.964
Parsimony Goodness of Fit Index (PGFI) = 0.788

Normed Fit Index (NFI) = 0.960
Non-Normed Fit Index (NNFI) = 0.967
Parsimony Normed Fit Index (PNFI) = 0.842

Comparative Fit Index (CFI) = 0.971
Incremental Fit Index (IFI) = 0.971
Relative Fit Index (RFI) = 0.955

Critical N (CN) = 897.908

VITA

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EDUCATION

Degree	Institution	Year of Graduation
MS	METU SSME.	2004
BS	METU SSME	2001
High School	Gazi High School, Antalya	1995

WORK EXPERIENCE

Year	Place	Enrollment
2008 December-Present	Teachers Academy Foundation	Senior Trainer
2007 -2009	Educational Volunteers Foundation of Turkey	Measurement and Evaluation Coordinator
2001-2007	METU, Department of Elementary Education	Research Assistant

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