STUDENT AND SCHOOL CHARACTERISTICS RELATED TO ELEMENTARY STUDENTS NATURE OF SCIENCE VIEWS

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy.

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ABSTRACT

STUDENT AND SCHOOL CHARACTERISTICS RELATED TO
ELEMENTARY STUDENTS NATURE OF SCIENCE VIEWS

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The purposes of this study were to explain the development and validation of a new instrument for assessing elementary students' views of the Nature of Science (NOS) and to investigate student and school level factors that help to explain the difference in NOS views. The sample included 3,062 elementary students elementary schools located in Çankaya. Different from these students, 782 elementary students were the sample for the first focus of this study. The Nature of Science Instrument, Learning Approach Questionnaire and Achievement Motivation Questionnaire were administered to the students. Hierarchical Linear Modeling (HLM) was selected as a modeling technique because of the nested structure of the data sets. This study provides an instrument for measuring elementary student views of the NOS regarding four dimensions. In this study, students had different views regarding each dimensions, therefore, many variables have been shown to relate to different dimensions of NOS. This study has established the importance of student socio-economic background with varying learning approaches, self-efficacy, and motivational goals in forming their NOS views. Findings revealed that quality of the physical infrastructure of schools and quality of educational resources in school, parent educational levels, student achievement, self efficacy, experience with meaningful learning, and learning goal orientation are positively related to student NOS views in many different dimensions. Additionally, performance goal orientation and rote learning approaches have negative relationship with different dimensions of student NOS views.

Keywords: Nature of Science, Student Level Factors, School Level Factors, Elementary Students, Hierarchical Linear Modeling.

ÖZ

İLKÖĞRETİM ÖĞRENCİLERİNİN BİLİMİN DOĞASINA YÖNELİK ALGILARI İLE İLİŞKİLİ ÖĞRENCİ VE OKUL DEĞİŞKENLERİ

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Bu çalışmanın amacı ilköğretim öğrencilerinin bilimin doğasına yönelik algılarını ölçmeyi amaçlayan bir ölçek geliştirmek ve öğrenci ve okul ile ilgili değişkenlerin öğrencilerin bilimin doğasına yönelik algılarını ne ölçüde açıklayabildiğini incelemektir. Çalışmanın örneklemini Çankaya' Ankara da öğrenim gören 3,062 ilköğretim öğrencisi oluşturmaktadır. Çalışmanın birinci amacı için, örneklem bu öğrencilerden farklı 782 ilköğretim öğrencisinden oluşmaktadır. Öğrencilere bilimin doğası ölçeği, öğrenme yaklaşımı anketi ve başarı motivasyonu anketi uygulanmıştır. Verinin guruplanmış yapısından ötürü, modelleme yöntemi olarak aşamalı doğrusal modelleme yöntemi seçilmiştir. Bu çalışma ilköğretim öğrencilerinin bilimin doğasına yönelik algılarını dört boyutta ölçebilmek için güvenilir ve geçerli bir ölçek sunmuştur. Öğrencilerin bilimin doğasına yönelik algıları değişik alt boyutlarda faklılıklar göstermektedir. Bu nedenle farklı öğrenci ve okul ile ilgili değişkenler bilimin doğasına yönelik farklı alt boyutlarla değişik yönlerde ilişkilidirler. Bu çalışma öğrencilerin öğrenme yaklaşımları, öz-yeterlikleri ve motivasyon amaçları ile birlikte çeşitlilik gösteren sosyoekonomik statülerinin onların bilimin doğasına yönelik algılarının şekillenmesindeki önemini vurgulamaktadır. Sonuçlar okulun fiziksel altyapısının, eğitsel kaynakların kalitesinin, öğrencilerin ailelerinin eğitim seviyelerinin, öğrenci başarısının, öz-yeterliklerinin, anlamlı öğrenme yaklaşımlarının, öğrenmeye yönelik motivasyon amaçlarının öğrencilerin bilimin doğasının değişik boyutlarına yönelik algıları ile pozitif yönde ilişkili olduğunu ortaya koymuştur. Sonuçlar aynı zamanda öğrencilerin performansa yönelik motivasyon amaçlarının, ezberleme ile ilgili öğrenme yaklaşımlarının, öğrencilerin bilimin doğasının değişik boyutlarına yönelik algıları ile negatif yönde ilişkili olduğunu ortaya koymuştur.

Anahtar Kelimeler: Bilimin Doğası, Öğrenci ile ilgili değişkenler, Okul ile ilgili değişkenler, İlköğretim öğrencileri, Hiyerarşik Lineer Modelleme.

To my beloved family who make life meaningful.
Words fail to describe their significance in my life

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SYMBOLS	
ABILITYG	Ability grouping between science classes
AGFI	Adjusted Goodness of Fit Index
CFA	Confirmatory Factor Analysis
COST	Conceptions of Scientific Theories Test
DOCUMENT	Whether they watch documentary film
DUMMYCOL	Parents' education level (College) (PEL)
DUMMYGRA	Parents' education level (Graduate)
DUMMYLIK	The course they like most
ECVI	Expected Cross Validation Index
EFA	Exploratory Factor Analysis
EMPIRICA	Empirical NOS
FAST	Facts about Science Test
FEMALESC	Proportion of female science teachers
GENDER	Gender
GFI	Goodness of Fit Index
GRADE7	7^{th} Grade level (GRADE)
GRADE8	8^{th} Grade level (GRADE)
HIGHINCS	School socio economic status (High)
IMEGCRAT	Imagination and Creativity
INCOMEHI	High Socio economic status (SES)
INCOMEME	Medium socio economic status (SES)
INTERNET	Whether they benefit from internet sites regarding science
KMO	Kaiser-Meyer-Olkin
LEARNGOA	Learning goal orientation
LIKINGSC	Student attitude toward science
LOWINCS	School socio economic status (Low)

MEANINGF	Meaningful learning approach
M-NSKS	Modified Nature of Scientific Knowledge Scale
NC	Normed Chi-Square
NOS	Nature of science
NOSI	Nature of science instruments
NOSS	Nature of Science Scale
NOST	Nature of Science Test
NSKS	Nature of Scientific Knowledge Scale
OBSVINF	Observation and Inferences
PARENTOC	Parents' occupational status
PERFGOAL	Performance goal orientation
PHYSICAL	Quality of school's physical infrastructure
PNSS	Pupils' Nature of Science Scale
QUALITYE	Quality of school's educational resources
READINGB	Whether they read articles or books regarding science
RMSEA	Root Mean Squared Error of Approximation
ROTELEAR	Rote learning approach
SCIENGRA	Science achievement
SELFEFFI	Self efficacy
SEVs	Students' Epistemological Views of Science
SHARINGI	Whether they share their ideas about science subject with their families
SPI	Science Process Inventory
SRMR	Standardized Root Mean Squared Residual
SSS	Science Support Scale
SUSSI	Student Understanding of Science and Scientific Inquiry
TENTATIV	Tentative NOS
TOUS	Test on Understanding Science
TSAS	Test on the Social Aspects of Science

VNOS	Views of Nature of Science
VOSE	Views on Science and Education Questionnaire
VOSTS	Views on Science-Technology-Society
WISP	Wisconsin Inventory of Science Processes

CHAPTER I

INTRODUCTION

Student understanding of the nature of science (NOS) has become a key issue in recent discussions concerning science education (Abd-El-Khalick, Bell, & Lederman, 1998; Dush, 1990; Griffiths & Barry, 1993; Huang, Tsai & Chang; 2005; Kang, Scharmann & Noh, 2005; Khishfe & Abd-El-Khalick, 2002; Khishfe & Lederman, 2006). The NOS has been described as "the epistemology of science, science as a way of knowing, or the values and beliefs inherent in the development of scientific knowledge" (Abd-El-Khalick & Lederman, 2000, p.666). Although no definition for the NOS is agreed on by all philosophers and sociologists of science, they do agree on several aspects of scientific knowledge: scientific knowledge is tentative, empirically based, subjective, partly the product of the human imagination and creativity, and socially and culturally embedded (Abd-El-Khalick & Lederman, 2000). In addition, during the scientific process one must make distinctions between observations and inferences, and also understand the relationships between scientific theories and laws (Abd-El-Khalick, Bell, & Lederman, 1998; Khishfe & Lederman, 2006; Schwartz & Lederman, 2007). The characteristics of scientific knowledge are explained using the framework proposed by Lederman, Abd-El-Khalick, Bell and Schwartz (2002).

Definitions of the characteristics of scientific knowledge;

The Tentative Nature of Scientific Knowledge (Tentative NOS): As there are advances in technology and thought, there will always be change on the existent scientific claims. Contrary to common belief scientific hypotheses, theories, and laws are prone to be disproved. Hence, since each case of theories is changeable, scientific knowledge can be viewed as tentative.

The Distinction between Observation and Inferences (Observation and Inferences): While observation can be distinguished as descriptive statement which can be perceived by the senses, inferences are statements that go beyond our senses that are not directly accessible to them. The comprehension of the differences between them is imperative in the internalization of terms and entities in science.

The Empirical Nature of Scientific Knowledge (Empirical NOS): Science at least partially based on observations of the natural world, and "sooner or later, the validity of scientific claims is settled by referring to observations of phenomena (AAAS, 1990,p.4)" (as cited in Lederman, Abd-El-Khalick, Bell & Schwartz, 2002) . Nevertheless, due to the fact that natural phenomena are not always observable, perceptions of these phenomena are possible via the theoretical frameworks within the perceiver.

The role of Imagination and Creativity in generating scientific knowledge (Imagination and Creativity): Science is empirical. For the advancement of science and explanation of scientific phenomenon, not only making observations of nature but also human imagination and creativity are essential.

Curriculum-reform studies address NOS issue worldwide, in countries as disparate as Canada, Venezuela, Taiwan, Lebanon, and Turkey (Dogan & Abd-El-Khalick, 2008). In Turkey, the vision of a new curriculum for science and technology course to emphasize the importance of having scientifically literate students, regardless of their individual differences (Ministry of National Education –MoNE-, 2008). The major skill of scientific literacy can be summarized as the ability to understand not only basic scientific concepts, but also the nature and development of science and scientific knowledge. This skill is critical because it allows individuals to make personal decisions in a society that is becoming highly dependent on science and technology (Dogan & Abd-El-Khalick, 2008; Lawson, 1995). Hurd (1998) describes some characteristics of scientifically literate persons as follows;

a) Understands the nature of scientific knowledge,

b) Applies appropriate science concepts, principles, laws, and theories in interacting with his universe,

c) Uses the process of science in solving problems, making decisions, and furthering his own understanding of the universe,

d) Interacts with values that underlie science,

e) Understands and appreciates the joint enterprises of science and technology and the interrelationship of these with each and with other aspects of society,

f) Extends science education throughout his or her life,

g) Develops numerous manipulative skills associated with science and technology (as cited in Yuenyong & Narjaikaew, 2009, p.336).

In Turkey the new science and technology curriculum was implemented nationwide in the sixth and seventh grades and piloted in the eight grades for the 2008 academic year. The new curriculum and textbooks emphasizes the importance of NOS. Thus both students and teachers were introduced to NOS aspects in the sixth and seventh grades. In this new curriculum some important features are emphasized. According to new curriculum, scientific method includes observation, stating hypotheses, collecting data, testing hypotheses, rejecting or accepting hypotheses, and interpreting data. It is stated that Imagination, creativity, objectivity, inquiry, and being openness to new ideas are all important in scientific processes. In science and technology education students should learn the way of attaining knowledge. When students learn new things through discovery, they should reconstruct their knowledge again. Also in the curriculum it is emphasized that knowledge in science is not constant but it is the best explanation known. Moreover, the new curriculum aims creating awareness of scientific methods in addition to scientific literacy per se. When these features are considered, the new science and technology curriculum embraces a “constructivist approach”. However, the previous science curriculum was student-centered and focused on the scientific method and investigation processes. However one of the most important differences between the new curriculum and the previous one is that, while the new curriculum has a spiral structure, the previous curriculum had a linear structure.

As a result of the integration of NOS in the curriculum worldwide, determining not only students’ and but also teachers’ understanding of NOS, has gained a high priority for science education and their researchers. Generally, researchers have explored students’ views about the NOS through qualitative methods (Griffiths & Barman, 1995; Griffiths & Barry, 1993; Sadler, Chambers, & Zeidler, 2004). Elementary school student understanding of the NOS has also been investigated qualitatively (Shiang-Yao & Lederman, 2002; Khishfe, 2008; Khishfe & Abd-El-Khalick, 2002; Khishfe & Lederman, 2006; Khishfe & Lederman, 2007).

In addition to qualitative research determining how students at different ages view NOS, researchers both in western cultures and non-western cultures have also investigated student views by using different instruments such as the Test on Understanding Science (TOUS) developed by Cooley and Klopher (1961), Nature of Scientific Knowledge Scale (NSKS), developed by Ruba and Anderson (1978), Views on Science-Technology-Society (VOSTS) developed by Aikenhead, Fleming, and Ryan (1987). In addition, there are some newly developed instruments; these are Pupils’ Nature of Science Scale (PNSS) developed by Huang et al. (2005), Student Understanding of Science and Scientific Inquiry (SUSSI) developed by Liang, Chen, Chen, Kaya, Adams, Macklin, and Ebenezer (2008), Views on Science and Education Questionnaire (VOSE) developed by Chen (2006), and Students' Epistemological Views of Science (SEVs) developed by Tsai and Liu (2005). Most of these instruments developed for high school or college level students. Table 1.1 provides a summary of these instruments and some others which were developed for measuring student NOS views.

Table 1.1 The Instruments Developed for Measuring Multi-Dimensional Characteristics of NOS

Instrument	**Year**	**Researchers**	**Target**	**Dimensions**
FAS	1954	Wilson	HSS	• science as an institution in society • knowledge of scientist as an occupational group
TOUS	1961	Cooley & Klopher	HSS	• scientific enterprise • the scientist • methods and aims of science
SPI and WISP	1967	Welch & Pella Scientific Literacy Center	HSS	• scientific activities • scientific assumptions • products and ethics of science
SSS	1968	Schwirian	HSS and CS	• rationality • utilitarianism • universalism • individualism • progress • meliorism
NOSS	1968	Kimball	CS	• curiosity in physical universe • curiosity in dynamic on-going activity • ever-increasing comprehensiveness and simplifications • scientific method • characteristics of the scientific method • a faith in the susceptibility of the physical universe • openness in science • tentativeness and uncertainty

Table 1.1 (Continued)

Instrument	Year	Researchers	Target	Dimensions
NOST	1975	Billeh & Hasan	CS	• Assumptions of science • Products of science • Processes of science • Ethics of science
VOST	1975	Hillis	HSS	• understanding of the tentativeness of science
TSAS	1969	Korth	HSS	• science and technology • science and society • nature of science • characteristic of science • scientists' role in society
NSKS	1978	Rubba & Andersen	HSS and CS	• science is amoral • science is creative • science is developmental • science is parsimonious • science is testable • science is unified
COST	1981	Cotham & Smith	CS	• ontological implications of theories • testing of theories • generation of theories • choice among competing theories
VOSTS	1987	Aikenhead , Fleming & Ryan	HSS	• science and technology • influence of society on science/technology • influence of science/technology on society • influence of school science on society • characteristic of scientist • social construction of scientific knowledge • social construction of technology • nature of scientific knowledge
VNOS-A, VNOS-B VNOS-C VNOS-D VNOS-E	2002	Lederman et al.	CS ES	• the tentative nature of scientific knowledge • the empirical nature of scientific knowledge • the theory-laden nature of scientific knowledge • the social and cultural embeddedness of scientific knowledge • the creative and imaginative nature of scientific knowledge • observations, inference, and theoretical entities in science • scientific theories and laws

Table 1.1 (Continued)

Instrument	Year	Researchers	Target	Dimensions
PNSS	2005	Huang et al.	ES	• changing NOS • role of social negotiation • cultural context
SEVs	2005	Tsai & Liu	HSS	• the changing and tentative feature of science knowledge • the invented and creative nature of science • the cultural impacts • the theory-laden exploration • the role of social negotiations
VOSE	2006	Chen	CS	• nature of observations • tentativeness • use of imagination • validation of scientific knowledge • theories and laws • scientific methods • subjectivity and objectivity
SUSSI	2008	Liang et al.	CS	• observations and inferences • tentativeness • creativity and imagination • scientific theories and laws • social and cultural embeddedness scientific methods

Target: CS: College Students, HSS: High School Students, ES: Elementary Students
Instruments: FAS: Facts about Science Test, TOUS: Test on Understanding Science, SPI: Science Process Inventory, WISP: The Wisconsin Inventory of Science Processes, SSS: Science Support Scale, NOSS: Nature of Science Scale, TSAS: Test on Special Aspect of Science, NSKS: Nature of Scientific Knowledge Survey, VOSTS: Views on Science-Technology-Society, VNOS: Views of Nature of Science, PNSS: Pupils' Nature of Science Scale, SEVs: Scientific Epistemological Views, VOSE: Views on Science and Education Questionnaire, SUSSI: Student Understanding of Science and Scientific Inquiry

Although many studies have investigated the NOS views of high school students (e.g., Chen, 2006; Griffiths & Barman, 1995; Griffiths & Barry, 1993; Lederman & O'Malley, 1990; Liang et al., 2008; Ryan & Aikenhead, 1992) and college students (e.g., Abd-El-Khalick, et al., 1998; Bell, Lederman, & Abd-El-Khalick, 2000; Eichinger, Abell, & Dagher, 1997; Lederman, Schwartz, Abd-El-Khlick, & Bell, 2001; Pomeroy, 1993; Tsai & Liu, 2005), in both western and nonwestern countries, only a limited number of studies have examined the views of students in elementary school settings (Akerson & Volrich, 2006; Huang et al., 2005; Kang, Scharmann & Noh, 2005; Khishfe, 2008; Khishfe & Abd-El-Khalick, 2002; Khishfe & Lederman, 2006; Khishfe & Lederman, 2007; Shiang-Yao & Lederman 2002). Most studies conducted at the elementary level were qualitative in nature; and in them, researchers tried to provide in more detail information and an explanation about NOS views of participants. However, in parallel with the globalization efforts in education (e.g., PISA and TIMMS), researchers need some general information about students' NOS views to better help these students develop sound NOS views. Quantitative studies can provide adequate "snapshot" information about different populations regarding their NOS views. This information can be valuable for administrators, curriculum developers, and policy makers who decide *how* and *what* to teach about the NOS.

Moreover, most of the qualitative studies reveal similar results regarding students' views about the characteristics of the NOS; for example high school and college students had a naive understanding about the social embeddedness of scientific knowledge and the relationships between scientific theories. Few studies have been conducted at the elementary level and these were mainly qualitative. Moreover, the studies revealed that students have naive understandings about the tentative, empirical, inferential, and creative aspects of the NOS. The results of these studies clearly indicate that the findings were consistent across different age groups and countries. Thus, by considering these consistent themes, it is necessary to investigate patterns across a large sample. To achieve this, it is necessary to develop valid and reliable instruments which can measure the students' concept of the NOS.

Many studies have explored gender and grade-level differences regarding student NOS views (e.g., Huang et al., 2005; Kang, Scharmann & Noh, 2005; Dogan & Abd-El-Khalick, 2008). Although there are some studies investigating the effect of some students' characteristics such as gender and grade level, it is crucial to investigate the effect of any other factors reflecting the individual differences. Individual differences play an important role in student learning (Koran & Koran, 1984). In addition to academic success, individual differences related to other factors such as learning approaches, motivation, cognition, and anxiety have been studied (Debacker & Nelson, 2000; Garcia & Pintrich, 1992; Lin & McKeachie, 1999; Qian, 1995; Koran & Koran, 1984; Zhang, 2000).

The findings of Edmondson's study (1989) as well as those by Edmondson and Novak (1993), reflect the relation between student views about NOS, their definitions of learning, and their approaches to studying and learning science. Learning approaches are categorized as meaningful learning approaches and rote learning approaches (Cavallo, Rozman, & Potter, 2004).

Cavallo (1996) explained Ausubel's *meaningful learning* as "the formulation of relationships between ideas, concepts, and information of science". When learner integrates the new idea or concept into his or her related concepts, learning will be meaningful. According to the theory, if they can't do this they may resort to using rote learning. In *rote learning*, newly learned knowledge is not associated or linked with prior relevant knowledge the learner already possesses. In this case, students do not associate what they learned with conceptual relationships, and memorize science facts. Novak (1988) thought that rote learning prevents students' meaningful learning of new science ideas and "interferes with their formulation of scientific understanding" (Cavallo et al., 2004, p.289).

Student meaningful understanding of scientific concepts is one of the goals of science education. When a learner integrates the new idea or concept into his/her existing concepts, and structures, learning will be meaningful. During this integration, being aware of prior knowledge and linking this knowledge with newly presented knowledge by engaging in a learning task constitute the main ingredients of the meaningful learning (Ausubel, 1963). Continuous integration of concepts helps the learner form meaningful learning sets. When the learner cannot integrate new concepts with their prior knowledge, they tend to use rote learning and express their understanding with the definitions of these concepts as isolated facts (Ausubel, 1963; Cavallo, Rozman, Larabee, & Ishikawa, 2001). Researchers have argued that rote learning prevents meaningful learning of new scientific concepts (Cavallo, Rozman, Blickenstaff, & Walker, 2003; Cavallo et al., 2004; Novak, Ring, & Tamir, 1971). Being successful in both rote and meaningful learning depends on the willingness of the learning and their tendency to make connections among concepts. In other words, it depends on learners' motivation to learn. The recent approaches investigate the motivation regarding goal orientations, interest and emotions, and self-perceptions (Woolfork, 2004, Murph & Alexander, 2000). In this study, goal orientations (motivational goals) and self-efficacy as one of the dimension of self-perceptions were explored to determine student motivation to learn. Motivational goals were derived from Bandura's social cognitive theory. According to Bandura "goal" is an important motivational process. Student motivation goals can be affected by peers or academic achievement (Pintrich & Schunk, 2002). *Motivation* is defined as "an internal state that arouses directs, and maintains behavior" (Woolfork, 2004, p.350). According to Pintrich (2002) "*motivational goals* includes not just the purposes or reasons for achievement, but reflects a type of standard by which individuals judge their performance and success of failure in reaching that goal" (Pintrich & Schunk, 2002, p.214). This quotation indicates that goal orientation consists of two dimensions: one is related to students' interest to learn something new and the other is related to the students' interest to get higher course grades (Cavallo et al., 2004). Dweck (1986) categorized these sub dimensions as learning oriented versus performance oriented. *Learning orientation* can be exemplified as learning something new, learning for the sake of learning, or improving oneself (Ames & Archer, 1988). *Performance orientation* can be exemplified as earning high grades, getting praise or performing better than the other students (Ames &

Archer, 1988). *Self-efficacy* is defined as “people’s judgments of their own capabilities to organize and execute courses of action required to attain designated types of performances” (Bandura, 1986, p.391). Self-efficacy focuses on this particular question “Can I do this task in this situation?” (Pintrinch & Schunk, 2002).

In literature there is an abundant number of studies available concerning about learning approach, goal orientations, and self-efficacy. Also in some studies, these factors are investigated together to explain student academic achievement. Development of epistemological beliefs is also associated with academic performance (Cavallo et al., 2003; Cavallo et al., 2004) and their learning approach (Schommer, 1990; Tsai 1998a, Tsai 1998b). Motivational goal and self-efficacy are also important factors that influence academic achievement (Bandura, 1993; Hacieminoglu, Yilmaz-Tuzun, & Ertepinar, 2009). Moreover, there are some studies related to the relationship between student efficacy beliefs and goal orientation. Literature reveals contradictory findings about academic efficacy. Academic efficacy is positively related to mastery goal orientation (Anderman & Young, 1994; Middleton & Midgley, 1997; Wolters, Yu & Pintrich, 1996) but relationship between academic efficacy and performance goal orientation is unclear (Middleton & Midgley, 1997). Learning goal orientation was the most important motivational factor in predicting student course achievement. Learning goal was positively related to the meaningful learning and tentative view of science (Cavallo et al., 2003). Literature also reveals positive relationships among self-efficacy, meaningful learning, and learning goals (Cavallo et al., 2003; Cavallo et al., 2004). Kizilgunes, Tekkaya and Sungur (2009) also investigated the relationship between achievement and epistemological beliefs, achievement motivation, and learning approach. They found that epistemological beliefs influence the learning approaches directly and also influence learning approach and achievement indirectly, since epistemological beliefs have direct effects on achievement motivation. On the other hand, Schommer (1993) investigated the direct relationship between beliefs about knowledge and high school students' GPA. The findings revealed that students supporting the idea that scientific knowledge is certain have lower GPA than the others. According to Hofer and Pintrich (1997), epistemological beliefs include learners' theories about knowing, the nature of knowledge, and knowledge acquisition (as cited in Kizilgunes et al., 2009). Moreover, Buehl's (2003) model proposed the model illustrating the association between student beliefs, achievement motivation and learning outcomes. Buehl's model hypothesizes that student epistemological beliefs have a direct influence on student motivation and learning strategies they use and have indirect effects on their achievement and academic performances. Literature also supports the idea that the more constructivist epistemological beliefs the students have, the more dynamic nature of scientific knowledge they support (Tsai, 1998a). Therefore the factors influencing students' epistemological beliefs and achievement might have effect on students' NOS views.

On the basis of this literature in this study, it might be expected that student learning approaches and motivational goals have an influence on students' NOS views. Therefore, in this study these factors were selected as one of the student level factors. Furthermore Yore, Anderson, and Shymansky (2002) have investigated the relationships among science achievement, student characteristics, and classroom factors. Results indicates that student level factors such as awareness of the nature of science, attitudes toward science, science and technology careers; school level factors like teacher characteristics, classroom environmental factors, parent home and community involvement have an influence on students' science achievement for different grade levels. That study reflects the fact that school level factors should be considered while investigating factors that influence student achievement.

The present study intended to develop the Nature of Science Instrument (NOSI) for elementary students and to investigate which of the students and school level factors helped best explain the difference in understanding the NOS views.

1.1 Significance of the Study

In this study, the Nature of Science Instrument (NOSI) was developed to measure elementary students' NOS views. As well as the development of this instrument, this study proposes a hierarchical linear model among NOS and other related factors to achievement.

In this study an instrument (NOSI) was developed for use in elementary school settings. It is proposed that valid and reliable instruments like NOSI will be helpful for researchers in testing the theoretical issues. For example, researchers argue that rather than implicit NOS teaching, the NOS should be taught explicitly because it would improve understanding of the NOS. Making these instruments widely available may assist researchers who intend to test this assumption with experimental designs.

Additionally, researchers have suggested that it is crucial to determine and improve students' understanding of the multi-dimensional characteristics of the NOS (Cotham & Smith, 1981; Huang et al., 2005; Tsai, 2002) and have used different Likert-type instruments to assess different sub-dimensions and characteristics of the NOS.

According to Aikenhead (1973), TOUS, SPI, TSAS, WISP, NOSS, and FAS have limited utility. For example, these instruments always measured the degree to which learning about science and scientists had been made explicit in science courses. In other words, these instruments measure student knowledge about science and scientists. Aikenhead (1973) also argued that these instruments were better suited for experimental research designs that stressed the *content* of science lessons. These instruments failed to address student NOS views in any particular science classroom, because each teacher has his/her own characteristics and uses varying teaching strategies. Moreover, these instruments were not parallel with the currently accepted characteristics of the NOS, as suggested by Abd-El-Khalick et al. (1998) and Lederman, Wade, and Bell (1998). However, even though SUSSI, VOSE, and SEVs included recently accepted characteristics of the NOS (as suggested by Abd-El-Khalick et al. 1998), they were developed for pre-service teachers or high school students. Of these instruments only PNSS was developed to assess 5th and 6th graders. Therefore, NOSI would be a valuable instrument for researchers interested in measuring elementary students' NOS views according to the currently accepted characteristics of the NOS.

Furthermore, most studies have focused on how to change students' NOS views, through interventions. The majority of these studies emphasized that students at different grade levels hold inadequate views regarding the characteristics of the NOS. More important is that these studies also reveal that students develop understanding of the NOS at early grade levels. This is crucial since studies have also shown that it is very difficult to exchange a student's pre-existing conception of the NOS with a scientifically accepted one. Thus, it is critical that elementary school student views concerning the NOS should be determined as early as possible (Kang, Scharmann & Noh, 2005; Meichtry, 1992). NOSI can serve as a tool for researchers to attain this most important goal. Although there are some studies investigating the effect of some student characteristics such as gender and grade level, it is crucial to investigate the effect of other student level factors such as students' background characteristics, factors related to students characteristics, factors related to student feelings and outside activities, learning and motivational factors.

Finally, in educational research area, importance of studies related to achievement has increased in elementary school. Therefore, new factors contributing to students learning have also become an important issue in recent years (Ma & Klinger, 2000). The factors which influence student learning has hierarchical structure such as students nested within schools or classrooms. Thus, it is recommended that researchers should consider not only student level factors but also school or classroom level factors in relation to student academic achievement (Ma & Klinger, 2000; Raudenbush & Bryk, 2002; Willms & Raudenbush, 1989). In this study, students NOS views are investigated considering these issues.

Therefore the primary purpose of this study is (1) to develop nature of science survey for elementary students. Other purposes of this study are (2) to describe elementary students NOS views, (3) to examine that the differences in students’ NOS views among schools, (4) to determine which of the school level factors are associated with students’ NOS views, (5) to investigate which of the student level factors (student background characteristics, factors related to students characteristics, factors related to student feelings and outside activities, learning and motivational factors) which help to explain the difference in understanding the nature of science (NOS) views, (6) to examine whether school level factors predict student NOS views and the strength of associations between students NOS views and student level factors.

1.2 Research Questions of this Study

1. Which of the tenets do explain elementary school students' NOS views?
2. What are the elementary students views about NOS regarding the tenets determined in the first question?
3. Are there any differences in students' NOS views among schools?
4. Which of the school level factors are associated with students' NOS views?
5. Which of the student level factors are associated with students' NOS views?
6. Whether school level factors predict student NOS views and the strength of associations between students NOS views and student level factors?

CHAPTER II

REVIEW OF THE LITERATURE

This chapter aims to present previous studies that have produced theoretical and empirical background for this study. These studies are related to both the instruments developed for measuring nature of science views of students, students' nature of science views and which factors influence such students NOS views.

2.1 The Instruments Developed for Measuring Students' Nature of Science Views

The development and assessment of students' NOS views have been an issue for science educators for over 40 years. During the past 40 years more than 30 different types of instruments including agree/disagree, Likert- type, multiple choice have been developed and used to assess students' NOS views (Lederman, 2007; Lederman et al., 2002).

One of the most widely used "paper and pencil" instruments is the Test on Understanding Science (TOUS), developed by Cooley and Klopher (1961). This instrument includes sixty items, in a multiple choice test, to evaluate junior high school students' understanding of science. It focuses on three dimensions, namely 1) understanding the scientific enterprise, 2) the scientist, and 3) the methods and aims of science. Reliability of this instrument was reported as .76. Welch (1969) criticized this instrument in terms of validity and suggested reorganizing all the items under two different subscales: the social aspects of science and the nature of scientific inquiry. Mackay (1971) assessed Australian secondary student views of the NOS aspects by using this instrument. The test was administered to 1,556 students at the beginning of a semester and to 1203 students at the end of a semester. Findings indicate that the students had insufficient perceptions about the function of scientific models, the role of creativity in science, and the differences among hypotheses, laws and theories. Moreover, TOUS was adapted by Jungwirth (1970) for Israeli Biological Science Curriculum Study (BSCS) adaptation project. This version of TOUS includes 53 items with the reliability of .73 for 9th grade and .77 for the 10th grade students. Before it was developed in 1961, there were some attempts to develop similar instruments. One of them was Facts about Science Test (FAST) developed by Stice (1958). This instrument included two subscales, namely understanding of science as an institution in society (38 items), and Knowledge of scientists as an occupational group (40 items). Since there were no statistical data related to reliability of FAST, the more improved instrument (TOUS) was developed. Therefore, two subscales of TOUS are very similar to FAST. Other similar instruments with TOUS consist of Science Process Inventory (SPI) Welch & Pella, 1967) and Wisconsin Inventory of Science Processes (WISP) (Scientific Literacy Research Center, 1967).

SPI is composed of 150 items with a forced choice inventory (form C) (agree/disagree). It measures the “understanding of the methods and processes by which scientific knowledge evolves”. Form D, more recent revision of the SPI, contains 135 items focusing on a student’s *awareness* of “the activities, assumptions, products, and ethics of science.” Reliability coefficient of this instrument was reported as 0.86. WISP is very similar to SPI in terms of its content and neither of them possesses any sub-dimensions. The only difference is that WISP contains 93 items with “accurate,” “inaccurate,” or “not understood” choices. However, all of these instruments mentioned were developed for use with high school students. After development of these instruments, Schwirian (1968) developed a likert-type scale named Science Support Scale (SSS) using the five values from Barber’s “Science and the Social Order” (rationality, utilitarianism, universalism, individualism, progress and meliorism). This instrument is appropriate for both high school and undergraduate students.

In 1968 Kimball developed the Nature of Science Scale (NOSS) to measure if science teachers have similar views of science as scientists. Validity and reliability studies were performed on undergraduate students. The instrument included 29 statements with different scoring scheme from the previous ones. The choices are as agree, disagree, and not sure, or neutral about the item. Kimball’s model has eight aspects, namely curiosity in physical universe, curiosity in dynamic on-going activity, ever-increasing comprehensiveness and simplifications, scientific method, characteristics of the scientific method, a faith in the susceptibility of the physical universe, openness in science and tentativeness and uncertainty. Split-half reliability coefficient was reported as 0.72 in preliminary study and 0.54 for the other survey study. The other instrument with different scoring system from the previous one is Test on the Social Aspects of Science (TSAS) developed by Korth (1969). TSAS has 52 statements with five point scale from "strongly disagree" to "strongly agree". This instrument concentrated on the interaction among science, technology and society, social nature of the scientific enterprise, and social and political responsibilities of scientists. TSAS was used to investigate the differences between science-oriented and non-science oriented high school students. TSAS comprises 37 items and five aspects, namely relationship between science and technology, interaction of science and society, understanding the nature of science, the characteristics of science, and the scientists' role in society. Reliability of this instrument was reported as 0.71.

Researchers continued the development of NOS instruments as years passed. Billeh and Hasan developed Nature of Science Test (NOST) in 1975. NOST was comprised of two types of items. One of the types assesses student knowledge related to the assumptions and processes of science, and the characteristics of scientific knowledge, while the other type demands students judgments in view of his/her understanding of the nature of science. NOST includes 60 multiple-choice items related to these aspects: Assumptions of science (8 items), Products of science (22 items), Processes of science (25 items), and Ethics of science (5 items). However, undivided score can be calculated rather than subscale score, which is the major deficiency of this instrument. In the same year Hillis developed Views of Science Test (VOST). VOST consists of 40 items with five- Likert-type format and concentrates on measuring understanding of the tentativeness of science. This instrument was thought to be very specific because of its focus in science.

Another instrument is Nature of Scientific Knowledge Scale (NSKS), developed by Ruba and Andersen (1978) for high school students. Researchers reported nine factors as tentative, public, replicable, probabilistic, humanistic, historic, unique, holistic, and empirical for the dimension of NSKS. Because of the overlapping among the factors, the researchers re-arranged the dimensions and designed a five-point Likert-type scale (*strongly agree, agree, neutral, disagree*, *strongly disagree*) questionnaire which included 48 items and six subscales, namely, being amoral, creative, developmental, parsimonious, testable, and unified. Ruba and Andersen (1978) conducted NSKS's validity and reliability studies for both high school and college students. Reliability coefficient varied between 0.65 and 0.88 for high school and college students. NSKS was modified by Meichtry in 1992 for 6^{th}, 7^{th} and 8^{th} graders. This Modified Nature of Scientific Knowledge Scale (M-NSKS) consists of 32 statements with four subscales of the NSKS, namely creative, developmental, testable, and unified.

As all of the instruments mentioned above were based on single interpretation of NOS until recently, non-judgmental acceptance of science conceptions has been needed. Therefore Cotham and Smith (1981) developed Conceptions of Scientific Theories Test (COST), which is an attitude inventory including of 40 four point-Likert scale items and four subscales, related to specific aspect of scientific theories. These are (I) ontological implications of theories; (II) testing of theories; (III) generation of theories; and (IV) choice among competing theories. This test also supplies a theoretical context for each item sets, these are; 1) Bohr's theory of the atom, 2) Darwin's theory of evolution, 3) Oparin's theory of abiogenesis, and 4) the theory of plate tectonics. This instrument was prepared for teachers and the validity studies were applied on undergraduate college students. Hence cognitive level of COST might not be appropriate for high school students.

Another instrument which is different from all extant instruments in terms of scoring nature is the Views on Science-Technology-Society (VOSTS), developed and designed for high school students by Aikenhead et al. (1987) to measure students' understanding of the nature of science, technology, and their interactions with society. Over a six-year period, Aikenhead and Ryan (1992) revised this instrument to enhance validity and reliability. In 1992, the new test was administered to large diverse samples in Canada. The revised VOSTS, concentrated on a wide range of issues related to science, technology, and society; and the number of items increased from 46 to 114 with the increasing number of science-technology-society (STS) issues. These issues are Science and Technology, Influence of Society on Science/Technology, Influence of Science/Technology on Society, Influence of School Science on Society, Characteristics of Scientists, Social Construction of Scientific Knowledge, Social Construction of Technology, and Nature of Scientific Knowledge. The VOSTS was developed and validated for 11^{th} and 12^{th} grade students. This instrument is focused on "self-generated" responses rather than numerical scores. VOSTS includes alternative "student position" statements derived from open-ended student "argumentative" paragraphs and also there is a part in which students can defend their position on STS issue.

Because of the problems during the development of the VOSTS mentioned by Aikenhead et al. (1987) and about the use of paper-and-pencil assessments as in the use of NSKS (Rubba, 1976) (as cited in Lederman, 2007), Views of Nature of Science, Form A (VNOS-A) was developed by Lederman and O'Malley (1990). VNOS-A is a seven-item-open-ended instrument which needs to have follow-up interviews to handle the difficulties with students' open-ended responses. These items are related to different aspects of tentativeness in science.

After VNOS-A was introduced; Critical Incidents instrument was developed by Nott and Wellington (1995) which was different from usual paper and pencil assessments until that time. Nott and Wellington created some "critical incidents" related to the descriptions of actual classroom events instead of merely asking what science is. For each incident, teachers are expected to answer the following three questions: 1) What would you do? 2) What could you do? and 3) What should you do? Even if this instrument is valuable for creating beneficial discussions for undergraduate or graduate courses, teacher views about NOS being connected to their responses was thought to be potentially controversial (Lederman, 2007).

Such type of the instruments initiated improvement with a series of instruments. Views of Nature of Science B, C, D, E (VNOS-B, VNOS-C, VNOS-D, VNOS-E) were developed by modifying and improving the original VNOS-A (Lederman & O'Malley, 1990) by the same research group (Lederman et al., 2002). All of these instruments include open-ended questions that focus on currently accepted dimensions of NOS which are, the tentative nature of scientific knowledge; the empirical nature of scientific knowledge; the theory-laden nature of scientific knowledge; the social and cultural embeddedness of scientific knowledge; the creative and imaginative nature of scientific knowledge; observations, inference, and theoretical entities in science; and scientific theories and laws (Abd-El-Khalick et al., 1998; Lederman et al., 2002; Khishfe & Lederman, 2006; Schwartz & Lederman, 2007). After the development of VNOS series, which was similar to those in western cultures, non-western researchers have recently shown interest in using instrumentation to measure NOS views. Pupils' Nature of Science Scale (PNSS) was developed by Huang et al. (2005) to assess how Taiwanese 5th and 6th graders understand NOS. The instrument was based on changing NOS views, the role of social negotiations in science, and the cultural context of science. This 5-1 Likert type instrument included 15 items (5 items for each subscale). For internal reliability, alpha coefficient was reported 0.68, 0.62, and 0.69, respectively for the three subscales. In another study, Kang, Scharmann and Noh (2005) developed an empirically derived multiple-choice format instrument, by modifying the VOSTS questionnaires originally developed by Solomon, Scott, and Duveen (1996) and Aikenhead et al. (1987). This instrument includes 5 questions with an open-ended section where students can write their responses for each question. These were used to investigate Korean elementary students' views of the NOS. This instrument aims at focusing on purpose of science, definition of scientific theory, nature of the model, tentativeness of scientific theory, origin of scientific theories.

In recent years, there have been some Likert-type instruments used to assess currently accepted dimensions of NOS (Lederman et al., 2002). One of the newest Likert-type instruments is the Student Understanding of Science and Scientific Inquiry (SUSSI), developed by Liang et al. (2008). A final version of SUSSI includes both 24 Likert-type items (4 items for each dimension) and 6 open-ended questions (1 open-ended questions for each dimension) in an effort to assess pre-service teachers' NOS views in terms of six aspects: observations and inferences ($\alpha = 0.61$), tentativeness ($\alpha = 0.56$), scientific theories and laws ($\alpha = 0.48$), social and cultural embeddedness ($\alpha = 0.64$), creativity and imagination (α = 0.89), and scientific methods (α = 0.44). Validity and reliability studies were conducted. Cronbach alpha reliability for the whole instrument was determined to be as 0.69. Another one is the Views on Science and Education Questionnaire (VOSE), developed by Chen (2006). Both were designed to assess college students' concerning NOS views. VOSE was developed by selecting some items from VOSTS and modifying them according to the results of interviews carried out for American and Taiwanese pre-service secondary science teachers (Chen, 2006). This instrument included 15 questions; each question had a different number of related items. A total of 85 follow-up items include seven dimensions: tentativeness (α = 0.34), nature of observations (α = 0.47), scientific methods (α = 0.48), theories and laws (α = 0.70), use of imagination (α = 0.71), validation of scientific knowledge (α = 0.44), and subjectivity and objectivity (α = 0.69). The other Likert-type instrument was developed by Tsai and Liu (2005)—the Students' Epistemological Views of Science (SEVs) Test. This instrument was constructed to assess NOS views of high-school students and included 19 items with 5 point Likert-scale in five dimensions: the role of social negotiation in science (α = 0.71), the invented and creative reality of science (α = 0.60), the theory-laden exploration of science (α = 0.68), the cultural impact on science (α = 0.71), and the changing and tentative features of scientific knowledge (α = 0.60). Overall alpha for this instrument was reported as 0.67.

2.2 Studies Related to the Students' NOS views.

In recent years student understanding of NOS has been investigated by many researchers in different levels of education. From elementary school level through the college level this topic has been studied with different instruments. In the literature researchers focus on NOS from different perspectives namely student and/or teacher conceptions about NOS, and the teaching and learning of NOS. In this part studies regarding student and teacher NOS views are outlined. There have been many curriculum development efforts designed to improve NOS views of both student and teachers.

2.2.1 Studies Regarding Curriculum Efforts and College Students' NOS Views

Historians and Philosophers of science have proposed curriculum efforts, including fluid inquiry. There are some examples of curriculum studies supporting the fluid nature of scientific inquiry, such as Schwab's Biological Sciences Curriculum Study (BSCS), Klopfer's Harvard Case Studies in Experimental Science. These were valuable curriculum efforts with the inclusion of the application of history of science to promote nature of science. In 1968 history and philosophy of science and science education were discussed in National Association for Research in Science Teaching Symposium. In presented papers, there were some important considerations concerning NOS. One of these; science education application of HPS was concentrated only on the curriculum rather than any focus on instructional design. Another was focused on the teacher beliefs about nature of science and their specific phrases used in class which has an effect on student understanding of nature of science. Also it supported the fluid or revolutionary nature of scientific knowledge (Duschl, 1993). Although some curriculum studies sought to improve student NOS (Crumb, 1965; Jones, 1965; Klopfer & Cooley, 1963; Ramsey & Howe, 1969) (as cited in Lederman, 2007) a focus on curriculum did not yield effective results. There were some other curriculum efforts which had no influence on student conceptions of NOS (Trent, 1965; Jungwirth, 1970; Tamir, 1972; Durkee, 1974) (as cited in Lederman, 2007). After these curriculum efforts, many realized that the teacher beliefs, explanations and performances as part of the curricula were ignored. Trent (1965) supported the idea that the same curriculum might be effective for one teacher and ineffective for another. Therefore, researchers gave importance to teachers and pre-service teachers to gain NOS understanding and promote their own views. In the early years, Lavach (1969) designed an experimental study with 26 science teachers, 11 for the experimental group and 15 for the control group. Instruction was selected to deal with the historical aspects of astronomy, mechanics, chemistry, heat, and electricity. They were given to the experimental group received but the teachers in the control group did not get lectures or laboratories regarding historical perspective. TOUS was applied as a pre-test and post-test to all teachers.

Findings of the study revealed significant improvement regarding NOS understanding in favor of the teachers in the experimental group.

In another study Scharmann (1990) investigated the effects of different instructional strategies rather than using traditional lecture approach with respect to college student understandings of the nature of scientific theories. Participants responded to four-open ended questions concerning their feelings and beliefs about evolution in both groups. After group discussion related to these questions, a 90-minute interactive lecture/discussion session was undertaken to overcome any misconceptions students might have. After that students reflected their views regarding discussion activities. Both groups gained significant NOS understanding. However, the experimental group was better than the control group. In recent years researchers generally have focused on explicit and reflective approaches to promote student NOS understanding. In one of these studies, Akerson, Abd-El-Khalick, and Lederman (2000), were interested in the development of elementary teacher understandings of NOS. Twenty-five undergraduate and 25 graduate pre-service elementary teachers enrolled two methods courses in which NOS aspects were referred to explicitly. An open-ended NOS questionnaire which was related to currently accepted dimensions of NOS was administered to pre-service teachers before and after experiencing the courses. The results revealed that explicit instruction improves teachers' understandings of NOS, but less improvement was detected with subjective, and social and cultural NOS.

Similarly Abd-El-Khalick and Akerson (2004) explored the effectiveness of an explicit, reflective approach in a science methods course enrolling prospective teacher for dealing with NOS views. It was realized from the analysis of questionnaires, interviews, and reflection papers, that pre-service teachers reached adequate level of NOS understanding. Moreover, Schwartz, Lederman, and Crawford (2004) assessed the secondary pre-service teacher NOS conceptions via explicit, reflective approach. Researchers concluded the same results with the study of Abd-El-Khalick and Akerson (2004). After the study related to the effectiveness of explicit, reflective approach in method course, Abd-El-Khalick (2005) investigated the effects of philosophy of science course as well as a methods course on pre-service secondary science teachers NOS understanding. All of the participants (56 undergraduate and graduate pre-service secondary science teachers) enrolled in a methods course and 10 pre-service teachers also enrolled in a graduate philosophy of science course as well as method course. VNOS-C was used with the participants at the beginning and end of the study. Results showed that the pre-service science teachers who were enrolled in the philosophy of science course had more informed understandings of NOS than the students who only enrolled in the science methods course. The researchers explained the results as fallows; 10 students enrolled in the philosophy of science course benefited from the methods course as a framework concerning NOS. They, therefore, significantly benefited from the philosophy of science course more than the other students.

Beside the methods course, there were other courses designed to teach through explicit, reflective approaches. For example, Abd-El-Khalick (2001) conducted a similar study and designed a physics course for prospective elementary teachers using an explicit, reflective approach. An open-ended NOS questionnaire was administered as a pretests and posttests. The researcher reached the same conclusion with the previous study that explicit, reflective approach was effective for significant improvement in the aspects of NOS. In another study Lin and Chen (2002) addressed the historical materials explicitly which are different from the other studies using history of science to improve pre-service teachers' understanding of NOS. Total of 63 pre service chemistry teachers from Taiwan were the sample of the study in experimental and control groups. In the experimental group historical cases following discussions were integrated in science courses. Findings showed that significant enhancement regarding pre-service teachers' NOS views, namely creativity in science, role of scientific theories, and theory-leadenness. This result is consistent with the study of Abd-El-Khalick and Lederman (2000) the purpose of which focused on the impact of history of science courses on college students' and pre-service teachers' NOS conceptions.

2.2.2 Qualitative Studies Related to K-12 Students NOS Views

In addition to the studies regarding investigation and improvement of the pre-service and in-service teachers NOS understanding, the studies regarding K-12 students' NOS views and enhancement of their views has been given importance in the literature. In one such study, Griffiths and Barry (1993) investigated 32 Canadian high school students' understanding of scientific facts, theories, and laws. Researchers used different techniques such as note-taking, videotaping, and audiotape recording during the interview process of that study. The results indicated that the students had many misconceptions. For example, the students believed that scientific theories are tentative, but that laws and facts are certain. Moreover, according to these students, theories become laws and laws represent a higher level of knowledge. Griffiths and Barman (1995) extended this work by studying students between 17 and 20 years old from a variety of countries, including Canada, United States, and Australia. Initially sample constituted nine schools and nine teachers, then four schools and eight teachers in each location were involved for the follow-up study. Data collection procedure was same as the study of Griffiths and Barry (1993). The results revealed differences among Canadian, American, and Australian students regarding their understanding of the NOS. For instance, while all Canadian students and most of the Australian students supported that science is tentative, of the participants, 60% of American students believed that scientific knowledge does not change. The authors argued that this finding may have arisen from the

American students' understanding of the scientific method. According to American students, "the actual method stays the same as I learned in the fifth grade: hypothesis, control, and experiment" (p250). In other words, the students argued that scientific knowledge can be generated if scientists follow a stepwise approach to the scientific method—developing a hypothesis, defining and controlling variables, conducting experiments and reaching the "truths"— a highly traditional approach (Bonner, 2005; Harwood, Reiff, & Phillipson, 2005). Moreover, 60% of Australian students, 45% of Canadians, and 25% of the Americans believed that observations come before theories. Most of the American students could not differentiate between observations and theories. Most participants, across all countries, did not fully appreciate the changing nature of scientific laws. Another study assessed 84 high school students' NOS conceptions in the context of a socio-scientific issue—global warming—regarding three different aspects of the NOS, namely empiricism, tentativeness, and social embeddedness (Sadler et al., 2004). As a sub-sample, 30 first-year high school students were interviewed to confirm their written responses. To better understand the empirical NOS, students should accurately comprehend both the meaning and use of data. The study found that about 80% of the students could define data. Among those students, 17% had some difficulties in describing data accurately, and also had very naïve view of the empirical NOS. Over 30% of the students could not recognize data, even if they believed that scientific knowledge is based on empirical evidence. Moreover, 53% of students held a contemporary perspective of both the definition of data and empirical views of the NOS. The students with informed NOS views were aware that science is embedded within society; in other words, they were aware of the influence of societal factors on global warming. The students explained social influences on global warming as economy, personal perspectives, societal causes, and societal effects. Regarding the tentative nature of science, only those students who could draw more than one conclusion from a single set of data understood that the nature of science is tentative. The other study (Moss, 2001) investigated the influence of hands-on activities on students NOS views. Five of the 11th and 12th grade students were observed and interviewed six times during the courses. At the end of the course there was no significant change regarding student NOS views because at the beginning of the course students had almost adequate views on at least half of the models of NOS researcher used.

Influence of explicit and implicit approach regarding student NOS has also been explored until now in different grade levels. In one such study of 29 seventh-grade gifted Taiwanese students, Liu and Lederman (2002) examined changes in how students conceive the NOS. During a summer course, these students were exposed to an explicit inquiry-oriented NOS instruction in which they carried out several activities emphasizing scientific inquiry and the NOS. Before and after the instruction, an open-ended questionnaire assessed the students' views about several aspects of the NOS. Pre-test results revealed that half of the participants held informed views on at least four dimensions of the

NOS. Regarding their initial NOS views—in terms of the empirical aspects of the NOS—most students regarded science as “a body of knowledge that requires evidence, observations, experimentation, and logical thinking" (p.117). Furthermore, most students held informed views about the tentative nature of science and believed that creativity and imagination play key roles in the development of scientific knowledge. Some students held a hierarchical view of the relationship between theories and laws, believing that theories become laws. Most students believed that “a law is correct and exists forever” (p.118). Only two students differentiated scientific theories from laws. In terms of subjectivity, most students pointed out that scientists could interpret a data set in more than one way, depending on their viewpoints, experiences, research backgrounds, and assumptions. Moreover, about half of the students provided detailed explanations about social and cultural values, and the way social expectations influence scientific activities. At the end of the summer course, the questionnaire was applied to students to measure whether the course influenced their views on the NOS. The finding was striking: the students’ views of the NOS remained unchanged. Indeed only nine participants showed changes in how they view the NOS and these changes were only modest. Another one is the study of Khishfe and Abd-El-Khalick (2002). The purpose of this study is to explore and compare the effect of an explicit and reflective inquiry-oriented approach compared with an implicit inquiry-oriented approach on sixth-grade students’ NOS view regarding the tentative, empirical, and creative and imaginative nature of scientific knowledge, and the distinction between observation and inference. Sixty-two sixth-grade students in two intact groups were the sample of that study. Both the explicit and implicit group got involved with the same inquiry activities. The only difference is that the intervention group had explicit references and reflective discussions of the target NOS aspects. Students were made to take six-item open ended questionnaire adapted from the study of Abd-El-Khalick (1998) supplemented with interviews. At the beginning of the study approximately 85% of the students had naïve views on all of the aspects of NOS measured on both of the groups. At the end of the intervention, while the implicit group did not show any difference, students in the explicit group had informed views on at least one aspect of NOS. Results reflected that an explicit and reflective inquiry-oriented approach was more effective than an implicit inquiry-oriented approach on advancement of students' NOS views.

Khisfe (2008) conducted a very similar study with 7^{th} grade students. The only difference from the study of Khisfe and Abd-El-Khalick (2002) was that there was no any control group in this study. Total of 18 seventh grade students were taught through explicit reflective inquiry oriented instructions for three months. After the instructions, students who had naïve NOS views developed their views of NOS aspects and rose to more informed or "intermediary" level. From this study, it can be concluded that improvement of NOS views is a difficult, continuous and long-term process. In addition to these studies, Khishfe and Lederman (2006), Khishfe and Lederman (2007) have focused on the comparison of two different explicit instructional approaches, namely integrated and non-integrated, with the sample of secondary level students, 9^{th} graders and 10^{th} /11^{th} graders respectively. An integrated approach requires NOS instructions to be taught explicitly and embedded within the science content. On the other hand non-integrated approach also necessitates explicitly NOS instruction but separate from the science content. In a non-integrated approach, NOS is addressed through inquiry activities, NOS activities or lectures. Both the studies continued over 6 weeks. While Khishfe and Lederman (2006) focused on global warming issues in integrated groups, Khishfe and Lederman (2007) concentrated on global warming, the atom theory and cells issues for their integrated environmental, chemistry and biology groups respectively. In their non-integrated groups, no connections were made between NOS and science content mentioned above. Results of the both studies revealed the improvements on students' NOS views in integrated and non-integrated groups. Therefore, these studies did not provide evidence regarding the fact that one of the instructional approaches is more effective than the other.

2.2.3 Quantitative Studies Related to K-12 Students NOS Views

Generally, researchers have explored students' views about NOS through qualitative methods. However, there are some studies conducted using quantitative research methods. Some of these studies also have explored gender and grade-level differences regarding students' NOS views (e.g., Huang et al., 2005; Kang, Scharmann & Noh, 2005; Dogan & Abd-El-Khalick, 2008; Zeidler, Walker, Ackett, & Simmons 2002). Huang et al. (2005) investigated 5th and 6th graders' understanding of the NOS and the effects of grade level and gender on these views. This questionnaire (PNSS) was applied to the 6,167 students in Taiwan. Findings showed that significant differences existed in students' NOS understanding with respect to gender and grade level. Males better understood the NOS regarding its tentative nature and importance of social negotiation in scientific studies; and when grade level was considered, it was found that 5th grade students hold more accurate NOS views than 6th grade students, concerning the changing nature of scientific knowledge.

Kang, Scharmann and Noh (2005) investigated 6th, 8th, and 10th grade Korean students' NOS views, using a modified version of VOSTS and compared their findings with those of studies conducted in western countries. In that study, students' NOS views were examined in terms of five aspects: the purpose of science, the definition of scientific theory, the nature of models, the tentativeness of scientific theory, and the origin of scientific theory. The study revealed that most students held a naïve understanding about scientific work, scientific theory, and yet held an informed view about the tentative nature of scientific theories. Although there was a statistically significant mean difference between 6th graders and the 8th and 10th graders, in terms of the nature of model and the tentativeness of scientific theory, older students showed no clear differences in their understanding of other NOS dimensions (the purpose of science, and the definition and origin of scientific theory). Authors argued that because of the differences in cultural characteristics and curricular materials, there are some differences between the western country's students' NOS views and Korean students' NOS views, for example with respect to a definition of scientific theory.

Also Zeidler et al. (2002) explored the students' conceptions of NOS. Sample was 9^{th} and 10^{th} grade general-science students, 11^{th} and 12^{th} grade honors biology, physics students. Most of the students had naïve views about scientific knowledge is tentative and partially subjective, and involve creativity. Different from the other studies findings, there were no significant differences between grade level with respect to students NOS.

In Turkey, some studies have used existing instruments to assess pre-service and in-service teachers' views of the NOS (Dogan & Abd-El Khalick, 2008; Erdogan, 2004; Macaroglu, Tasar & Cataloglu, 1998; Sahin, Deniz & Gorgen, 2006; Yakmacı, 1998; Yalvac & Crawford, 2002). One of these studies Dogan and Abd-El Khalick (2008) used a pre-existing instrument to assess a large sample which included 2,020 10th grade students and 362 teachers from seven geographical regions of Turkey. To assess the NOS views held by students, a 25-item questionnaire adapted from VOSTS was administered and interviews were conducted. Results of this study showed that, while participants had naive views of the nature of scientific models, target NOS, and the relationship among hypotheses, theories and laws, they had informed views concerning the tentative nature of scientific knowledge. All participants believed that hypotheses, theories and laws are hierarchically related assuming that when scientists find new scientific evidence, hypotheses become theories and then laws. Most students did not appreciate the role creativity plays in generating scientific knowledge. Moreover, the findings indicated that while most of the students' views regarding the NOS are the same as their teachers', their views about how theory drives the NOS, the relationship between classification schemes and reality, the nature of scientific theories, myths regarding "the scientific method" and the epistemological status of scientific theories are significantly different.

In another study, Kılıç, Sungur, Çakıroğlu, and Tekkaya (2005) explored ninth grade students' understanding of the NOS and the effects of gender and school types on their understanding. An adapted version of the Nature of Scientific Knowledge Scale (NSKS) developed by Ruba and Anderson (1978) was administered to the students. The results of the study revealed that Turkish high school students possessed understanding of the NOS that was inadequate. Also, results revealed that students in vocational high school have more traditional views about the nature of scientific ideas than those students in general high, Anatolian high and super lycee. Also, a significant gender difference was found regarding unified and amoral dimensions of NSKS, showing that, at this age, girls held a deeper appreciation of these complicating factors. Rubba and Andersen (1978) supported these findings with the sample of high school students during the development of NSKS and Rubba, Horner, and Smith (1981) found similar result with a sample of 102 high ability 7th- and 8th-grade students that “laws are mature theories and that laws represent absolute truth”. Sutherland and Dennick (2002) also conducted similar study using NSKS with 7th grade students. Both Cree students and Euro-Canadian students had inadequate views regarding all aspects of NSKS. Moreover it was found that cultural factors influenced students’ NOS views.

2.3 Studies Investigating Other Variables Influencing NOS

Researchers also investigated the effects of background variables, science achievement, classroom climate, teachers’ belief, and classroom practice on teachers NOS understanding.

One of these studies is the study of Haukoos and Penick (1983). In that study, researchers investigated the effects of classroom climate on college students’ learning of science process skills. Researchers found that the classroom climate influenced students’ learning of science processes. However, Haukoos and Penick could not replicate this finding in 1985. With respect to teachers classroom practice, contrary to the study of Lederman and Zeidler (1987) and Lederman (1999), Brickhouse (1990) supports the relation between teachers’ conceptions of NOS and their classroom practice.

In another study related to the classroom practice, Bell et al. (2000) investigated whether teachers can transfer their conception about NOS in their instructional planning and classroom practice. The subjects were 13 pre-service teachers. VNOS questionnaire was applied to assess the teachers' views of NOS before and after student teaching. To evaluate instructional planning and classroom practice daily lesson plans, classroom videotapes, portfolios, and observation notes throughout the student teaching experience were analyzed. The finding revealed that all of the pre-service teachers presented sufficient NOS understanding but they could not integrate NOS in to their instruction explicitly. The idea that having an adequate NOS understanding does not mean that teachers can automatically translate their NOS understanding into their classroom practice is also supported by Akerson et al. (2000). On the other hand, Schwartz and Lederman (2002) investigated teachers' understandings of NOS and integration of their understanding into their classroom practice. Two beginning teachers whose subject matter knowledge is different from each other constituted the sample of the study. Researchers found that the more comprehensive subject matter background and the more developed understanding of NOS the teacher has, the better they integrate NOS concepts in their teachings.

The other study is the study of Yore et al. (2002). The purpose of this study is to create a model regarding the relationships among science achievement, students' attributes, classroom teachers' characteristics, and classroom environmental factors. This study was designed in the Science Co-op local Systemic Change Project through the five years (2000-2005). Released items of Third International Mathematics and Science Study (TIMSS) were used to assess students' achievement. Students' Perception of Constructivist Classroom (SPOCC-2000) subscales were applied to measure student attributes, teacher characteristics, and classroom factors. This study included 74 elementary schools, 2,616 students (1,134 of them were 3th grade students and 1,482 of them were 6th grade students) and 176 teachers (98 of them were 3th grade teachers, 78 of them were 6th grade teachers) in 38 school districts. Student attributes can be considered as grade level, gender, awareness of the nature of science, attitudes towards science, school science and science and technology careers. Teacher characteristics included students' perceptions of the teachers using students' ideas, discourse and collaboration subscales. Classroom environmental factors consisted of the subscales regarding students' perceptions roles of the value of test in classroom science lessons and of parent, home and community involvement in a classroom science program. HLM analyses were conducted to describe the hierarchical linear models of students' achievement, teacher characteristics and classroom environmental factors. The results of this study were examined with respect to grade 3 and grade 6 separately. Grade 3 analyses indicated that awareness of the NOS and attitudes toward science, school science, and science and technology careers had significant and positive influence on students' achievement. With respect to classroom teacher characteristics and environmental factors, students' perception of teachers' use of their ideas, discourse and collaboration had significant and positive effect on the awareness of NOS influence on students' achievement. However, students' perception of the role and value of text in classroom science lesson significantly and negatively influenced the attitudes toward science, school science and technology careers influence on students' science achievement. Grade 6 analysis revealed that awareness of the NOS and gender had significant effects on students' achievement. Moreover, findings indicated that students' perception of the role and value of text had significant and negative effects on the gender's influence on science achievement. On the other hand, students' attitudes toward science, school science and science and technology careers did not have significant effects on 6^{th} graders achievement.

Literature also supports that nature of science is closely related to some dimensions of epistemological beliefs such as tentative nature of science (Conley, Pintrich, Vekiri, & Harrison, 2004; Schommer, 1990; Schommer 1993). Therefore, in the following part the studies regarding variables related to student epistemological beliefs and achievement are examined.

2.3.1 Epistemological Beliefs and Learning Approaches

One such study investigated the interaction between eight grade Taiwanese students' scientific epistemological beliefs and learning approaches (Tsai, 1998b). Chinese version of Pomeroy's (1993) questionnaire was used to assess students' beliefs about science from empiricist to constructivist. The empiricist views about science refers to; "1)scientific knowledge is unproblematic and it provides right answers, 2) scientific knowledge is discovered by the objective data gathered from observing and experimenting or from an universal scientific method, 3) scientific knowledge is additive and evidence accumulated will result in infallible knowledge, on the other hand the constructivist views supports that scientific knowledge is constructed by scientist, scientific knowledge is tentative, and its development experiences a series of revolution or paradigm shifts" (p.475). As a sample of this study 20 students were selected from initial sampling of 202 students using maximum variation sampling. Findings revealed that students with constructivist epistemological beliefs about science prefer to use meaningful learning strategies (deep approach) while they are learning. They construct their own ideas using their previous knowledge. On the other hand, students having empiricist epistemological beliefs tented to use rote learning strategies (surface approach) in their learning such as memorization.

Holschuh (1998), Saunders (1998), Chan (2003) and Cano (2005) conducted similar study with different samples. One of the common findings of these studies is that while authority knowledge is positively correlated with deep approach, certainty knowledge is positively related to surface approach. Findings of the study of Chan (2003) conducted with the sample of teacher education students indicate that surface approach is related to the idea that scientific knowledge is definite and unchanging. However deep approach is connected to the idea that scientific knowledge is tentative. Besides the relationship between epistemological belief and learning approach Cano (2005) and Holschuh (1998) investigated the interrelationship among these variables and academic achievement. Findings reveal significant influence of epistemological beliefs and learning approach on students' achievement.

The other recently conducted study Ozkal, Tekkaya, Cakiroglu and Sungur (2009) proposed a model to explain relationships among constructivist learning environment, perception variables, scientific epistemological belief variables (fixed and tentative), and learning approach. Participants were 1,152 8^{th} grade elementary school students in this study. Path analysis of this study reveals that student perceptions of constructivist learning environment have a direct influence on learning approach, and an indirect influence on scientific epistemological beliefs. Also, personal relevance, uncertainty, critical voice, and student negotiation is positively related to tentative beliefs and learning approach.

2.3.2 Achievement, Motivational Goal, Learning Approach and Self-efficacy

One of these studies is the study of Cavallo et al. (2003). They investigated the relationships among high school students' learning approaches, motivational goals, and achievement in two different science subject matter courses (biology and pyhsics) in a college. While one group of students (physics nonmajors) took an inquiry based course, the other group (physic major) was instructed in an expository based physics course. Biology students received both inquiry and didactic, expository-based approach. Results indicated that, the biology students used rote learning approach more than physics major students did. Learning goal is the most important motivational factor in predicting biology students' course achievement. While learning goal is positively related to the meaningful learning for all students in three different science courses, performance goal is positively related to rote learning only for biology students. Furthermore, findings reveal a negative relationship between rote learning and course achievement for physics nonmajors.

In another study conducted by BouJaoude (1992) intended to explore the relationship among high school students' learning approaches, attitudes towards chemistry, and their performance, and to determine the differences between the responses of students with different learning approaches on the same test. Learning approach Questionnaire (developed by Novak, Kerr, Donn, & Cobern, 1989) was administered to 49 suburban students, registered in two sections of The New York State Regents Chemistry Course instructed by the same teacher, in order to measure students' approaches to learning. Results indicated that meaningful learners performed better than the rote learners did on the misunderstanding test. Furthermore, having developed coherent understanding, meaningful learners gave more correct answers on both the multiple choice and explanation parts of question than the rote learners. While meaningful learners were able to connect the new information they learned to their prior knowledge and organized them in bigger groups, rote learners could not do this, and they stored their information in smaller groups.

In the literature findings often reveal that learning orientation is related to meaningful learning approach, and performance goal orientation is correlated with rote learning approach. For instance, Kaplan and Midgley (1997) conducted a study with 229 seventh grade students in southeastern Michigan. Results of that study showed a positive relationship between performance goal orientation and surface approaches to learning. However, Wolters et al. (1996) found a positive relationship between 7th and 8th graders' performance goal orientations and deeper learning strategies.

Kang, Scharmann, Noh and Koh (2005) explored the relationship among motivational variables, cognitive conflict and conceptual change. Total of 159 seventh grade students constituted the sample of this study. Scientific density concepts were taught through computer assisted instruction. Students' learning approach, mastery goal orientation, self efficacy and some other variables have been considered as motivational variables. After the instruction, a conception test was also administered to students. Interestingly, regression analysis reveals non-significant relationship between conception test scores and motivational variables (meaningful learning approach, mastery goal orientations, and self-efficacy).

Anderman and Young (1994) investigated 6th and 7th grade students' motivation and learning strategies. Patterns of adaptive learning scale were administered to 678 sixth and seventh grade students and 24 science teachers. HLM analyses indicated a positive correlation between students' self-efficacy and mastery goal orientations (γ=.19, $p<.001$).

A similar study was conducted by Middleton and Midgley (1997) with 703 sixth grade students to explore the relationship between students' goal orientations and some related variables with mathematics domain. Findings reveal that while mastery goal orientation is positively related to academic efficacy (β=.43, $p<.001$), performance avoid goal orientation is negatively related to academic efficacy (β=-.13, $p<.001$). Contrary to that study, Skaalvik (1997) found a positive relationship between performance-approach goal orientation, self-efficacy and also academic achievement. Wolters et al. (1996) conducted correlational study with 434 seventh and eighth grade students. Findings revealed a positive relationship between 7^{th} and 8^{th} graders' performance goal orientations and deeper learning strategies Mastery goal orientation was positively related to students' academic performance and self-efficacy. No correlation was found between performance approach goal orientation and academic achievement in contrast to the study of Skaalvik (1997).

Recently in Turkey researchers gave importance to these variables in their research. One of these studies is the study of Hacieminoglu, Yilmaz-Tuzun, and Ertepinar (2009). As a preliminary study of this dissertation, researchers examined the relationships among students' learning approaches, motivational goals, previous science grades, and their science achievement for the concepts related to atomic theory. They also explored the effects of gender and sociodemographic variables on students' learning approaches, motivational goals, and their science achievement for the concepts related to atomic theory. The sample constituted 416 seventh grade students. Results of the correlation analyses reveal positive relationships among meaningful learning, performance orientation, and self efficacy. Students' previous science grades is positively correlated with achievement, meaningful learning, and self-efficacy and negatively correlated with rote learning and performance orientations. ANOVA results reveal that the educational level of participants' parents education level has significant effect on their achievement and meaningful learning, rote learning, and approach performance orientations.

In another study, Kizilgunes, Tekkaya & Sungur (2009) developed a model to show the relationship between achievement and epistemological belief, achievement motivation, learning approach. A total of 1,041 6^{th} grade elementary students were the sample of the study. Results show that epistemological beliefs influence learning approach directly and also influence learning approach and achievement indirectly, since epistemological beliefs have direct effect on achievement motivation. Findings also reveal that learning goal orientation, and beliefs about certainty knowledge are positively related to learning approaches. Negative association is obtained among performance goal, self-efficacy, beliefs about source of knowledge, and learning approach. While certainty beliefs are negatively related to performance and learning goal, they are positively related to learning approach. Although learning goal and meaningful learning are positively related to each other, performance goal and self-efficacy are negatively related to the learning approaches. Also, learning approaches are positively correlated with achievement.

2.3.3 Gender Difference and Socioeconomic Status

Gender differences in science and sociodemographic variables have been investigated in terms of students' achievement and motivation in science education research for the last two decades. In these studies, gender was generally considered as an important subject characteristic. Moreover, both students Socioeconomic Status (SES) and school SES are one of the main factors with significant attribution on student academic achievement (Ma & Klinger, 2000; Sammons, West & Hind, 1997). According to Willms (1992) students with schools having high SES are more likely to achieve than the other students, also Willms decline school SES has more influence on student achievement than students individual SES (as cited in Ma & Klinger, 2000).

Ma and Klinger (2000) conducted the study to emphasize the importance of factors regarding student background and school environment. They investigated the influence of that factors on 6^{th} grade student achievement in four different context namely mathematics, science, reading and writing. Total of 6,883 6^{th} grade students from 148 schools constituted the sample of this study.

HLM results shows that students enrolled in schools having SES achieved better than the other students in terms of mathematics, reading and writing. Also students individual SES, disciplinary climate is positively related to students' mathematics, reading and writing. Gender differences were observed in favor of male in mathematics and science as was supported in the literature that boys performed better than the girls in science (Kahle & Meece, 1994).

In one such study Cavallo et al. (2004) focused on gender difference on high school students' learning approaches, motivational goals, self efficacy, and their achievement in inquiry-based physics course and investigated the contribution of these variables on students' understanding of physics concepts. Considering the gender difference on course achievement, self-efficacy, and performance goal orientation, male students are found to gain higher scores. While self-efficacy positively contributes to the students' physic achievement for both male and female students, rote learning has negative contribution to male students' achievement. Positive relationships are investigated among self-efficacy, meaningful learning, and learning goals for both male and female students. Rote learner females and males had low self-efficacy and low achievement respectively.

In another study, Reap and Cavallo (1992) explored the gender differences regarding achievement, achievement motivation, and meaningful learning orientation. For this purpose, they assessed 10th grade students' achievement by using both state biology course exam (the exam mainly included multiple choice questions) and an open-ended (mental-model) test, which was developed by the researchers to assess students' meaningful understanding of biology topics. The results of the study revealed that gender difference was observed only in terms of achievement motivation in favor of boys. There is no significant difference between girls and boys in terms of meaningful learning orientation and achievement assessed by the mental model test. Researches decline that there are several reasons for having gender differences. These reasons can be summarized as limited science-related outside activities of girls', gender biases of teachers when asking questions, cultural influences such as society and school, background information and socioeconomic status and parental education (Dimitrov, 1999; Greenfield, 1997; Kahle & Meece, 1994; Steinkamp & Maehr, 1984).

In the literature there are also some studies regarding influence of gender ratios of teachers and effectiveness of school resources on some of the student outcomes. Studies in the literature (Crombie, Pyke, Silverthorn, Jones, & Piccinin, 2003; Huffman, Lawrenz,& Minger, 1997; Le Mare & Sohbat, 2002) supports the idea that students having female teachers feel themselves more comfortable and confident. Moreover both male and female students think that female teachers are more tolerant and pleasant than male teachers (as cited in Gilmartin, Denson, Li, Bryant & Aschbacher, 2007). However, Gilmartin, et. all, (2007) found no relationship between percent of female science faculty and high school students self-concept and their interest in science.

In accordance with the quality of the school resources Burtless (1996) indicates that school resources is highly significantly related to student achievement. Also one of the meta analysis studies' (Fuller, 1987) conducted in early years revealed the positive influence of instructional materials on students achievement in 16 of the 24 analyses. Another significant indicator is the quality of school library as an instructional resource which affects student achievement positively in 15 of 18 analyses. The other factor is about the use of laboratories in science teaching. Findings revealed that number of students in laboratory classes and time spent in laboratory classrooms as indicators of effective utilization of science laboratories were related students achievement positively in three developing countries namely India, Thailand, and Iran. However these factors were not significant predictors of student performance in Latin America. Another meta-analysis study conducted by Hanushek (1997) indicated that there is no consistent result about the effectiveness of availability of laboratories, the size and presence of a library, and the property of the school on student performance.

In the literature, it was mentioned that there were some studies revealing the evidence regarding the relationship between student achievement and student NOS views. Moreover, there are some studies investigating the relationship among achievement, learning approach, motivational goal, and epistemological beliefs such as tentative NOS. Therefore, in this study researcher proposed that these factors should not be considered separately due to their close relationships while investigating science related constructs such as nature of science and investigated the relationship between student level factors (students' background factors, factors related to students characteristics, factors related to student feelings and outside activities, learning and motivational factors) and student NOS views in order to see the relationship from a wide perspective. Furthermore, in this study, whether school level factors (school socio economic status, proportion of female science teachers, ability grouping between science classes, quality of school's physical infrastructure, quality of school's educational resources) are related to student NOS understanding was taken into consideration.

CHAPTER III

METHOD

The present chapter is devoted to inform about methodological details of the study. This chapter is organized in seven parts, consisting overall design of the study, population and sample, factors, selection and development of measuring tools, procedure, data analyses, and assumptions.

3.1 Overall Design of the Study

The overall design of this study is mainly a cross-sectional survey and correlational. Fraenkel and Wallen (2003) stated that the survey type of research is used to describe the characteristics of a population through asking a set of questions. Moreover, correlational type of research is used to determine the relationships among two or more factors without any manipulation.

3.2 Population and Sample

All sixth, seventh and eighth grade public schools' students in Çankaya district of Ankara were defined as the accessible population of this study. The population of 6^{th} grade students sampled in this study was a total of 9,123 students, 4,779 of whom (52 %) were male and 4,344 were female (48 %). The population of 7^{th} grade students sampled in this study was a total of 9,145 students, 4,763 of whom (52.08 %) were male and 4,382 were female (47.92 %).

The population of 8th grade students sampled in this study was a total of 9,448 students, 4,936 of whom (52.2 %) were male and 4,512 were female (47.8 %). Thus, the population included 27,716 students in all grades. A total of 14,478 students (52.2 %) were male and 13,238 students (47.8 %) were female. Of these students, 3,653 students were reached to collect data. Due to missing data 591 participants' responses to the instrument were excluded from the study. Therefore, 3,062 students constituted the sample of this study. Different from these students 782 elementary students in the same district were the sample for the first focus of this study. Çankaya district in Ankara was selected based on its presence of the diversity in parents' education level as well as parents' incomes. This is the unique characteristic of Çankaya therefore this district was selected purposefully. The total number of the elementary public schools in Çankaya is 103. Ideally the researcher aimed to collect data from each school in the district. For this purpose researchers obtained an alphabetical list of schools in Çankaya and each school principal was asked whether they would like to involve in the study or not. Out of 103 schools, only 23 elementary schools responded positively. In accordance with the research design, data were gathered from 6th, 7th and 8th grade elementary students in these 23 schools located in different parts of Çankaya. Therefore, the sampling methodology can be characterized as volunteer sampling in this study. In this sampling technique, sometimes participants may not be representative of accessible population that is one of the limitation of this type of sampling, but in this study our sample represent accessible population of this study in specific aspect such as, 6th and 7th grade level distribution and gender distribution. Since the researcher administered the surveys in classrooms, the return rate of the study was almost 90% at each data collection site.

The distribution of the students' demographic characteristics was presented in Table 3.1. The ages of the students ranged between 12 and 14. 1,567 of them were female (51.2%) and 1,495 were male (48.8%). 1,415 (46.2%) of the students were from 6th grade, 1,397 (45.6%) were from 7th grade and 250 (8.2%) were from 8th grade. In terms of parents' educational level, 59 of the mothers and 5 of the fathers were uneducated. It means that they did not participate in any level of education. Most of the mothers (n=1,016) completed high school and most of the fathers (n= 1,096) completed college level of education. Number of the mothers and fathers who completed either master or PhD. was quite low.

Income of the parents of the students varied. Family income of 172 students (5.6%) was 500 TL and below, of 561 students (18.3%) was between 501 TL and 1000 TL, of 1138 students (37.2%) was between 1001 TL and 1500 TL, of 424 students (13.8%) was between 1501 TL and 2000 TL, of 295 students (9.6%) was between 2001 TL and 2500 TL, and of 472 students (15.4 %) was 2500 TL and above.

Table 3.1 Demographic Characteristics of Participants

Demographic Characteristics		N	Percent
Gender	Female	1567	51.2
	Male	1495	48.8
Grade Level	6th grade	1415	46.2
	7th grade	1397	45.6
	8th grade	250	8.2
Mother Education Level	Uneducated	59	1.9
	Elementary School	721	23.5
	Secondary School	474	15.5
	High School	1016	33.2
	College	645	21.1
	Master Level	130	4.2
	Doctorate Level	17	.6
Father Education Level	Uneducated	5	.2
	Elementary School	314	10.3
	Secondary School	345	11.3
	High School	837	27.3
	College	1096	35.8
	Master Level	368	12.0
	Doctorate Level	97	3.2
Income	500 TL and below	172	5.6
	501 – 1000	561	18.3
	1001 – 1500	1138	37.2
	1501 – 2000	424	13.8
	2001 – 2500	295	9.6
	2500 and above	472	15.4

3.3 Factors

In this study factors considered are labeled as outcome factors, student level factors (Level-1) and school level factors (Level-2).

3.3.1 Outcome Factors

The outcome factor of this study is students' NOS views. Students' NOS views were investigated in terms of four aspects. These are their views about tentative nature of scientific knowledge (Tentative NOS), the distinction between observation and inferences (Observation and Inferences), the empirical nature of scientific knowledge (Empirical NOS), the role of imagination and creativity in generating scientific knowledge (Imagination and Creativity).

3.3.2 Student Level (Level-1) Factors

Student Level (Level-1) Factors were students' background characteristics, factors related to students characteristics, factors related to student feelings and outside activities, learning and motivational factors.

3.3.2.1 Students' Background Characteristics

Students' background characteristics were their socio economic status, parents' education level, parents' occupational status.

3.3.2.2 Factors related to Students Characteristics

Grade level, Science achievement (science grades), gender were factors related to students characteristics. Science grades refer to the achievement scores obtained from trial high school exam test, which is a standardized test applied by the Ministry National Education for all elementary school.

3.3.2.3 Factors related to Student Feelings and Outside Activities

Student attitude towards science, the course they like most, whether they read articles or books regarding science, whether they benefit from the internet sites regarding science, whether they watch documentary film, whether they share their ideas about science subject with their families were the factors related to student feelings and outside activities.

3.3.2.4 Learning and Motivational Factors

Performance goal orientation, learning goal orientation, self efficacy, rote learning approach and meaningful learning approach were the factors regarding learning and motivation.

3.3.3 School Level (Level-2) Factors

School Level (Level-2) factors were school socio economic status, proportion of female science teachers, ability grouping between science classes, quality of school's physical infrastructure, quality of school's educational resources.

3.4 Selection and Development of Measuring Tools

3.4.1 Nature of Science Instrument (NOSI)

The Nature of Science Instrument (NOSI) was developed for the purpose of this study. In light of the available information about NOS in the literature, hypothetical NOSI dimensions and items were determined by a research team.

The steps below were followed while determining the hypothetical dimensions and developing the items for each of these hypothetical dimensions of NOSI:

First, professional literature in the World and in Turkey regarding Nature of Science views, especially elementary student NOS views, was initially reviewed. This review of literature of NOS revealed common aspects of scientific knowledge including its being tentative, empirically based, subjective, partly the product of human imagination and creativity, socially and culturally embedded, able to make distinctions between observations and inferences, and concerned with the understanding of relationships between scientific theories and laws (Abd-El-Khalick et al., 1998; Khishfe & Lederman, 2006; Schwartz & Lederman, 2007).

Second, the research team thoroughly analyzed articles published in highly-refereed science-education journals (e.g. Science Education, Journal of Research in Science Teaching, and International Journal of Science Education). Once the articles obtained, articles were examined regarding the grade levels of students and the dimensions of NOS taken into consideration. The team then selected the studies carried out by Khishfe (2008), Khishfe and Lederman (2007), Akerson and Volrich (2006), Khishfe and Lederman (2006), and Khishfe and Abd-El-Khalick (2002) for use as a template for the instrument of this study. These studies were chosen for several reasons. Initially, the qualitative nature of these studies provided valuable information to us, allowing us to become familiar with elementary students' NOS views in their own words.

For this purpose, we examined quotes from students' before and after an interview. Based on these quotes, we formed an item pool. Items originally written in English were translated into Turkish by the research team. The original items and their translated version were also examined by two English-language experts and an associate professor. Revisions of the items were completed when all parties agreed on the translation of each item. Thus, with this procedure, we could better represent students' thoughts and their expressions of scientific phenomena, and use these to structure the NOSI items. Second, while determining the hypothetical dimensions of NOSI, the NOS characteristics most commonly investigated in these studies were considered as a basis for the hypothetical dimensions of the NOSI. Thus, in this study, the hypothetical dimensions were as follows: the tentative nature of scientific knowledge (Tentative NOS), the distinction between observation and inferences (Observation and Inferences), the empirical nature of scientific knowledge (Empirical NOS), the role of imagination and creativity in generating scientific knowledge (Imagination and Creativity). In the literature researchers decline that these four aspects are accessible to sixth graders (Khishfe & Abd-El-Khalick, 2006). Hypothetical dimensions and sample items for each are presented in Table 3.2.

Table 3.2 Sample Items of the NOSI and Dimensions

Hypothetical Dimensions of NOSI	Sample Items
Tentative NOS	Scientific knowledge would not change, because if scientists are not sure about it they do not put it in the books for student.
Imagination and Creativity	Science could never involve human aspects, such as imagination and creativity, because this would result in incorrect or wrong findings and knowledge.
Observation and inferences	Scientists are certain about the structure of atoms because they were able to see atoms using microscopes.
Empirical NOS	Modern atomic theory accepted today might change in the future as long as scientists get new evidence.

As a fourth step, the validity and reliability of NOSI instrument were assessed, in four pilot studies. Since the purpose was to capture students' NOS views, the researchers assessed not only the students' selection of the number (in Likert scale) that best represents their preferences, but also their understanding about each. To do this, for each pilot study, students were given a chance to explain the reasons behind their opinions and their critiques for the items. The students provided this information in a space given after each item. Oral feedback, from students and their science teachers, was also recorded. The research team took this into consideration when revising the items. During this process, it became clear that small changes in the item structure resulted in big differences in reliability as well as substantial differences in the nature of the factor structures obtained from factor analysis. Because of this, several pilot tests were performed, to better outlay the students' real understanding of each item and to include this understanding in the item structure. After each pilot study, a revised item structure was judged by the research team; and reliability and validity were analyzed. The scale was piloted in schools from two different cities, in the fourth pilot study. First, second, third, and fourth pilot studies were carried out with 75, 90, 86, and 131 students, respectively.

The face validity of the NOSI was then verified by science teachers. For construct-validity evidence, factor analyses were conducted. To determine which type of rotation to employ during factor analysis, we calculated the bi-variate correlation coefficients among the dimensions of the NOSI (Table 3.3).

Table 3.3 Bivariate Correlations among NOSI Dimensions

	Observation and Inferences	Tentative NOS	Empirical NOS	Imagination and Creativity
Observation and Inferences	1	.244*	.144*	.138*
Tentative NOS		1	.394*	.127*
Empirical NOS			1	.156*
Imagination and Creativity				1

* Correlation is significant at the 0.01 level (2-tailed)
* Tentative nature of scientific knowledge (Tentative NOS), the distinction between observation and inference (Observation and Inferences), the empirical nature of scientific knowledge (Empirical NOS), the role of imagination and creativity in generating scientific knowledge (Imagination and Creativity)

According to the results, because the four scales correlated with each other, an oblique rotation was used in the factor analyses (Kim & Mueller, 1978). For reliability analyses, the Cronbach alpha was calculated. To determine internal consistency of NOSI during the fourth pilot study, Cronbach's alpha was calculated and found to be 0.61, 0.45, 0.35, and 0.63 for each pilot study, respectively. For the first two pilot studies, the instrument contained 20 items; later, items were added concerning scientific theories, laws and facts. For the third pilot study, however, these items were removed because of low factor loading. The forth pilot study also included 20 items. Factor analysis showed that, except for item 15 and item 10, all items were successfully loaded into their expected dimensions. Since two items were not explained, with respect to their loaded hypothetical dimensions, they were eliminated from the NOSI and further analyses. Moreover items 5, 7, 13, 14 and 6 were removed from the analyses because of low factor loading. Therefore, the final version of NOSI included 13 items, 8 negatively-written and 5 positively-written, with a 3 point Likert-type scale that included "wrong", "undecided", and "right" options. Having high scores from NOSI resulted in having a good understanding about the NOS. These items were loaded in four factors namely, the distinction between observation and inference (2 items), the tentative nature of scientific knowledge (3 items), the role of imagination and creativity in generating scientific knowledge (5 items), and the empirical nature of scientific knowledge (3 items). After getting satisfactory factor-analysis results from the fourth pilot study, the researchers were ready to conduct the real study with this latest version of the NOSI. The final version of NOSI was applied 782 students enrolled in sixth, seventh, and eighth grade elementary schools located in Çankaya district of

Ankara, capital of Turkey. The distribution of the students according to demographic characteristics was presented in Table 3.4.

Table 3.4 Demographic Characteristics of Participants

Demographic Characteristics		N	Percent
Gender	Female	391	50
	Male	391	50
Grade Level	6^{th} grade	329	42.1
	7^{th} grade	320	40.9
	8^{th} grade	133	17.0

3.4.1.1 Validity of the Data Collection Instrument

Validity refers to "*appropriateness, correctness, meaningfulness and usefulness* (Fraenkel & Wallen, 2003; p.158)" of inferences based on the data. In order to provide both internal validity of NOSI, the content and face related evidences were needed; therefore expert opinions and a wide review of literature were obtained. Moreover, construct validity was supplied by applying statistical procedure, i.e. factor analysis, structural equation modeling. Each of these procedures is explained in the following sections.

3.4.1.1.1. Content and Face Validity

Content validity focuses on content and format of the instrument. It reflects whether the items in the instrument are related to the content area also it is concerned about if the instrument has appropriate format for the target group. Face validity is related to the format of the instrument such as clarity of printing, size of type, adequacy of work space, appropriateness of language and clarity of directions (Fraenkel and Wallen, 2003). Table of specification which provides content coverage of the overall instrument was prepared for NOSI. Furthermore expert opinion was obtained in terms of the format of the instrument.

3.4.1.1.2. Construct Validity

Construct-related evidence of validity is concerned about whether the instrument measures the hypothetical construct to be tested (Fraenkel & Wallen, 2003). In this study, factor analysis was preferred to test the construct validity of NOSI.

Factor Structure of the NOSI

To confirm the factor analysis obtained during the pilot studies, an exploratory factor analysis (EFA) was again conducted for the data of this study. Similarly, Cronbach's alpha reliabilities were calculated, to determine the internal consistencies of the total NOSI and each dimension of the NOSI.

There are three major assumptions of confirmatory factor analysis, namely adequacy of sample size, multivariate normality, identity matrix that underlies the use of factor analysis.

The sample size of the data is 782, and this is adequate to run factor analysis. The Kaiser-Meyer-Olkin measure of sampling adequacy tests whether partial correlations among factors are small. KMO value is 0.718 which is excellent value according to the literature (Tabachnick & Field, 1996). This value also indicates that this data has multivariate normality. Bartlett's test of sphericity measures whether the correlation matrix is an identity matrix. Significance value p= .000 indicates that these data do not produce an identity matrix, thus multivariate normal and acceptable for factor analysis. Results of KMO and Bartlett's Test was indicated in Table 3.5.

Table 3.5 KMO and Bartlett's Test Results

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.718
Bartlett's Test of Sphericity	Approx. Chi-Square	3033.675
	df	78
	Sig.	.000

Exploratory Factor Analysis (EFA) of the NOSI

Factor analysis enabled us to determine the number and the characteristics of factors that could account for students' responses in the NOSI. With oblique rotation and an eigenvalue that is greater than one (as a cutoff point for factors), "Maximum likelihood extraction" generated four factors that account for 64.34 % of the variance. In addition to that the scree plot revealed four sharp descent and other plots started to level off (Figure 1). Factor analysis revealed four factor structures in the data.

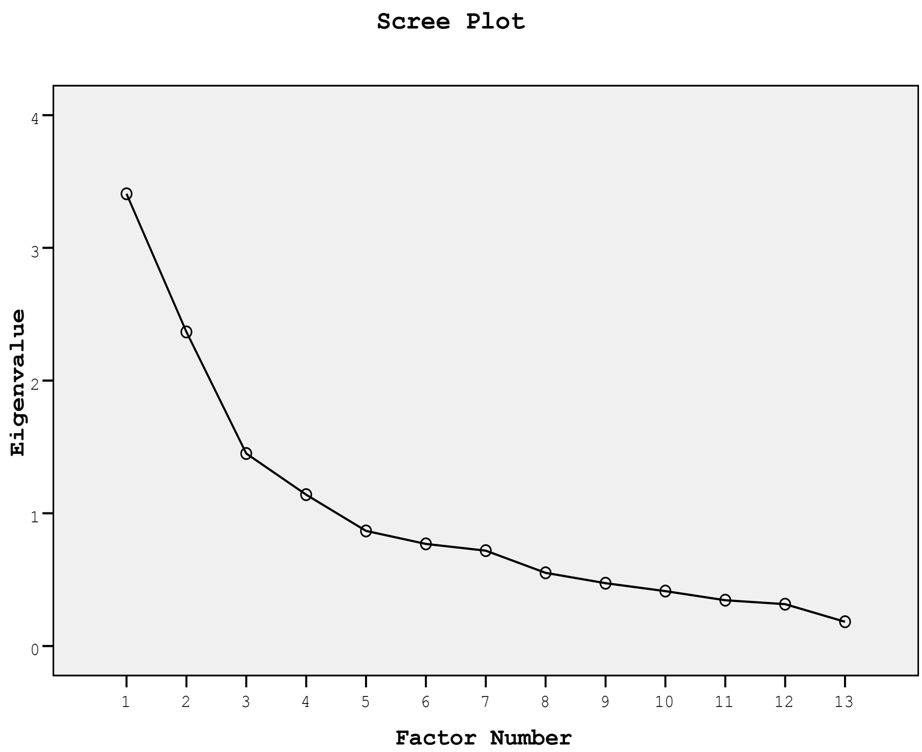

Figure 1. Scree plot for NOSI

Factors 1, 2, 3, and 4 were named 1) observation and inferences, 2) tentative NOS, 3) imagination and creativity, and 4) empirical NOS, respectively (Table 3.6). For the total, NOSI Cronbach's alpha reliability was found as 0.76. For each dimension, Cronbach alpha values ranged from .63 to .80. The smallest alpha value was obtained for the empirical NOS dimension of the NOSI.

Table 3.6. Factor Loadings for Final NOSI Items

NOSI Dimensions	Items		Factor 1	Factor 2	Factor 3	Factor 4
Observation and	7	Negative	.990			
Inferences	8	Positive	.595			
Cronbach Alpha = .74						
Tentative NOS	2	Negative		.975		
	1	Negative		.846		
	4	Negative		.353		
Cronbach Alpha = .76						
Imagination and	5	Negative			.750	
Creativity	10	Negative			.682	
	6	Negative			.670	
	12	Negative			.646	
	11	Positive			.588	
Cronbach Alpha = .80						
Empirical NOS	9	Positive				.881
	3	Positive				.756
	13	Positive				.249
Cronbach Alpha = .63						
Eigenvalues			3.40	2.36	1.45	1.14
Variance (%)			26.21	18.20	11.15	8.77
Total Scale Alpha=.76						

Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) was conducted to identify the best-fit structure and verify the EFA factor solution. LISREL 8.30 was used to determine how well the 13 items fit the proposed four latent factors: observation and inferences, tentative NOS, imagination and creativity, empirical NOS. For the purpose of examining the overall fit of confirmatory factor analysis and model fit, the related fit indexes such as goodness of fit index (GFI), adjusted goodness of fit index (AGFI), root mean squared error of approximation (RMSEA) and standardized root mean squared residual (SRMR), expected cross validation index (ECVI) were taken into account.

Chi-Square (χ^2) alone is not an adequate indicator that the model fits the data, usually it is interpreted with its degrees of freedom. Here *df* refers to the difference between known values and unknown value estimates, and the Normed Chi-Square (NC), which is calculated by ratio of Chi-Square to Degrees of Freedom χ^2 / *df* determines the identification of a model. As a general rule, a ratio less than 5 is considered to be acceptable and as the value of the ratio gets closer to 1, the model is accepted to be a fitting model. In our model the Chi-Square, χ^2 =367.676; with degrees of freedom, df = 84, and the significance level, p = 0.0. In addition, Normed Chi-Square (NC), the χ^2 /df, of the model is 4.37 which is less than 5 indicating good fit to the data. Goodness of Fit Index (GFI)= 0.940 and Adjusted Goodness of Fit Index (AGFI)=0.914 has a range from 0 to 1, with values exceeding 0.9 indicating a good fit to the data (Kelloway, 1998).

Root Mean Square Error of Approximation (RMSEA) is relatively insensitive to sample size and it takes into account the error of approximation in the population. A test of significance of the RMSEA values less than .08 are considered to be acceptable values (Kelloway, 1998). Values below 0.10 indicate a good fit, values below 0.05 indicate a very good fit and the rarely obtained values below 0.01 indicate an outstanding fit to the data (Steiger, 1989).Root Mean Square Error of Approximation (RMSEA) of the our model is 0.067. The RMSEA of the model is contained in the 90 percent confidence interval for RMSEA which is from 0.0608 to 0.0745. The RMSEA value of the model is between the values of the confidence interval and below the values 0.10, it can be said that the model indicates a good fit to the data. Also the standardized RMR has a lower bound of 0 and an upper bound of 1. For our model standardized RMR=0.068 indicated an acceptable fit to the data.

The Expected Cross Validation Index (ECVI) of the model is 0.583. The ECVI of the model is contained in the 90 percent confidence interval for ECVI which is from 0.510 to 0.666. The ECVI value of the model is between the values of the confidence interval, it can be said that the model indicates a good fit to the data. Model derived from Confirmatory factor analyses were presented in Figure 2.

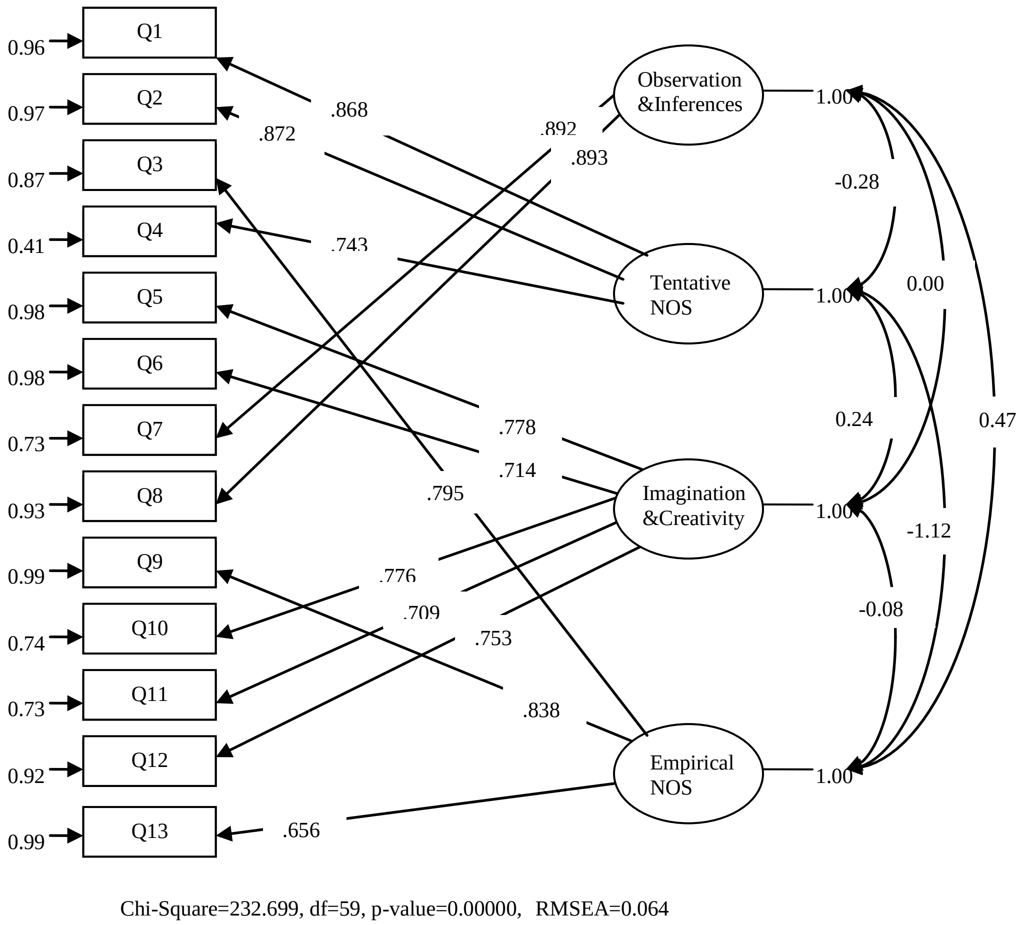

Figure 2. Model Derived from Confirmatory Factor Analysis

3.4.2 Learning Approach Questionnaire

Learning Approach Questionnaire used in Bou Joude (1992) and Cavallo and Schafer (1994) studies was utilized in order to measure the students' learning approach. Questionnaire included 22 items and used a 4-point Likert scale (Of the 22 items 11 items measure rote learning and 11 items measure meaningful learning). Sample items for each scale are presented in Table 3.7. The cronbach alpha internal consistency was reported as 0.81 for the meaningful scale and .76

for the rote scale (Cavallo et al., 2004). High score from the test indicates meaningful learning and low score indicates rote learning orientation.

The questionnaire was originally translated into Turkish by Caliskan, (2004) for high school students. A pilot study was carried out to investigate appropriateness of items for elementary school students. Apart from a few changes in wording, all of the items were kept the same in the pilot study. For the pilot study Cronbach's alpha reliability of the test was found to be 0.77 for the meaningful scale, 0.71 for the rote scale.

Table 3.7 Sample Items of the Learning Approach Questionnaire

Scales	Sample Items
Meaningful learning	I try to relate new material, as I am reading it, to what I have already known about the topic.
Rote Learning	I tend to remember things best if I concentrate on the order in which they were presented by the instructor.

3.4.3 Achievement Motivation Questionnaire

The achievement questionnaire, used in Cavallo et al. (2004) was utilized to measure students' motivational goals. The questionnaire included 14 items and used a 5-point Likert scale. The achievement motivation questionnaire consists of three scales measuring students' learning-goal orientation, performance goal orientation, and students' self-efficacy in the science courses. Among these scales performance goal orientation consists of two subscales:

avoidance performance orientation and approach performance orientation (Elliot & Church, 1997). Sample items for each scale are presented in Table 3.8. The learning-goal orientation consisted of 5 items, the performance-goal orientation consisted of 5 items and students' self-efficacy consisted of 4 items. The cronbach alpha reliability was reported as .94 for learning goals, 0.82 for performance goals, and 0.89 for self-efficacy.

Similar to learning approach questionnaire, this questionnaire was also translated into Turkish by Caliskan (2004) for high school students. A pilot study was carried out to investigate appropriateness of items for elementary school students. Apart from a few changes in wording, all of the items were kept the same in the pilot study. For the pilot study Cronbach's alpha reliability of the test was found to be 0.83 for learning goals, 0.73 for performance goals, and 0.75 for self-efficacy.

Table 3.8 Sample Items of the Achievement Motivation Questionnaire

Scales	Sample Items
Approach performance orientation	One of my primary goals in this class is to do better than other students.
Avoidance performance orientation	One of my primary goals is to not look foolish or stupid when doing science activities in this class.
Learning Orientation	One of my primary goals in this class is to try to improve my knowledge.
Self Efficacy	I am confident I can do well on the science problems we are given in this class.

3.5 Procedure

In this study 6th, 7th, 8th grade elementary students' nature of science (NOS) views, learning approaches, and motivational goals were investigated. Moreover the relationship between students' NOS views and student level and school level factors were investigated. Thus, the design of this study was both cross-sectional survey, and correlational study. Initially, this study began with the literature review in the aspect of the purpose. Educational Resources Information Center (ERIC), International Dissertations Abstracts, Ebscohost, Science Direct, Kluweronline databases, Internet (Google), thesis and other studies done in Turkey were searched by the help of a keyword list. All the articles and thesis were read, and the results of the studies were compared.

After completing the literature review, the participant schools and subjects of the study were determined, and permission was granted for the study from the Ministry of Education. Before the Nature of Science views instrument (NOSI) was prepared, the most appropriate instrument measuring students' learning approaches, and motivational goals had been selected and preliminary study had been conducted to investigate elementary students' learning approaches, motivational goals and science achievement. After selection and development of measuring tool a demographic information part and an introductory part was prepared. The detailed information about the preparation of the instrument was given in section 3.3.

For the ease of administration and data entry, an optical form was designed. The data was collected with these optical forms. After gaining approval from both the Ministry of National Education's ethics committee and the University's ethics committee, the researcher obtained an alphabetical list of schools in Çankaya district. Each school's principal in this list was contacted by phone. Once the principal's permission was obtained, the instrument was administered at their school. The school principal specified the days we could administer the test. Researcher of this study and one or two teachers, appointed by the school's principal, administered the instrument to the students at each data collection site. Data collection was carried out during the spring 2008. The same administrative procedure was followed, to remediate any potential factors that location might have on the results of the tests. During administration, the researcher explained the purpose of the study to the students, in their classroom, and invited them to participate voluntarily. The students were given a class hour to provide their answers. The participant's anonymity was protected by assigning numbers to each form. Students were asked not to write their names on the forms and told that their responses would not affect their grades.

After the data collection procedure, data entry was made by the firm who prepared the optical forms. The data was given to the researcher as an Excel file. Then the researcher coded all the categories of the factors in the data. Female students were coded as 1, and male students were coded as 2. Six grade students were coded as 6, seven grade students were coded as 7 and eight grade students were coded as 8. In terms of their families income level; “less than 500 TL” was coded as 1, “between 501 TL- 1000 TL” was coded as 2, “between 1001 TL-1500 TL” was coded as 3, “between 1501 TL- 2000TL” was coded as 4, “between 2001 TL – 2500 TL” was coded as 5 and “more than 2500 TL” was coded as 6. For the mother’s and father’s education level items, “uneducated” was coded as 1, “primary school” was coded as 2, “elementary school” was coded as 3, “high school” was coded as 4, “university” was coded as 5, “master” was coded as 6 and “doctorate” was coded as 7. For working of their mother and father, “yes” was coded as 1 and “no” was coded as 2. For the lesson they like most, “science” was coded as 1, “social studies” was coded as 2, “mathematic” was coded as 3, and “others” was coded as 4. For whether they read articles or books regarding science “yes” was coded as 1 and “no” was coded as 2. For whether they use internet sites regarding science, “yes” was coded as 1 and “no” was coded as 2. For whether they watch documentary film, “yes” was coded as 1 and “no” was coded as 2. For whether they share their ideas about science subject with their families “yes” was coded as 1 and “no” was coded as 2. For the responses to the Nature of science instrument, “I agree” was coded as 3, “I do not know” was coded as 2, and “I do not agree” was coded as 1. For motivation goal questionnaire, and learning approach questionnaire never was coded as 1, sometimes was coded 2, usually was coded as 3, and always was coded as 4.

For school level factors, different questionnaire was prepared considering literature and some of the questions were taken from OECD Publications (2004, p.316). School socio economic status was calculated as mean scores of students' socio economic status as a school level (Level-2) predictors, also information about school socio economic status was obtained from school principles, proportion of female science teachers was calculated from the information obtained from school principles. For ability grouping between science classes, "Schools with no ability grouping between any classes" was coded 1, "schools with one of these forms of ability grouping between classes for some classes" was coded 2, and "schools with one of these forms of ability grouping for all classes" was coded 3. Quality of school's physical infrastructure was categorized as, "school buildings and grounds", "heating/cooling and lighting systems, "instructional space (eg., classrooms)", Quality of school's educational resources was categorized as "instructional materials (eg. textbooks)", "science laboratory equipment and material", "computers for instruction", "library materials", "audio-visual resources". For these two dimensions four point scale categorized "not at all"=1, "very little"=2, "to some extent"=3, and "a lot"=4 was used. Some arrangements were performed while constructing the file for HLM analysis for both student and school level factors.

3.6 Threats of Internal Validity

For this study subject characteristics, location, and instrumentation internal validity threats must be controlled. In order to eliminate potentially confounding factors, data related to the subject characteristics, such as gender, socio economic status (SES) and parents' education level were also obtained as the background information, 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. Location could be a problem because; teachers, textbooks, methods used by teachers, materials used in the courses, economic and social conditions may be different for each other. To overcome this problem, school level (level-2) factors were obtained and taken in to consideration. Also, the attitude of the subjects and instrumentation might affect the results of this study, because data collector characteristics may have an effect the data they get. To prevent this factor same directions and necessary explanations about the instrument were given to all of the participants, and the instrumentation process was standardized. Possibility of harm to the participants was not appeared to be a problem for this study. Also deception of the students was not existed.

3.6 Data Analyses

Data file consisting of outcome factors (tentative nature of scientific knowledge (Tentative NOS), the distinction between observation and inferences (Observation and Inferences), the empirical nature of scientific knowledge

(Empirical NOS), the role of imagination and creativity in generating scientific knowledge (Imagination and Creativity), student level (Level-1) factors (students' background characteristic, factors related to students characteristics, factors related to student feelings and outside activities, learning and motivational factors) and school level (Level-2) factors (school socio economic status, proportion of female science teachers, ability grouping between science classes, quality of school's physical infrastructure, quality of school's educational resources) was prepared by using SPSS in which columns show factors and rows show the participants by the researcher. All of the student and school level factors were investigated on the basis of descriptive data analyses such as missing data analyses, data cleaning procedures and descriptive statistical procedures. Explanatory and confirmatory factor analyses were conducted to draw common factorial structures of questionnaires.

Hierarchical Linear Modeling (HLM) was selected as a modeling technique in order to investigate how the school level factors and student level factors related to the students NOS views because of the nested structure of the data sets that means students nested within schools. In educational research data generally have a nested structure. Each student might be nested within some schools or classrooms. Beside this, these schools or classrooms might be nested within any other location such as district, province, region, or country. If these hierarchical data are analyzed with traditional linear model, some of the basic assumptions especially the independence of observation is violated. The students in the same group (a classroom or a school) are more similar than the students in different groups. All the students of a school or a class are affected by the school or class atmosphere in the same manner. Additionally, the factors that effected the students in the same group (a school or a classroom) have the same effects on only all the students in the same group. For example; the educational resources of school A affect all the students of school A in the same way. On the other hand they do not have any effects on the students of school B. Therefore, students in different group can be independent; however the students in the same group like same classroom or same school have the same value on some classroom or school factors. If the independence of observation assumption is violated, estimating the coefficients can be biased, and the estimates of standard errors can be smaller than they should be. In the hierarchical linear modeling technique, each of the groups has a different regression model, and each of the levels in the data is outlined by its own sub-models representing structural relations and residual variability at that level. These sub-models explain both the relationships among factors within specific level and how factors at that level influence the relations happening at another level. Therefore HLM is a more reliable statistical technique for researchers to identify the relations within the hierarchical-structured data (Raudenbush & Bryk, 2002). According to Snijders and Bosker (1999) multiple level analyses needs minimum of 10 groups. Level-2 units regression parameters and level-1 variance components exhibited little bias with at least 10 level. However, when the number of the groups gets closer to 30, parameter estimates for the regression slopes and both level-1 and level-2 variance components tended to exhibit very little bias. Therefore, if the researchers study with small number of groups (n<10, according to Snijders and Bosker, 1999) it is recommended to use fixed effect approach (Cohen, Cohen, Stephen & Leona, 2003). In this research there were 23 groups and 3,062 students, namely the number of the students in each group large enough to identify intraclass correlation. According to Kreft and de Leeuw (1998) if group size are not too small, 20 groups is appropriate for identify intraclass correlation (as cited in Cohen, Cohen, Stephen & Leona, 2003). Then, models were developed by using HLM 6.0 in order to examine the relations between school level and students level factors.

3.7 Assumptions

The assumption of this study considered by the researcher is that the participant students of the study responded to the items of the instrument seriously.

CHAPTER IV

RESULTS

This chapter is devoted to the presentation of the results of the present study and included three main sections namely; Descriptive Statistic of the Factors, Hierarchical Linear Modeling (HLM) Assumptions, and Hierarchical Linear Modeling (HLM) Analyses.

4.1 Descriptive Statistics of the Factors

Descriptive measures as descriptive statistics were examined for all the factors included in the study. Descriptive measures of the factors aim to describe distributions.

There were data for 3,062 students to investigate student level factors with data for 23 schools to examine school level factors. Outcome, student and school level factors are shown in table 4.1.

Descriptive analyses revealed that, regarding the mean scores of each NOSI dimension, the most favorable NOS views were obtained for the empirical nature of scientific knowledge. The students were uncertain about NOS views related to tentative NOS and imagination and creativity. The least favorable NOS views were obtained for observation and inferences. Descriptive statistic for outcome, student and school level factor were presented in table 4.2.

Table 4.1 Outcome, Student and School level Factors

Outcome Factors	Dimensions of NOS	Tentative NOS	TENTATIV
		Observation and Inferences	OBSVINF
		Empirical NOS	EMPIRICA
		Imagination and Creativity	IMEGCRAT
Student Level (Level-1) Factors	Students' background characteristics	Socio economic status (SES)	INCOMEME INCOMEHI
		Parents' education level (PEL)	DUMMYCOL DUMMYGRA
		Parents' occupational status	PARENTOC
	Factors related to students characteristics	Grade level (GRADE)	GRADE7 GRADE8
		Science achievement	SCIENGRA
		Gender	GENDER
	Factors related to Student Feelings and Outside Activities	Student attitude toward science	LIKINGSC
		The course they like most	DUMMYLIK
		Whether they read articles or books regarding science	READINGB
		Whether they benefit from internet sites regarding science	INTERNET
		Whether they watch documentary film	DOCUMENT
		Whether they share their ideas about science subject with their families	SHARINGI
	Learning and Motivational Factors	Performance goal orientation	PERFGOAL
		Learning goal orientation	LEARNGOA
		Self efficacy	SELFEFFI
		Meaningful learning approach	MEANINGF
		Rote learning approach	ROTELEAR
School Level (Level-2) Factors	Factors related to school characteristics	School socio economic status	HIGHINCS LOWINCS
		Proportion of female science teachers	FEMALESC
		Ability grouping between science classes	ABILITYG
		Quality of school's physical infrastructure	PHYSICAL
		Quality of school's educational resources	QUALITYE

Table 4.2 Descriptive Statistic for Outcome, Student and School Level Factor

Level	Factors	Type	N	M	SD
	Outcome				
	TENTATIV	Continuous	3043	1.81	.71
	IMEGCRAT	Continuous	3034	2.16	.69
	OBSVINF	Continuous	3021	2.24	.56
	EMPIRICA	Continuous	3044	2.59	.47
	Factors				
Student Level (Level-1) Factors	INCOMEME	Dummy Coded	3062	0.51	0.50
	INCOMEHI	Dummy Coded	3062	0.25	0.43
	DUMMYCOL	Dummy Coded	3062	0.36	0.48
	DUMMYGRA	Dummy Coded	3062	0.15	0.36
	PARENTOC	Dummy Coded	3062	0.96	0.20
	GRADE7	Dummy Coded	3062	0.46	0.50
	GRADE8	Dummy Coded	3062	0.08	0.27
	SCIENGRA	Continuous	3062	2.59	1.19
	GENDER	Dummy Coded	3062	0.49	0.50
	LIKINGSC	Dummy Coded	3062	0.87	0.34
	DUMMYLIK	Dummy Coded	3062	0.36	0.48
	READINGB	Dummy Coded	3062	0.74	0.44
	INTERNET	Dummy Coded	3062	0.70	0.46
	DOCUMENT	Dummy Coded	3062	0.79	0.41
	SHARINGI	Continuous	3062	0.71	0.45
	PERFGOAL	Continuous	3021	2.70	0.72
	LEARNGOA	Continuous	3028	3.41	0.54
	SELFEFFI	Continuous	3024	3.04	0.59
	MEANINGF	Continuous	3005	3.06	0.53
	ROTELEAR	Continuous	3000	2.47	0.51
School Level (Level-2) Factors	HIGHINCS	Continuous	23	24.59	17.26
	LOWINCS	Continuous	23	28.07	17.32
	FEMALESC	Continuous	23	79.23	25.16
	ABILITYG	Dummy Coded	23	0.17	0.39
	PHYSICAL	Continuous	23	2.85	0.54
	QUALITYE	Continuous	23	2.98	0.83

4.2 Hierarchical Linear Modeling (HLM) Assumptions

General level 1 and level 2 models are:

Level 1

Student Level: $Y_{ij} = B_{0j} + \sum_{q=1}^{Q} B_{qj} X_{qij} + r_{ij}$

where,

Q is the number of independent variables in the level 1 model

X may be centered or uncentered level 1 predictors.

Level 2

School Level: $B_{qj} = \gamma_{q0} + \sum_{s=1}^{sq} \gamma_{qs} W_{sj} + u_{qj}$

where,

Sq is the number of level 2 predictors for the q^{th} level 1 effect

Formally, followings assumptions are made (Raudenbush, & Bryk, 2002, p. 255):

1. Each r_{ij} is independent and normally distributed with a mean of 0 and variance σ^2 for every level-1 unit i within each level-2 unit j.

2. The level-1 predictors, Xq_{ij}, are independent of r_{ij}.

3. The vectors of Q + 1 random errors at level-2 are multivariate normal, each with a mean of 0, some variance τ_{qq}, and covariance among the random

elements, q and q', or $\tau_{qq'}$. The random-error vectors are independent among the J level-2 units.

4. The set of level-2 predictors (i.e., all the unique elements in W_{sj} across the Q + 1 equations) are independent of every u_{qj}.

5. The errors at both levels (level-1 and level-2) are independent of each other.

6. The predictors at each level are not correlated with the random effects at other level.

"Assumptions 2, 4, and 6 focus on the relationship between the variables included in the structural portion of the model- the *X*s and *W*s- and those factors related to the error terms, r_{ij} and u_{ij}. They pertain to the adequacy of model specification. Their tenability affects the bias in estimating γ_{qs}. Assumptions 1, 3, and 5 focus only on the random portion of the model (i.e., r_{ij} and u_{ij}). Their tenability affects the consistency of the estimates of standard errors of $\hat{\gamma}_{qs}$, the adequacy of β^*_{qj}, $\hat{\sigma}^2$, and $\hat{\mathrm{T}}$ and the accuracy of hypothesis tests and confidence intervals" (Raudenbush, & Bryk, 2002, p. 255).

In addition to the assumptions above, all variables should be measured adequately, that is reliable scores, free from error, and represent desired construct.

In order to check the tenability of the assumptions HLM residual files can be used. Two different residual files; level 1 residual file and level 2 residual file can be formed in HLM program. A level-1 residual file includes (Raudenbush, Bryk, Cheong & Congdon, 2004, p.15).

- The level-1 residuals (discrepancies between the observed and fitted values).
- Fitted values for each level-1 unit (that is, values predicted on the basis of the model).
- The observed values of all predictors included in the model.
- Selected level-2 predictors useful in exploring possible relationships between such predictors and level-1 residuals.

A level-2 residual file includes (Raudenbush et al., 2004, p.16):

- Fitted values for each level-1 coefficient (that is, values predicted on the basis of the level-2 model).
- Ordinary least squares (OL) and empirical Bayes (EB) estimates of level-2 residuals (discrepancies between level-1 coefficient and fitted values).
- Empirical Bayes coefficients, which are the sum of the EB estimates and the fitted values.
- Dispersion estimates useful in exploring sources of variance heterogeneity at level 1.
- Expected and observed Mahalanobis distance measures useful in assessing the multivariate normality assumption for the level-2 residuals.
- Posterior variances.

The assumption tests for the study are presented at end of the thesis, in Appendix A.

4.3 Hierarchical Linear Modeling (HLM) Analyses

In this part of the chapter, the results of Hierarchical Linear Modeling (HLM) analyses are presented in four parts as the results of HLM analyses for Observation and Inferences, Tentative NOS, Imagination and Creativity, and Empirical NOS. For each aspect of NOS, four models were built in order to investigate the association between student and school level factors and students' nature of science understanding in the HLM analyses.

4.3.1 HLM Analyses for Observation and Inferences.

4.3.1.1 Results of Research Question III (One-Way ANOVA with Random Effects)

With respect to Observation and Inferences , in order to answer the third research question of if there are any differences in students' NOS views among schools one-way ANOVA with random effects model was conducted.

For i= 1, …, nj students in school j, and j = 1, …, 23 schools, equations at two levels are:

Level 1 (Students level) Model:

$Y_{ij} = \beta_{0j} + r_{ij}$

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + u_{0j}$

where

Y_{ij} = the endogenous factor, Observation and Inferences for i^{th} students in j^{th} school

β_{0j} = the intercept (the mean Observation and Inferences for the j^{th} school)

r_{ij} = the student level error

γ_{00} = the grand mean

u_{0j} = the random effect associated with unit j (school)

The final estimation of fixed effects obtained from analysis of variance model of Observation and Inferences is represented in the Table 4.3.

Table 4.3 Final Estimation of Fixed Effects for One-Way ANOVA with Random Effects for Observation and Inferences

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Average school mean, γ_{00}	1.787295	0.028297	63.163	0.000

The analysis of variance indicates that average school mean of Observation and Inferences, the grand-mean of Observation and Inferences (γ_{00}), is statistically different from zero. That means there are significant differences among schools.

The grand-mean of Observation and Inferences is 1.787 with a standard error of 0.028, indicating a 95% confidence interval of:

Confidence Interval = 1.787 ± 1.96 (0.028) = (1.732, 1.841)

Table 4.4 Final Estimation of Variance Components for One-Way ANOVA with Random Effects for Observation and Inferences

Random Effect	*Variance Component*	*df*	*Chi-square*	**p-value**
School mean, u_{0j}	0.01312	22	74.61126	0.000
Level-1 Effect, r_{ij}	0.50063			

The final estimation of variance components obtained from the one-way ANOVA with random effects model is represented in the Table 4.4.

The findings indicated significant ($p< .005$) variation does exist among schools in their Observation and Inferences ($X^2 = 74.61126$, df = 22). The result also revealed that school level factors might account for the differences in the students' Observation and Inferences understanding.

At the student level Var (r_{ij}) = $\sigma^2 = 0.50063$. At the school level, τ_{00} is the variance of the true school means, β_{0j}, around the grand-mean, γ_{00}. Var(u_{0j})= τ_{00} = 0.01312.

The intraclass correlation (ICC), which represents proportion of variance in Y (Observation and Inferences) among schools, is

$ICC = \tau_{00} / (\tau_{00} + \sigma^2) = 0.01312 / (0.01312+0.50063) = 0.025$

indicating that about 2.5 % of the variance in Observation and Inferences is among schools.

HLM also provides an estimate of the reliability of the sample mean in any school. The reliability is an estimate of the true school mean and is affected by the sample size within each school. The overall estimate of reliability is the average of the school reliabilities. ρ = .713 indicating that the sample means tend to be a reliable indicator of true school means. The equation for determining reliability of the mean Observation and Inferences within each school is: $\rho = \tau_{00} / [\tau_{00} + (\sigma^2 / nj)]$. Therefore, the reliability of the sample mean varies from school to school because the sample size, n*j*, varies.

In the following models, additional level 1 (student level) factors will be tried to reduce the variation within schools (σ^2) and additional level 2 (school level) factors will be tried to explain between school differences (τ_{00}).

4.3.1.2 Results of Research Question IV (Means as Outcomes Model)

In order to answer the forth research question of which of the school level factors are associated with students' NOS views with respect to Observation and Inferences , means-as-outcome model was applied.

Equations at two levels are:

Level 1 (Students level) Model:

$Y_{ij} = \beta_{0j} + r_{ij}$

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{01}$ (HIGHINCS) + γ_{02} (FEMALESC) + γ_{03} (ABILITYG) + γ_{04} (PHYSICAL) + γ_{05} (QUALITYE) + u_{0j}

for j = 1, 2, …, n schools

where

β_{0j} = the school mean on Observation and Inferences

γ_{00} = the intercept (the grand mean for Observation and Inferences , that is the average of the school means on Observation and Inferences scores across the population of schools)

γ_{01} = the differentiating effect of high level school socio economic status on the school mean on Observation and Inferences.

γ_{02} = the differentiating effect of proportion of female science teachers on the school mean on Observation and Inferences.

γ_{03} = the differentiating effect of ability grouping between science classes on the school mean on Observation and Inferences.

γ_{04} = the differentiating effect of quality of school's physical infrastructure on the school mean on Observation and Inferences.

γ_{05} = the differentiating effect of quality of school's educational resources on the school mean on Observation and Inferences.

τ_{00} = the conditional variance or school level variance in β_{0j} after controlling for these school level factors.

u_{0j} = the residual

The model was first run with all five factors, but *High level school socio economic status, Proportion of female science teachers, Ability grouping between science classes, and Quality of school's educational resources* were not significant and were removed from the final analysis. The final estimation of fixed effects obtained from means as outcomes model of Observation and Inferences is represented in the Table 4.5.

The results revealed significant and positive relationship between quality of school's physical infrastructure and Observation and Inferences (γ_{01}= 0.146, se= 0.044).

Table 4.5 Final Estimation of Fixed Effects for Means as Outcomes Model for Observation and Inferences

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Model for School Means[1]				
Intercepts, γ_{00}	1.788	0.022	80.308	0.000
PHYSICAL, γ_{01}	0.146	0.044	3.280	0.004

[1] The student level factors were Grand Mean Centered before analysis.

The final estimation of variance components obtained from means as outcomes model is represented in the Table 4.6. The degrees of freedom for this model (Means as Outcomes Model) is based on the number of schools with sufficient data, and the number of school level factors included in the model.

Degrees of Freedom = J – Q – 1, where

J = the number of schools with sufficient data

Q = number of school level factors included in the model

Thus, all schools were used in this analysis and degrees of freedom for this model is:

df = J – Q – 1 = 23 – 1 – 1 = 21

Table 4.6 Final Estimation of Variance Components for Means as Outcomes Model for Observation and Inferences

Random Effect	*Variance Component*	*df*	*Chi-square* χ^2	**p-value**
School mean, u_{0j}	0.00642	21	51.82437	0.000
Level-1 Effect, r_{ij}	0.50100			

The residual variance between schools (τ_{00} = 0.00642) is substantially smaller than the original variance (τ_{00} = 0.01312) resulting from the analysis of variance model. This reduction is due to the inclusion of school level factors.

Proportion of variance explained at

$$\text{level1} = \frac{\tau_{00}(\text{ANOVA}) - \tau_{00}(\text{Means as Outcomes})}{\tau_{00}(\text{ANOVA})}$$

$$\text{Proportion of variance explained at level 1} = \frac{0.01312 - 0.00642}{0.01312} = 0.510$$

This result indicates that 51.0% of the true between school variance in Observation and Inferences is accounted for by *Quality of school's physical infrastructure.*

Finally, in order to examine whether the school Observation and Inferences means vary significantly when Quality of school's physical infrastructure is controlled, chi-square statistic was conducted. Chi-square statistic χ^2 is found as 51.82437 (df=21, p< .05). This finding indicated that this school level factor did not account for all the variation in the intercepts. However, even after controlling quality of school's physical infrastructure, schools still vary significantly in their average Observation and Inferences views.

4.3.1.3 Results of Research Question V (Random Coefficient Model)

In order to answer the fifth research question of which of the student level factors help to explain the difference in understanding the Observation and Inferences views Random Coefficient Model was conducted.

The equations to answer this question are:

Level 1(Students level):

$$Y_{ij} = \beta_{0j} + \beta_{1j}(\text{GRADE7}) + \beta_{2j}(\text{GRADE8}) + \beta_{3j}(\text{SCIENGRA}) + \beta_{4j}(\text{GENDER}) + \beta_{5j}(\text{INCOMEME}) + \beta_{6j}(\text{INCOMEHI}) + \beta_{7j}(\text{DUMMYCOL}) + \beta_{8j}(\text{DUMMYGRA}) + \beta_{9j}(\text{PARENTOC}) + \beta_{10j}(\text{LIKINGSC}) + \beta_{11j}(\text{DUMMYLIK}) + \beta_{12j}(\text{READINGB}) + \beta_{13j}(\text{INTERNET}) + \beta_{14j}(\text{DOCUMENT}) + \beta_{15j}(\text{SHARINGI}) + \beta_{16j}(\text{PERFGOAL}) + \beta_{17j}(\text{LEARNGOA}) + \beta_{18j}(\text{SELFEFFI}) + \beta_{19j}(\text{MEANINGF}) + \beta_{20j}(\text{ROTELEAR}) + r_{ij}$$

Level 2(School level):

$\beta_{0j} = \gamma_{00} + u_{0j}$

$\beta_{qj} = \gamma_{q0} + u_{qj}$

where

Y_{ij} = Observation and Inferences of student *i* in class *j*

β_{0j} = the school mean on Observation and Inferences

β_{1j} = the differentiating effect of 7^{th} grade level in school j

β_{2j} = the differentiating effect of 8^{th} grade level in school j

β_{3j} = the differentiating effect of science achievement in school j

β_{4j} = the differentiating effect of gender in school j

β_{5j} = the differentiating effect of medium level income in school j

β_{6j} = the differentiating effect of high level income in school j

β_{7j} = the differentiating effect of college education level as a highest educational level of parents in school j

β_{8j} = the differentiating effect of graduate education level as a highest educational level of parents in school j

β_{9j} = the differentiating effect of highest parental occupational status in school j

β_{10j} = the differentiating effect of student attitude toward science in school j

β_{11j} = the differentiating effect of the course student like most in school j

β_{12j} = the differentiating effect of if students reads articles or books regarding science in school j

β_{13j} = the differentiating effect of if students benefit from internet sites regarding science in school j

β_{14j} = the differentiating effect of if students watch documentary film in school j

β_{15j} = the differentiating effect of if students share their ideas about science subjects with their families in school j

β_{16j} = the differentiating effect of students' performance goal orientation in school j

β_{17j} = the differentiating effect of students' learning goal orientation in school j

β_{18j} = the differentiating effect of students' self efficacy in school j

β_{19j} = the differentiating effect of students' meaningful learning approach in school j

β_{20j} = the differentiating effect of students' rote learning approach in school j

βqj = the coefficient for factor q for class j after accounting for other factors

γ_{00} = the average of school mean on Observation and Inferences across the population of schools

γ_{q0} = the average q factor- Observation and Inferences slope across those schools

u_{0j} = the unique increment to the intercept associated with school j

u_{qj} = the unique increment to the slope associated with school j

The building strategy recommended by Raudenbush and Bryk (2002) was used. A randomly varying coefficient or factor is defined as a slope whose value varies significantly among schools, or slope effects are allowed to randomly vary across schools. Student background characteristics were first examined (*INCOMEME, INCOMEHI, DUMMYCOL, DUMMYGRA, PARENTOC*) to determine whether they were significantly related to Observation and Inferences and whether or not they were randomly varying. All of these factors were found to be non-significant and non-randomly varying, thus, they were removed from the model.

After, the factors related to students characteristics *GRADE7,GRADE8, SCIENGRA, GENDER*) were examined along with the student background characteristics examined before. Among these factors seven grade level (*GRADE7*) was found to be significant and randomly varying, science achievement factor (*SCIENGRA*) were found to be significant, but non randomly varying. Therefore this factor will be examined as non-randomly varying factor in the model.

Then, factors related to student feelings and outside activities (*LIKINGSC, DUMMYLIK, READINGB, INTERNET, DOCUMENT, SHARINGI*) were added to the model. Among these factors only students' sharing their ideas about science subjects with their families (*SHARINGI*) was found to be significant and non-randomly varying. Therefore these factors will be examined as non-randomly varying factor in the model. The other factors (*LIKINGSC, DUMMYLIK, READINGB, INTERNET*) were all non-significant, thus removed from the model.

Lastly learning and motivational factors (PERFGOAL, LEARNGOA, SELFEFFI, MEANINGF, ROTELEAR) were added to the model. All of these factors were found to be non-significant and non-randomly varying, so they were removed from the model. Moreover, in this step, students' sharing their ideas about science subjects with their families (*SHARINGI*) becomes non-significant and this factor was removed from the model.

Therefore, the final Random Coefficient Model includes two student level factors: *seventh grade level, science achievement, (*student characteristics). Among these two student level factors, only one factor seventh grade level (*GRADE7*) was found as randomly varying. Therefore, the other factor (*SCIENGRA),* found as non-randomly varying, were included in the model as fixed.

The final random coefficient model included the factors not only significantly related to Observation and Inferences but also the factors both significantly related to Observation and Inferences and randomly varying. The final estimation of fixed effects obtained from random coefficient model of is displayed in the Table 4.7.

Table 4.7 Final Estimation of Fixed Effects for Random Coefficient Model for Observation and Inferences

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Overall mean Observation and Inferences [1], γ_{00}	1.728	0.031	54.450	0.000
GRADE7, γ_{10}	0.132	0.041	3.234	0.004
SCIENGRA, γ_{20}	0.034	0.011	3.014	0.003

[1] The student level factors were Group Mean Centered before analysis.

The Grade-Observation and Inferences *slope* coefficients indicates that students from different grades had significantly different understanding on the Observation and Inferences. Students from seventh grades (γ_{10}= .132, se= .041) scored significantly higher than the students from sixth grades on the Observation and Inferences. There is no statistically significant difference between eight graders and other grade levels.

The Science grade-Observation and Inferences slope coefficients (γ_{30}= .034, se= .011) indicates that students' science achievement is significantly and positively related to students' Observation and Inferences understanding. Students having higher achievement had better Observation and Inferences understanding than the other students.

The final estimation of variance components obtained from random coefficient model is displayed in Table 4.8.

Table 4.8 Final Estimation of Variance Components for Random Coefficient Model for Observation and Inferences

Random Effect	*Variance Component*	*df*	*Chi-square* X^2	**p-value**
School mean, u_{0j}	0.01413	22	59.07827	0.000
GRADE7, u_{1j}	0.01863	22	49.25883	0.001
Level-1 Effect, r_{ij}	0.49208			

Variance among the school means τ_{00}= 0.014 with a chi-square statistic of 59.078 is found to be statistically significant ($p < .005$). This significant difference (variability) in 23 schools might be explained by incorporating school level factors in to the model. The variances of the science grade slope τ_{11}= .001 (χ^2= 49.258, $p < .005$) are found to be significant. This significant difference indicates that in some schools, the slopes are much steeper than for other schools, namely, relationship with Observation and Inferences is much stronger in some schools than in other schools. The variability among schools also suggests that school level factors might account for some of the differences.

The variances in the Analysis of Variances Model and Random Coefficient Model will be compared to calculate the variance explained at the student level. It can be compared by creating an index of the proportion of reduction in variance at the student level by comparing the σ^2 estimates from these two models.

Proportion of variance explained at

$$\text{level 1=}\frac{\sigma^2(\text{ANOVA}) - \sigma^2(\text{Random Coefficient})}{\sigma^2(\text{ANOVA})}$$

$$\text{Proportion of variance explained at level 1=}\frac{0.50063 - 0.4920}{0.50063} = 0.017$$

By including these student level factors (seventh grade level, science achievement,) as predictors of Observation and Inferences within school variance was reduced by 1.7 %. Therefore, these factors account for about 1.7 % of the student level variance in Observation and Inferences.

Findings related to reliability estimates of intercepts and randomly varying slopes indicate that the reliability of intercepts is 0.61, the reliability of randomly varying slopes are, 0.50 for seventh grade level. According to Raudenbush and Bryk (2002) the primary reason for the lower reliability of the slopes is that the true slope variance across schools is much smaller than the variance of the true means and many schools are relatively homogenous on the randomly varying factors (e.g. GRADE7).

4.3.1.4 Results of Research Question VI (Intercepts and Slopes as Outcomes)

In order to answer sixth research question of whether school level factors predict student NOS views and the strength of associations between students NOS views and student level factors in terms of Observation and Inferences, Intercepts and Slopes as Outcomes Model was applied. In this model, the coefficients (slopes) of the factors will be modeled to account for the variability of the regression equations across schools. The coefficient refers to the amount of influence a factor has on the endogenous factor. The Level-2 factors that are significantly associated with Level-1 factors are described as cross-level interactions. In this model there will be only one Level-2 equation for each Level-1 Beta value.

This research question includes three previous research questions. The first model was the Analysis of Variance Model which was explained the differences in students' Observation and Inferences views among schools (Research Question 3). The variability of students' Observation and Inferences views was modeled with school level factors in the Means as Outcomes Model (Research Question 4). One student level factor or coefficient science seventh grade level (*GRADE7*) were observed to be randomly varying in the Random Coefficient Model (Research Question 5). Therefore, this coefficient can be modeled with school level factors. The school level factors which are significantly related to the random coefficients are termed as cross-level interactions that mean school level factor influences a student level slope. First of all, the intercept is modeled, and then randomly varying coefficient is modeled.

The equations for the first model in this analysis are:

Level 1(Students level):

$Y_{ij} = \beta_{0j} + \beta_{1j}$ (GRADE7) + β_{2j} (SCIENGRA) + r_{ij}

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{01}$ (PHYSICAL) + u_{0j}

$\beta_{1j} = \gamma_{10} + u_{1j}$

$\beta_{2j} = \gamma_{20}$

This factor *Quality of school's physical infrastructure* was significantly related to students' Observation and Inferences views. Then, this factor was included in the seven grade level (*GRADE7*) coefficient model with the previous results.

The equations for the second model in this analysis are:

Level 1(Students level):

$Y_{ij} = \beta_{0j} + \beta_{1j}$(GRADE7) + β_{2j}(SCIENGRA) + r_{ij}

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{01}$ (PHYSICAL) + u_{0j}

$\beta_{1j} = \gamma_{10} + \gamma_{11}$ (PHYSICAL) + u_{0j}

$\beta_{2j} = \gamma_{20}$

This factor, *Quality of school's physical infrastructure* was not significantly related to seven grade level (*GRADE7*) slope and removed from the model. Since all of the coefficients (slopes) were found to be non-randomly varying, only the intercept is modeled.

Finally, the full final Intercepts and Slopes as Outcomes Model was analyzed and the equations for the final full model are:

Level 1(Students level):

$Y_{ij} = \beta_{0j} + \beta_{1j}(\text{GRADE7}) + \beta_{3j}(\text{SCIENGRA}) + r_{ij}$

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{01}\,(\text{PHYSICAL}) + u_{0j}$

$\beta_{1j} = \gamma_{10} + u_{1j}$

$\beta_{2j} = \gamma_{20}$

Table 4.9 Final Estimation of Fixed Effects of Final Full Model for Intercepts and Slopes as Outcomes Model for Observation and Inferences

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Overall mean Observation and Inferences, γ_{00}	1.726	0.028	61.037	0.000
PHYSICAL, γ_{01}	0.143	0.038	3.670	0.002
GRADE7, γ_{10}	0.137	0.041	3.318	0.004
SCIENGRA, γ_{20}	0.034	0.011	3.020	0.003

The results of the final estimation of fixed effects obtained from the full final Intercepts and Slopes as Outcomes Model were presented in Table 4.9. As stated before, the results from Means as Outcomes Model are reported in the final full Intercepts and Outcomes Model.

The results revealed significant and positive relationship between Quality of school's physical infrastructure and Observation and Inferences (γ_{01}= 0.143, se=0.038) indicating that the higher the Quality of school's physical infrastructure is, the better Observation and Inferences students have.

In addition to these, the results from the Random Coefficient Model are reported in the final full Intercepts and Slopes as Outcomes Model. *Seventh grade level and science achievement* are significantly related to students' Observation and Inferences views.

The Grade-Observation and Inferences *slope* coefficients indicates that students from different grades had significantly different understanding on the Observation and Inferences. Students from seventh grades (γ_{10}= .137, se= .041) performed significantly higher than the students from sixth grades on the Observation and Inferences. There is no statistically significant difference between eight graders and other grade levels.

The Science grade-Observation and Inferences slope coefficients (γ_{30}= .034, se= .011) indicates that students' science achievement is significantly and positively related to students' Observation and Inferences understanding. Students having higher achievement had better Observation and Inferences understanding than the other students.

It can be seen that the coefficients have very slight differences in their magnitude, but the directions and the interpretations are same with the Random Coefficient Model because of the small reduction of the number of students analyzed in the final full model.

In the final full Intercepts and Slopes as Outcomes Model, only one school level factors was significantly related to a student level slope.

The results of the final estimation of variance components obtained from the full final Intercepts and Slopes as Outcomes Model were presented in Table 4.10. The degrees of freedom for this model (Intercepts and Slopes as Outcomes Model) is based on the number of schools with sufficient data, and the number of school level factors included in the model.

Degrees of Freedom = J – Q – 1, where

J = the number of schools with sufficient data

Q = number of school level factors included in the model

There were 23 schools with sufficient data.

df = J – Q – 1 = 23 – 1 – 1 = 21 (df for *School Mean*)

df = J – Q – 1 = 23 – 1 – 1 = 21 (df for seven grade level (*GRADE 7*))

Table 4.10 Final Estimation of Variance Components for Intercepts and Slopes as Outcomes Model for Observation and Inferences

Random Effect	*Variance Component*	*df*	*Chi-square* χ^2	**p-value**
School mean, u_{0j}	0.00960	21	50.43901	0.000
GRADE7, u_{1j}	0.01974	21	49.61615	0.001
Level-1 Effect, r_{ij}	0.49246			

The proportion of variance explained for each Observation and Inferences slope model with significant school level factors could be examined. For this study, that would be the *seven grade level* and *Observation and Inferences*. The equation is

The proportion of variance explained in β_{0j}

$$= \frac{\tau_{00}(\text{Random Coefficien t}) - \tau_{00}(\text{Intercepts and Slopes as Outcomes})}{\tau_{00}(\text{Random Coefficien t})}$$

β_{0j} = Observation and Inferences or the slope coefficient for a given factor

The proportion of variance explained in Observation and Inferences

$$= \frac{0.01413 - 0.00960}{0.01413} = 0.320$$

It can be concluded that 32.0 % of the variance in the between school differences in mean Observation and Inferences is accounted for by *Quality of school's physical infrastructure.* However, significant differences still remains (χ^2= 50.439, p< .005) between schools.

4.3.2 HLM Analyses for Tentative NOS views.

4.3.2.1 Results of Research Question III (One-Way ANOVA with Random Effects)

With respect to Tentative NOS, in order to answer the third research question of if there are any differences in students' NOS views among schools one-way ANOVA with random effects model was conducted.

For i= 1, …, nj students in school j, and j = 1, …, 23 schools, equations at two levels are:

Level 1 (Students level) Model:

$Y_{ij} = \beta_{0j} + r_{ij}$

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + u_{0j}$

where

Y_{ij} = the endogenous factor, tentative NOS for i^{th} students in j^{th} school

β_{0j} = the intercept (the mean Tentative NOS for the j^{th} school)

r_{ij} = the student level error

γ_{00} = the grand mean

u_{0j} = the random effect associated with unit j (school)

The final estimation of fixed effects obtained from analysis of variance model of Tentative NOS is represented in the Table 4.11.

Table 4.11 Final Estimation of Fixed Effects for One-Way ANOVA with Random Effects for Tentative NOS

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Average school mean, γ_{00}	2.131597	0.035903	59.371	0.000

The analysis of variance indicates that average school mean of tentative NOS, the grand-mean of Tentative NOS (γ_{00}), is statistically different from zero. That means there are significant differences among schools.

The grand-mean of tentative NOS is 2.131 with a standard error of 0.035, indicating a 95% confidence interval of:

Confidence Interval = 2.131 ± 1.96 (0.035) = (2.062, 2.199)

Table 4.12 Final Estimation of Variance Components for One-Way ANOVA with Random Effects for Tentative NOS

Random Effect	*Variance Component*	*df*	*Chi-square*	**p-value**
School mean, u_{0j}	0.02455	22	152.41264	0.000
Level-1 Effect, r_{ij}	0.45942			

The final estimation of variance components obtained from the one-way ANOVA with random effects model is represented in the Table 4.12.

The findings also indicated significant ($p< .005$) variation does exist among schools in their tentative NOS (χ^2 = 152.41264, df = 22). The result also revealed that school level factors might account for the differences in the students' tentative NOS understanding.

At the student level $Var(r_{ij}) = \sigma^2 = 0.45942$. At the school level, τ_{00} is the variance of the true school means, β_{0j}, around the grand-mean, γ_{00}. $Var(u_{0j}) = \tau_{00} = 0.02455$.

The intraclass correlation (ICC), which represents proportion of variance in Y (tentative NOS) among schools, is

$ICC = \tau_{00} / (\tau_{00} + \sigma^2) = 0.02455 / (0.02455 + 0.45942) = 0.050$

indicating that about 5.0% of the variance in tentative NOS is among schools.

HLM also provides an estimate of the reliability of the sample mean in any school. The reliability is an estimate of the true school mean and is affected by the sample size within each school. The overall estimate of reliability is the average of the school reliabilities. $\rho = .828$ indicating that the sample means tend to be a reliable indicator of true school means. The equation for determining reliability of the mean tentative NOS within each school is:

$\rho = \tau_{00} / [\tau_{00} + (\sigma^2 / nj)]$. Therefore, the reliability of the sample mean varies from school to school because the sample size, nj, varies.

In the following models, additional level 1 (student level) factors will be tried to reduce the variation within schools ($\sigma 2$) and additional level 2 (school level) factors will be tried to explain between school differences ($\tau 00$).

4.3.2.2 Results of Research Question IV (Means as Outcomes Model)

In order to answer the forth research question of which of the school level factors are associated with students' NOS views with respect to Tentative NOS, means-as-outcome model was applied.

Equations at two levels are:

Level 1 (Students level) Model:

$Y_{ij} = \beta_{0j} + r_{ij}$

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{01}$ (HIGHINCS) $+ \gamma_{02}$ (FEMALESC) $+ \gamma_{03}$ (ABILITYG) $+ \gamma_{04}$ (PHYSICAL) $+ \gamma_{05}$ (QUALITYE) $+ u_{0j}$

for j = 1, 2, …, n schools

where

β_{0j} = the school mean on Tentative NOS

γ_{00} = the intercept (the grand mean for Tentative NOS, that is the average of the school means on Tentative NOS scores across the population of schools)

γ_{01} = the differentiating effect of high level school socio economic status on the school mean on Tentative NOS.

γ_{02} = the differentiating effect of proportion of female science teachers on the school mean on Tentative NOS.

γ_{03} = the differentiating effect of ability grouping between science classes on the school mean on Tentative NOS.

γ_{04} = the differentiating effect of quality of school's physical infrastructure on the school mean on Tentative NOS.

γ_{05} = the differentiating effect of quality of school's educational resources on the school mean on Tentative NOS.

τ_{00} = the conditional variance or school level variance in β_{0j} after controlling for these school level factors.

u_{0j} = the residual

The model was first run with all five factors, but *Proportion of female science teachers, Ability grouping between science classes, Quality of school's physical infrastructure* were not significant and were removed from the final analysis. The final estimation of fixed effects obtained from means as outcomes model of Tentative NOS is represented in the Table 4.13.

The results revealed significant and positive relationship between high level school socio economic status and Tentative NOS (γ_{01}= 0.006, se=0.001); quality of school's educational resources and Tentative NOS (γ_{01}= 0.066, se=0.027).

Table 4.13 Final Estimation of Fixed Effects for Means as Outcomes Model for Tentative NOS

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Model for School Means[1]				
Intercepts, γ_{00}	2.138	0.018	115.121	0.000
HIGHINCS, γ_{01}	0.006	0.001	4.675	0.000
QUALITYE, γ_{02}	0.066	0.027	2.402	0.026

[1] The student level factors were Grand Mean Centered before analysis.

The final estimation of variance components obtained from means as outcomes model is represented in the Table 4.14. The degrees of freedom for this model (Means as Outcomes Model) is based on the number of schools with sufficient data, and the number of school level factors included in the model.

Degrees of Freedom = J – Q – 1, where

J = the number of schools with sufficient data

Q = number of school level factors included in the model

Thus, all schools were used in this analysis and degrees of freedom for this model is:

df = J – Q – 1 = 23 – 2 – 1 = 20

Table 4.14 Final Estimation of Variance Components for Means as Outcomes Model for Tentative NOS

Random Effect	*Variance Component*	*df*	*Chi-square* χ^2	**p-value**
School mean, u_{0j}	0.00359	20	41.32965	0.004
Level-1 Effect, r_{ij}	0.45977			

The residual variance between schools (τ_{00} = 0.00359) is substantially smaller than the original variance (τ_{00} = 0.02455) resulting from the analysis of variance model. This reduction is due to the inclusion of school level factors.

Proportion of variance explained at

$$\text{level 1}=\frac{\tau_{00}(\text{ANOVA}) - \tau_{00}(\text{Means as Outcomes})}{\tau_{00}(\text{ANOVA})}$$

$$\text{Proportion of variance explained at level 1}=\frac{0.02455-0.00359}{0.02455}=0.853$$

This result indicates that 85.3% of the true between school variance in Tentative NOS is accounted for by *High level school socio economic status, and Quality of school's educational resources.*

Finally, in order to examine whether the school Tentative NOS means vary significantly when high level school socio economic status and quality of school's educational resources are controlled chi-square statistic was conducted. Chi-square statistic χ^2 is found as 41.32965 (df=20, p< .05). This finding indicated that these two school level factors did not account for all the variation in the intercepts. However, even after controlling for high level school socio economic status and quality of school's educational resources, schools still vary significantly in their average Tentative NOS views.

4.3.2.3 Results of Research Question V (Random Coefficient Model)

In order to answer the fifth research question of which of the student level factors help to explain the difference in understanding the Tentative NOS views Random Coefficient Model was conducted.

The equations to answer this question are:

Level 1(Students level):

Y_{ij} = β_{0j} + β_{1j}(GRADE7) + β_{2j}(GRADE8) + β_{3j}(SCIENGRA) + β_{4j}(GENDER) + β_{5j} (INCOMEME) + β_{6j}(INCOMEHI) + β_{7j}(DUMMYCOL) + β_{8j}(DUMMYGRA) + β_{9j} (PARENTOC) + β_{10j}(LIKINGSC) + β_{11j}(DUMMYLIK) + β_{12j}(READINGB) + β_{13j}(INTERNET) + β_{14j}(DOCUMENT) + β_{15j}(SHARINGI) + β_{16j}(PERFGOAL) + β_{17j}(LEARNGOA) + β_{18j}(SELFEFFI) + β_{19j}(MEANINGF) + β_{20j}(ROTELEAR) + r_{ij}

Level 2(School level):

$\beta_{0j} = \gamma_{00} + u_{0j}$

$\beta_{qj} = \gamma_{q0} + u_{qj},$

where

Y_{ij} = Tentative NOS of student *i* in class *j*

β_{0j} = the school mean on Tentative NOS

β_{1j} = the differentiating effect of 7th grade level in school j

β_{2j} = the differentiating effect of 8th grade level in school j

β_{3j} = the differentiating effect of science achievement in school j

β_{4j} = the differentiating effect of gender in school j

β_{5j} = the differentiating effect of medium level income in school j

β_{6j} = the differentiating effect of high level income in school j

β_{7j} = the differentiating effect of college education level as a highest educational level of parents in school j

β_{8j} = the differentiating effect of graduate education level as a highest educational level of parents in school j

β_{9j} = the differentiating effect of highest parental occupational status in school j

β_{10j} = the differentiating effect of student attitude toward science in school j

β_{11j} = the differentiating effect of the course student like most in school j

β_{12j} = the differentiating effect of if students reads articles or books regarding science in school j

β_{13j} = the differentiating effect of if students benefit from internet sites regarding science in school j

β_{14j} = the differentiating effect of if students watch documentary film in school j

β_{15j} = the differentiating effect of if students share their ideas about science subjects with their families in school j

β_{16j} = the differentiating effect of students' performance goal orientation in school j

β_{17j} = the differentiating effect of students' learning goal orientation in school j

β_{18j} = the differentiating effect of students' self efficacy in school j

β_{19j} = the differentiating effect of students' meaningful learning approach in school j

β_{20j} = the differentiating effect of students' rote learning approach in school j

βqj = the coefficient for factor *q* for class j after accounting for other factors

γ_{00} = the average of school mean on tentative NOS across the population of schools

γ_{q0} = the average *q* factor- tentative NOS slope across those schools

u_{0j} = the unique increment to the intercept associated with school *j*

u_{qj} = the unique increment to the slope associated with school *j*

The building strategy recommended by Raudenbush and Bryk (2002) was used. A randomly varying coefficient or factor is defined as a slope whose value varies significantly among schools, or slope effects are allowed to randomly vary across schools. Student background characteristics were first examined (*INCOMEME, INCOMEHI, DUMMYCOL, DUMMYGRA, PARENTOC*) to determine whether they were significantly related to tentative NOS and whether or not they were randomly varying. Only highest parental occupational status (*PARENTOC)*, were found to be non-significant and non-randomly varying, thus, it was removed from the model. The other four background characteristics, medium level income, high level income, college education level as a highest educational level of parents, graduate education level as a highest educational level of parents (*INCOMEME, INCOMEHI*, *DUMMYCOL*, *DUMMYGRA),* were found to be significant, and non-randomly varying. Therefore these factors will be examined as non-randomly varying factor in the model.

After, the factors related to students characteristics (*GRADE7*,*GRADE8*, *SCIENGRA*, *GENDER*) were examined along with the student background factors examined before. All of the factors were found to be significant, but only science achievement factor (*SCIENGRA*) were found randomly varying factors among the factors related to student characteristics. Moreover, in this step, medium income level (*INCOMEME)*, becomes non-significant, this factor was removed from the model.

Then, factors related to student feelings and outside activities (*LIKINGSC, DUMMYLIK, READINGB, INTERNET, DOCUMENT, SHARINGI*) were added to the model. Among these factors only students' watching documentary film (*DOCUMENT*) was found to be significant and non-randomly varying. Therefore these factors will be examined as non-randomly varying factor in the model. The other factors (*LIKINGSC, DUMMYLIK, READINGB, INTERNET, SHARINGI*) were all non-significant, thus removed from the model.

Lastly, learning and motivational factors (PERFGOAL, LEARNGOA, SELFEFFI, MEANINGF, ROTELEAR) were added to the model. From the learning and motivational factors, students' performance goal orientation, self efficacy, and students' rote learning approach (PERFGOAL, SELFEFFI, ROTELEAR) were found to be significant and non-randomly varying. Therefore, these factors will be examined as non-randomly varying factor in the model. The other factors about learning and motivational factors, learning goal orientation and meaningful learning approach (LEARNGOA, MEANINGF), were not significant and non-randomly varying, so they were removed from the model.

Therefore, the final Random Coefficient Model includes eleven student level factors: *high level income, college education level as a highest educational level of parents, graduate education level as a highest educational level of parents* (student background), *seventh grade level*, *eight grade level*, *science achievement*, *gender*, *(*student characteristics), *students' watching documentary film* (student feelings and outside activities), *students' performance goal orientation, self efficacy, and students' rote learning approach,* (learning and motivational factors). Among these eleven student level factors, only one factor science achievement (SCIENGRA) was found as randomly varying. Therefore, the other ten factors found as non-randomly varying, were included in the model as fixed.

The final random coefficient model included the factors significantly related to Tentative NOS and the factors both significantly related to Tentative NOS and randomly varying. The final estimation of fixed effects obtained from random coefficient model of is displayed in the Table 4.15.

Table 4.15 Final Estimation of Fixed Effects for Random Coefficient Model for Tentative NOS

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Overall mean tentative NOS[1], γ_{00}	1.857	0.043	42.849	0.000
GRADE7, γ_{10}	0.251	0.023	10.559	0.000
GRADE8, γ_{20}	0.161	0.051	3.127	0.002
SCIENGRA, γ_{30}	0.132	0.018	7.340	0.000
GENDER, γ_{40}	-0.055	0.022	-2.423	0.016
INCOMEHI, γ_{50}	0.118	0.029	4.019	0.000
DUMMYCOL, γ_{60}	0.134	0.026	5.029	0.000
DUMMYGRA, γ_{70}	0.120	0.036	3.310	0.001
DOCUMENT, γ_{80}	0.104	0.027	3.766	0.000
PERFGOAL, γ_{90}	-0.057	0.016	-3.515	0.001
SELFEFFI, γ_{100}	0.085	0.021	4.029	0.000
ROTELEAR, γ_{110}	-0.191	0.024	-7.914	0.000

[1] The student level factors were Group Mean Centered before analysis.

The Grade-Tentative NOS *slope* coefficients indicates that students from different grades had significantly different understanding on the Tentative NOS.

Students from seventh grades (γ_{10}= .251, se= .023) and eighth grades (γ_{20}= .161, se= .051) performed significantly higher than the students from sixth grades on the Tentative NOS.

The Science grade-Tentative NOS slope coefficients (γ_{30}= .132, se= .018) indicates that students' science achievement is significantly and positively related to students' Tentative NOS understanding. Students having higher achievement had better Tentative NOS understanding than the other students.

The Gender- Tentative NOS slope coefficients (γ_{40}= -.055, se= .022) indicates that females had better understanding about Tentative NOS.

The High level income- Tentative NOS slope coefficients (γ_{50}= .118, se= .029) indicates that high level income is significantly and positively related to students' Tentative NOS understanding. Students having parents with high level income had better Tentative NOS understanding.

The college education level as a highest educational level of parents - Tentative NOS slope coefficients (γ_{60}= .134, se= .026) and the graduate education level as a highest educational level of parents-Tentative NOS slope coefficients (γ_{70}= .120, se= .036) indicates that highest educational level of parents is significantly and positively related to students' Tentative NOS understanding.

The Students' watching documentary film- Tentative NOS slope coefficients (γ_{80}= .104, se= .027) indicates that students' watching documentary film is significantly and positively related to students' Tentative NOS understanding. The students' watching documentary film had better Tentative NOS understanding.

The Performance goal orientation- Tentative NOS slope coefficients (γ_{90}= -.057, se= .016) indicates that students' performance goal orientation is significantly and negatively related to students' Tentative NOS understanding. Students having performance goal orientation had lower Tentative NOS understanding.

The Self efficacy- Tentative NOS slope coefficients (γ_{100}= .085, se= .021) indicates that students' self efficacy is significantly and positively related to students' Tentative NOS understanding. Students having high self efficacy had better Tentative NOS understanding.

The Rote learning approach - Tentative NOS slope coefficients (γ_{110}= -.191, se= .024) indicates that students' Rote learning approach is significantly and negatively related to students' Tentative NOS understanding. Students having rote learning approach had lower Tentative NOS understanding.

The final estimation of variance components obtained from random coefficient model is displayed in Table 4.16

Table 4.16 Final Estimation of Variance Components for Random Coefficient Model for Tentative NOS

Random Effect	*Variance Component*	*df*	*Chi-square* χ^2	**p-value**
School mean, u_{0j}	0.01776	22	127.58464	0.000
SCIENGRA, u_{1j}	0.00377	22	50.90884	0.001
Level-1 Effect, r_{ij}	0.36397			

Variance among the school means τ_{00}= 0.017 with a chi-square statistic of 127.584 is found to be statistically significant ($p< .005$). This significant difference (variability) in 23 schools might be explained by incorporating school-level factors in to the model. The variances of the science grade slope τ_{11}= .003 (χ^2= 50.908, $p< .005$) are found to be significant. This significant difference indicates that in some schools, the slopes are much steeper than for other schools, namely, relationship with Tentative NOS is much stronger in some schools than in other schools. The variability among schools also suggests that school level factors might account for some of the differences.

The variances in the Analysis of Variances Model and Random Coefficient Model will be compared to calculate the variance explained at the student level. It can be compared by creating an index of the proportion of reduction in variance at the student level by comparing the σ^2 estimates from these two models.

Proportion of variance explained at

$$\text{level 1} = \frac{\sigma^2(\text{ANOVA}) - \sigma^2(\text{Random Coefficient})}{\sigma^2(\text{ANOVA})}$$

$$\text{Proportion of variance explained at level 1} = \frac{0.4594 - 0.3639}{0.4594} = 0.207$$

By including these student level factors (high level income, college education level as a highest educational level of parents, graduate education level as a highest educational level of parents, seventh grade level, eight grade level, science achievement, gender, students' watching documentary film, students' performance goal orientation, self efficacy, and students' rote learning approach) as predictors of Tentative NOS within school variance was reduced by 20.7%. Therefore, these factors account for about 21% of the student level variance in Tentative NOS.

Findings related to reliability estimates of intercepts and randomly varying slopes indicate that the reliability of intercepts is 0.81, the reliability of randomly varying slopes are, 0.54 for Science achievement. According to Raudenbush and Bryk (2002) the primary reason for the lower reliability of the slopes is that the true slope variance across schools is much smaller than the variance of the true means and many schools are relatively homogenous on the randomly varying factors (e.g. SCIENGRA).

4.3.2.4 Results of Research Question VI (Intercepts and Slopes as Outcomes)

In order to answer sixth research question of whether school level factors predict student NOS views and the strength of associations between students NOS views and student level factors in terms of Tentative NOS, Intercepts and Slopes as Outcomes Model was applied. In this model, the coefficients (slopes) of the factors will be modeled to account for the variability of the regression equations across classes. The coefficient refers to the amount of influence a factor has on the endogenous factor. The Level-2 factors that are significantly associated with Level-1 factors are described as cross-level interactions. In this model there will be only one Level-2 equation for each Level-1 Beta value.

This research question includes three previous research questions. The first model was the Analysis of Variance Model which was explained the differences in students' Tentative NOS views among schools (Research Question 3). The variability of students' Tentative NOS views was modeled with school level factors in the Means as Outcomes Model (Research Question 4). One student level factor or coefficient science achievement factor (*SCIENGRA*) were observed to be randomly varying in the Random Coefficient Model (Research Question 5). Therefore, this coefficient can be modeled with school level factors. The school level factors which are significantly related to the random coefficients are termed as cross-level interactions that mean school level factor influences a student level slope. First of all, the intercept is modeled, and then randomly varying coefficient is modeled.

The equations for the first model in this analysis are:

Level 1(Students level):

Y_{ij} = β_{0j} + β_{1j}(GRADE7) + β_{2j}(GRADE8) + β_{3j}(SCIENGRA) + β_{4j}(GENDER) + β_{5j}(INCOMEHI) + β_{6j}(DUMMYCOL) + β_{7j}(DUMMYGRA) + β_{8j}(DOCUMENT) + β_{9j}(PERFGOAL) + β_{10j}(SELFEFFI) + β_{11j}(ROTELEAR) + r_{ij}

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{01}$ (HIGHINCS) + γ_{02} (QUALITYE) + u_{0j}

$\beta_{1j} = \gamma_{10}$

$\beta_{2j} = \gamma_{20}$

$\beta_{3j} = \gamma_{30} + u_{3j}$

$\beta_{4j} = \gamma_{40}$

$\beta_{5j} = \gamma_{50}$

$\beta_{6j} = \gamma_{60}$

$\beta_{7j} = \gamma_{70}$

$\beta_{8j} = \gamma_{80}$

$\beta_{9j} = \gamma_{90}$

$\beta_{10j} = \gamma_{100}$

$\beta_{11j} = \gamma_{110}$

Of the two school level factors, one of these factors, *Quality of school's physical infrastructure* was found as non-significant and removed from the model. Thus, the other factor was significantly related to students' Tentative NOS views. Then, these two factors were included in the science achievement factor (*SCIENGRA*) coefficient model with the previous results.

The equations for the second model in this analysis are:

Level 1(Students level):

Y_{ij} = β_{0j} + β_{1j}(GRADE7) + β_{2j}(GRADE8) + β_{3j}(SCIENGRA) + β_{4j}(GENDER) + β_{5j}(INCOMEHI) + β_{6j}(DUMMYCOL) + β_{7j}(DUMMYGRA) + β_{8j}(DOCUMENT) + β_{9j}(PERFGOAL) + β_{10j}(SELFEFFI) + β_{11j}(ROTELEAR) + r_{ij}

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{01}$ (HIGHINCS) + u_{0j}

$\beta_{1j} = \gamma_{10}$

$\beta_{2j} = \gamma_{20}$

$\beta_{3j} = \gamma_{30} + \gamma_{31}$ (HIGHINCS) + γ_{32} (QUALITYE) +u_{3j}

$\beta_{4j} = \gamma_{40}$

$\beta_{5j} = \gamma_{50}$

$\beta_{6j} = \gamma_{60}$

$\beta_{7j} = \gamma_{70}$

$\beta_{8j} = \gamma_{80}$

$\beta_{9j} = \gamma_{90}$

$\beta_{10j} = \gamma_{100}$

$\beta_{11j} = \gamma_{110}$

Of the two school level factors, one of these factors, *Quality of school's physical infrastructure* was not significantly related to the science achievement (*SCIENGRA*) slope and removed from the model. Thus, the other factor was significantly related to students' Tentative NOS views.

Finally, the full final Intercepts and Slopes as Outcomes Model was analyzed and the equations for the final full model are:

Level 1(Students level):

$Y_{ij} = \beta_{0j} + \beta_{1j}(\text{GRADE7}) + \beta_{2j}(\text{GRADE8}) + \beta_{3j}(\text{SCIENGRA}) + \beta_{4j}(\text{GENDER}) + \beta_{5j}(\text{INCOMEHI}) + \beta_{6j}(\text{DUMMYCOL}) + \beta_{7j}(\text{DUMMYGRA}) + \beta_{8j}(\text{DOCUMENT}) + \beta_{9j}(\text{PERFGOAL}) + \beta_{10j}(\text{SELFEFFI}) + \beta_{11j}(\text{ROTELEAR}) + r_{ij}$

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{HIGHINCS}) + u_{0j}$

$\beta_{1j} = \gamma_{10}$

$\beta_{2j} = \gamma_{20}$

$\beta_{3j} = \gamma_{30} + \gamma_{31}(\text{HIGHINCS}) + u_{3j}$

$\beta_{4j} = \gamma_{40}$

$\beta_{5j} = \gamma_{50}$

$\beta_{6j} = \gamma_{60}$

$\beta_{7j} = \gamma_{70}$

$\beta_{8j} = \gamma_{80}$

$\beta_{9j} = \gamma_{90}$

$\beta_{10j} = \gamma_{100}$

$\beta_{11j} = \gamma_{110}$

Table 4.17 Final Estimation of Fixed Effects of Final Full Model for Intercepts and Slopes as Outcomes Model for Tentative NOS

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Overall mean tentative NOS, γ_{00}	1.866	0.037	49.333	0.000
HIGHINCS, γ_{01}	0.005	0.001	4.007	0.001
GRADE7, γ_{10}	0.254	0.023	10.685	0.000
GRADE8, γ_{20}	0.161	0.050	3.213	0.002
SCIENGRA, γ_{30}	0.139	0.016	8.495	0.000
HIGHINCS, γ_{31}	0.002	0.001	2.699	0.014
GENDER, γ_{40}	-0.054	0.022	-2.369	0.018
INCOMEHI, γ_{50}	0.106	0.029	3.606	0.001
DUMMYCOL, γ_{60}	0.129	0.026	4.797	0.000
DUMMYGRA, γ_{70}	0.112	0.036	3.071	0.003
DOCUMENT, γ_{80}	0.104	0.027	3.770	0.000
PERFGOAL, γ_{90}	-0.057	0.016	-3.515	0.001
SELFEFFI, γ_{100}	0.085	0.021	4.032	0.000
ROTELEAR, γ_{110}	-0.191	0.024	-7.914	0.000

The results of the final estimation of fixed effects obtained from the full final Intercepts and Slopes as Outcomes Model were presented in Table 4.17. As stated before, the results from Means as Outcomes Model are reported in the final full Intercepts and Outcomes Model.

The results revealed significant and positive relationship between high level school socio economic status and Tentative NOS (γ_{01}= 0.005, se=0.001) indicating that the higher the school socio economic status is, the better Tentative NOS students have.

In addition to these, the results from the Random Coefficient Model are reported in the final full Intercepts and Slopes as Outcomes Model. *High level income, college education level as a highest educational level of parents, graduate education level as a highest educational level of parents*, *seventh grade level, eight grade level, science achievement, gender, students' watching documentary film*, *students' performance goal orientation, self efficacy, and students' rote learning approach* are significantly related to students' Tentative NOS views.

The Grade-Tentative NOS *slope* coefficients indicates that students from different grades had significantly different understanding on the Tentative NOS. Students from seventh grades (γ_{10}= .254, se= .023) and eighth grades (γ_{20}= .161, se= .050) performed significantly higher than the students from sixth grades on the Tentative NOS.

The Science grade-Tentative NOS slope coefficients (γ_{30}= .139, se= .016) indicates that students' science achievement is significantly and positively related to students' Tentative NOS understanding. Students having higher achievement had better Tentative NOS understanding than the other students.

The Gender- Tentative NOS slope coefficients (γ_{40}= -.054, se= .022) indicates that females had better understanding about Tentative NOS.

The High level income- Tentative NOS slope coefficients (γ_{50}= .106, se= .029) indicates that high level income is significantly and positively related to students' Tentative NOS understanding. Students having parents with high level income had better Tentative NOS understanding.

The college education level as a highest educational level of parents - Tentative NOS slope coefficients (γ_{60}= .129, se= .026) and the graduate education level as a highest educational level of parents-Tentative NOS slope coefficients (γ_{70}= .112, se= .036) indicates that highest educational level of parents is significantly and positively related to students' Tentative NOS understanding.

The Students' watching documentary film- Tentative NOS slope coefficients (γ_{80}= .104, se= .027) indicates that students' watching documentary film is significantly and positively related to students' Tentative NOS understanding. The students' watching documentary film had better Tentative NOS understanding.

The Performance goal orientation- Tentative NOS slope coefficients (γ_{90}= -.057, se= .016) indicates that students' performance goal orientation is significantly and negatively related to students' Tentative NOS understanding. Students having performance goal orientation had lower Tentative NOS understanding.

The Self efficacy- Tentative NOS slope coefficients (γ_{100}= .085, se= .021) indicates that students' self efficacy is significantly and positively related to students' Tentative NOS understanding. Students having high self efficacy had better Tentative NOS understanding.

The Rote learning approach - Tentative NOS slope coefficients (γ_{110}= -.191, se= .024) indicates that students' Rote learning approach is significantly and negatively related to students' Tentative NOS understanding. Students having rote learning approach had lower Tentative NOS understanding.

It can be seen that the coefficients have very slight differences in their magnitude, but the directions and the interpretations are same with the Random Coefficient Model because of the reduction of the number of students analyzed in the final full model.

In the final full Intercepts and Slopes as Outcomes Model, only one school level factors was significantly related to a student level slope. As previously stated, the *science achievement* (SCIENGRA) had one significant school level factors; high level school socio economic status (HIGHINCS) (γ_{40}= .002, se= .001). That means *science achievement* has more influence on students' Tentative NOS understanding in schools with high level socio economic status.

The results of the final estimation of variance components obtained from the full final Intercepts and Slopes as Outcomes Model were presented in Table 4.18. The degrees of freedom for this model (Intercepts and Slopes as Outcomes Model) is based on the number of schools with sufficient data, and the number of school level factors included in the model.

Degrees of Freedom = J – Q – 1, where

J = the number of schools with sufficient data

Q = number of school level factors included in the model

There were 23 schools with sufficient data.

df = J – Q – 1 = 23 – 1 – 1 = 21 (df for *School Mean*)

df = J – Q – 1 = 23 – 1 – 1 = 21 (df for Science Achievement (SCIENGRA))

Table 4.18 Final Estimation of Variance Components for Intercepts and Slopes as Outcomes Model for Tentative NOS

Random Effect	*Variance Component*	*df*	*Chi-square* χ^2	**p-value**
School mean, u_{0j}	0.00767	21	67.32578	0.000
SCIENGRA, u_{3j}	0.00239	21	41.73255	0.005
Level-1 Effect, r_{ij}	0.36403			

The proportion of variance explained for each Tentative NOS slope model with significant school level factors could be examined. For this study, that would be the *Science achievement* and *Tentative NOS*. The equation is:

The proportion of variance explained in β_{0j}

$$= \frac{\tau_{00}\text{(Random Coefficien t)} - \tau_{00}\text{(Intercepts and Slopes as Outcomes)}}{\tau_{00}\text{(Random Coefficien t)}}$$

β_{0j} = Tentative NOS or the slope coefficient for a given factor

The proportion of variance explained in Tentative

$$\text{NOS}= \frac{0.01776 - 0.00767}{0.01776} = 0.568$$

The proportion of variance explained in Science achievement (SCIENGRA);

$$\beta_{3j} = \frac{0.00377 - 0.00239}{0.00377} = 0.366$$

It can be concluded that 56.8 % of the variance in the between school differences in mean Tentative NOS is accounted for by *High level school socio economic status*. 36.6 % reduction in the variances was accounted for by *High level school socio economic status* for Science Achievement (SCIENGRA). However, significant differences still remains (χ^2= 67.325, p< .005) between schools. All of these proportions showed that substantial amount of variation had been accounted for.

4.3.3 HLM Analyses for Imagination and Creativity.

4.3.3.1 Results of Research Question III (One-Way ANOVA with Random Effects)

With respect to Imagination and Creativity, in order to answer the third research question of if there are any differences in students' NOS views among schools one-way ANOVA with random effects model was conducted.

For i= 1, …, nj students in school j, and j = 1, …, 23 schools, equations at two levels are:

Level 1 (Students level) Model:

$Y_{ij} = \beta_{0j} + r_{ij}$

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + u_{0j}$

where

Y_{ij} = the endogenous factor, Imagination and Creativity for i^{th} students in j^{th} school

β_{0j} = the intercept (the mean Imagination and Creativity for the j^{th} school)

r_{ij} = the student level error

γ_{00} = the grand mean

u_{0j} = the random effect associated with unit j (school)

The final estimation of fixed effects obtained from analysis of variance model of Imagination and Creativity is represented in the Table 4.19.

Table 4.19 Final Estimation of Fixed Effects for One-Way ANOVA with Random Effects for Imagination and Creativity

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Average school mean, γ_{00}	2.240071	0.022158	101.094	0.000

The analysis of variance indicates that average school mean of Imagination and Creativity, the grand-mean of Imagination and Creativity (γ_{00}), is statistically different from zero. That means there are significant differences among schools.

The grand-mean of Imagination and Creativity is 2.240 with a standard error of 0.022, indicating a 95% confidence interval of:

Confidence Interval = 2.240 ± 1.96 (0.022) = (2.283, 2.196)

Table 4.20 Final Estimation of Variance Components for One-Way ANOVA with Random Effects for Imagination and Creativity

Random Effect	*Variance Component*	*df*	*Chi-square*	**p-value**
School mean, u_{0j}	0.00807	22	92.70205	0.000
Level-1 Effect, r_{ij}	0.30636			

The final estimation of variance components obtained from the one-way ANOVA with random effects model is represented in the Table 4.20.

The findings indicated significant ($p < .005$) variation does exist among schools in their Imagination and Creativity ($X^2 = 92.70205$, df = 22). The result also revealed that school level factors might account for the differences in the students' Imagination and Creativity understanding.

At the student level $Var(r_{ij}) = \sigma^2 = 0.30636$. At the school level, τ_{00} is the variance of the true school means, β_{0j}, around the grand-mean, γ_{00}. $Var(u_{0j}) = \tau_{00} = 0.00807$.

The intraclass correlation (ICC), which represents proportion of variance in Y (Imagination and Creativity) among schools, is

$ICC = \tau_{00} / (\tau_{00} + \sigma^2) = 0.00807/ (0.00807+0.30636) = 0.025$

indicating that about 2.5 % of the variance in Imagination and Creativity is among schools.

HLM also provides an estimate of the reliability of the sample mean in any school. The reliability is an estimate of the true school mean and is affected by the sample size within each school. The overall estimate of reliability is the average of the school reliabilities. $\rho = .714$ indicating that the sample means tend to be a reliable indicator of true school means. The equation for determining reliability of the mean Imagination and Creativity within each school is: $\rho = \tau_{00} / [\tau_{00} + (\sigma^2 / nj)]$. Therefore, the reliability of the sample mean varies from school to school because the sample size, nj, varies.

In the following models, additional level 1 (student level) factors will be tried to reduce the variation within schools ($\sigma 2$) and additional level 2 (school level) factors will be tried to explain between school differences ($\tau 00$).

4.3.3.2 Results of Research Question IV (Means as Outcomes Model)

In order to answer the forth research question of which of the school level factors are associated with students' NOS views with respect to Imagination and Creativity, means-as-outcome model was applied.

Equations at two levels are:

Level 1 (Students level) Model:

$Y_{ij} = \beta_{0j} + r_{ij}$

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{01}$ (HIGHINCS) + γ_{02} (FEMALESC) + γ_{03} (ABILITYG) + γ_{04} (PHYSICAL) + γ_{05} (QUALITYE) + u_{0j}

for j = 1, 2, …, n schools

where

β_{0j} = the school mean on Imagination and Creativity

γ_{00} = the intercept (the grand mean for Imagination and Creativity, that is the average of the school means on Imagination and Creativity scores across the population of schools)

γ_{01} = the differentiating effect of high level school socio economic status on the school mean on Imagination and Creativity.

γ_{02} = the differentiating effect of proportion of female science teachers on the school mean on Imagination and Creativity.

γ_{03} = the differentiating effect of ability grouping between science classes on the school mean on Imagination and Creativity.

γ_{04} = the differentiating effect of quality of school's physical infrastructure on the school mean on Imagination and Creativity.

γ_{05} = the differentiating effect of quality of school's educational resources on the school mean on Imagination and Creativity.

τ_{00} = the conditional variance or school level variance in β_{0j} after controlling for these school level factors.

u_{0j} = the residual

The model was first run with all five factors, but *High level school socio economic status, Proportion of female science teachers,* and *quality of school's physical infrastructure* were not significant and were removed from the final analysis. The final estimation of fixed effects obtained from means as outcomes model of Imagination and Creativity is represented in the Table 4.21.

The results revealed significant and negative relationship between ability grouping between science classes and Imagination and Creativity (γ_{01}= -0.110, se= 0.037); quality of school's educational resources and Imagination and Creativity (γ_{01}= 0.068, se= 0.019).

Table 4.21 Final Estimation of Fixed Effects for Means as Outcomes Model for Imagination and Creativity

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Model for School Means[1]				
Intercepts, γ_{00}	2.240	0.015	145.866	0.000
ABILITYG, γ_{01}	-0.110	0.037	-2.955	0.008
QUALITYE, γ_{02}	0.068	0.019	3.438	0.003

[1] The student level factors were Grand Mean Centered before analysis.

The final estimation of variance components obtained from means as outcomes model is represented in the Table 4.22. The degrees of freedom for this model (Means as Outcomes Model) is based on the number of schools with sufficient data, and the number of school level factors included in the model.

Degrees of Freedom = J – Q – 1, where

J = the number of schools with sufficient data

Q = number of school level factors included in the model

Thus, all schools were used in this analysis and degrees of freedom for this model is:

df = J – Q – 1 = 23 – 2 – 1 = 20

Table 4.22 Final Estimation of Variance Components for Means as Outcomes Model for Imagination and Creativity

Random Effect	*Variance Component*	*df*	*Chi-square* χ^2	**p-value**
School mean, u_{0j}	0.00247	20	39.08215	0.007
Level-1 Effect, r_{ij}	0.30648			

The residual variance between schools (τ_{00} = 0.00247) is substantially smaller than the original variance (τ_{00} = 0.00807) resulting from the analysis of variance model. This reduction is due to the inclusion of school level factors.

Proportion of variance explained at

$$\text{level 1} = \frac{\tau_{00}(\text{ANOVA}) - \tau_{00}(\text{Means as Outcomes})}{\tau_{00}(\text{ANOVA})}$$

$$\text{Proportion of variance explained at level 1} = \frac{0.00807 - 0.00247}{0.00807} = 0.693$$

This result indicates that 69.3% of the true between school variance in Imagination and Creativity is accounted for by *Ability grouping between science classes, and Quality of school's educational resources.*

Finally, in order to examine whether the school Imagination and Creativity means vary significantly when ability grouping between science classes and quality of school's educational resources are controlled chi-square statistic was conducted. Chi-square statistic χ^2 is found as 39.08215 (df=20, p<

.05). This finding indicated that these two school level factors did not account for all the variation in the intercepts. However, even after controlling for ability grouping between science classes and quality of school's educational resources, schools still vary significantly in their average Imagination and Creativity views.

4.3.3.3 Results of Research Question V (Random Coefficient Model)

In order to answer the fifth research question of which of the student level factors help to explain the difference in understanding the Imagination and Creativity views Random Coefficient Model was conducted.

The equations to answer this question are:

Level 1(Students level):

$Y_{ij} = \beta_{0j} + \beta_{1j}$(GRADE7) + β_{2j}(GRADE8) + β_{3j}(SCIENGRA) + β_{4j}(GENDER) + β_{5j} (INCOMEME) + β_{6j}(INCOMEHI) + β_{7j}(DUMMYCOL) + β_{8j}(DUMMYGRA) + β_{9j} (PARENTOC) + β_{10j}(LIKINGSC) + β_{11j}(DUMMYLIK) + β_{12j}(READINGB) + β_{13j}(INTERNET) + β_{14j}(DOCUMENT) + β_{15j}(SHARINGI) + β_{16j}(PERFGOAL) + β_{17j}(LEARNGOA) + β_{18j}(SELFEFFI) + β_{19j}(MEANINGF) + β_{20j}(ROTELEAR) + r_{ij}

Level 2(School level):

$\beta_{0j} = \gamma_{00} + u_{0j}$

$\beta qj = \gamma_{q0} + u_{qj}$

where

Y_{ij} = Imagination and Creativity of student *i* in class *j*

β_{0j} = the class mean on Imagination and Creativity

β_{1j} = the differentiating effect of 7^{th} grade level in school j

β_{2j} = the differentiating effect of 8^{th} grade level in school j

β_{3j} = the differentiating effect of science achievement in school j

β_{4j} = the differentiating effect of gender in school j

β_{5j} = the differentiating effect of medium level income in school j

β_{6j} = the differentiating effect of high level income in school j

β_{7j} = the differentiating effect of college education level as a highest educational level of parents in school j

β_{8j} = the differentiating effect of graduate education level as a highest educational level of parents in school j

β_{9j} = the differentiating effect of highest parental occupational status in school j

β_{10j} = the differentiating effect of student attitude toward science in school j

β_{11j} = the differentiating effect of the course student like most in school j

β_{12j} = the differentiating effect of if students reads articles or books regarding science in school j

β_{13j} = the differentiating effect of if students benefit from internet sites regarding science in school j

β_{14j} = the differentiating effect of if students watch documentary film in school j

β_{15j} = the differentiating effect of if students share their ideas about science subjects with their families in school j

β_{16j} = the differentiating effect of students' performance goal orientation in school j

β_{17j} = the differentiating effect of students' learning goal orientation in school j

β_{18j} = the differentiating effect of students' self efficacy in school j

β_{19j} = the differentiating effect of students' meaningful learning approach in school j

β_{20j} = the differentiating effect of students' rote learning approach in school j

βqj = the coefficient for factor *q* for class j after accounting for other factors

γ_{00} = the average of school mean on Imagination and Creativity across the population of schools

γ_{q0} = the average *q* factor- Imagination and Creativity slope across those schools

u_{0j} = the unique increment to the intercept associated with school *j*

u_{qj} = the unique increment to the slope associated with school *j*

The building strategy recommended by Raudenbush and Bryk (2002) was used. A randomly varying coefficient or factor is defined as a slope whose value varies significantly among schools, or slope effects are allowed to randomly vary across schools. Student background characteristics were first examined (*INCOMEME, INCOMEHI, DUMMYCOL, DUMMYGRA, PARENTOC*) to determine whether they were significantly related to Imagination and Creativity and whether or not they were randomly varying.

Among these factors only high level income (*INCOMEHI*) was found to be significant and non-randomly varying. Therefore these factors will be examined as non-randomly varying factor in the model. The other factors (*INCOMEME, DUMMYCOL, DUMMYGRA, PARENTOC*) were all non-significant, thus removed from the model.

After, the factors related to students characteristics (*GRADE7, GRADE8, SCIENGRA, GENDER*) were examined along with the student background factors examined before. Among these factors seven grade level (*GRADE7*) was found to be nonsignificant and non-randomly varying, Therefore this factor will be removed from the model and the other factors (*GRADE8, SCIENGRA, GENDER)* will be examined as non-randomly varying factors in the model.

Then, factors related to student feelings and outside activities (*LIKINGSC, DUMMYLIK, READINGB, INTERNET, DOCUMENT, SHARINGI*) were added to the model. Among these factors students' sharing their ideas about science subjects with their families (*SHARINGI*) and student attitude toward science (*LIKINGSC)* was found to be significant and non-randomly varying. Therefore these factors will be examined as non-randomly varying factor in the model. The other factors (*DUMMYLIK, READINGB, INTERNET*) were all non-significant, thus removed from the model. Moreover, in this step, science achievement factor (*SCIENGRA*), becomes non-significant, this factor was removed from the model.

Lastly, learning and motivational factors (PERFGOAL, LEARNGOA, SELFEFFI, MEANINGF, ROTELEAR) were added to the model. From the learning and motivational factors, students' self efficacy, students' meaningful learning and rote learning approach (SELFEFFI, MEANINGF, ROTELEAR) were found to be significant and non-randomly varying. Therefore, these factors will be examined as non-randomly varying factor in the model. The other factors about learning and motivational factors, performance goal orientation, learning goal orientation and meaningful learning approach (PERFGOAL, LEARNGOA,), were not significant and non-randomly varying, so they were removed from the model. Also, in this step, gender (*GENDER),* students' sharing their ideas about science subjects with their families (*SHARINGI*) and student attitude toward science (*LIKINGSC)*, become non-significant, these factors were removed from the model.

Therefore, the final Random Coefficient Model includes four student level factors: *eight grade level (*student characteristics), *students' self efficacy, students' meaningful learning and rote learning approach,* (learning and motivational factors). Among these four student level factors, none of these factors was found as randomly varying. Therefore, these factors found as non-randomly varying, were included in the model as fixed.

The final random coefficient model included the factors significantly related to Imagination and Creativity. The final estimation of fixed effects obtained from random coefficient model of is displayed in the Table 4.23.

Table 4.23 Final Estimation of Fixed Effects for Random Coefficient Model for Imagination and Creativity

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Overall mean Imagination and Creativity[1], γ_{00}	2.252	0.021	106.282	0.000
GRADE8, γ_{10}	-0.136	0.043	-3.123	0.002
SELFEFFI, γ_{20}	0.095	0.019	4.777	0.000
MEANINGF, γ_{30}	0.055	0.021	2.550	0.011
ROTELEAR, γ_{40}	-0.075	0.020	-3.593	0.001

[1] The student level factors were Group Mean Centered before analysis.

The Grade-Imagination and Creativity *slope* coefficients indicates that students from different grades had significantly different understanding on the Imagination and Creativity. Students from eight grades (γ_{10}= -.136, se= .043) performed significantly lower than the students from sixth grades on the Observation and Inferences. There is no statistically significant difference between seven graders and other grade levels.

The Students' self efficacy - Imagination and Creativity slope coefficients (γ_{80}= .095, se= .019) indicates that students' self efficacy is significantly and positively related to students' Imagination and Creativity understanding. Students having high self efficacy had better Imagination and Creativity understanding.

The Meaningful learning approach - Imagination and Creativity slope coefficients (γ_{110}= .055, se= .021) indicates that students' Meaningful learning approach is significantly and positively related to students' Imagination and Creativity understanding. Students having meaningful learning approach had higher Imagination and Creativity understanding.

The Rote learning approach - Imagination and Creativity slope coefficients (γ_{110}= -.057, se= .020) indicates that students' Rote learning approach is significantly and negatively related to students' Imagination and Creativity understanding. Students having rote learning approach had lower Imagination and Creativity understanding.

The final estimation of variance components obtained from random coefficient model is displayed in Table 4.24.

Table 4.24 Final Estimation of Variance Components for Random Coefficient Model for Imagination and Creativity

Random Effect	*Variance Component*	*df*	*Chi-square* X^2	**p-value**
School mean, u_{0j}	0.00674	22	79.42759	0.000
Level-1 Effect, r_{ij}	0.29898			

Variance among the school means τ_{00}= 0.006 with a chi-square statistic of 79.42759 is found to be statistically significant (p< .005). This significant difference (variability) in 23 schools might be explained by incorporating school-level factors in to the model.

The variances in the Analysis of Variances Model and Random Coefficient Model will be compared to calculate the variance explained at the student level. It can be compared by creating an index of the proportion of reduction in variance at the student level by comparing the σ^2 estimates from these two models.

Proportion of variance explained at

$$\text{level 1} = \frac{\sigma^2(\text{ANOVA}) - \sigma^2(\text{Random Coefficient})}{\sigma^2(\text{ANOVA})}$$

$$\text{Proportion of variance explained at level 1} = \frac{0.30636 - 0.29898}{0.30636} = 0.024$$

By including these student level factors (eight grade level, students', students' self efficacy, students' meaningful learning and rote learning approach) as predictors of Imagination and Creativity within school variance was reduced by 2.4%. Therefore, these factors account for about 2,4% of the student level variance in Imagination and Creativity. Findings related to reliability estimates of intercepts and randomly varying slopes indicate that the reliability of intercepts is 0.68.

4.3.3.4 Results of Research Question VI (Intercepts and Slopes as Outcomes)

In order to answer sixth research question of whether school level factors predict student NOS views and the strength of associations between students NOS views and student level factors in terms of Imagination and Creativity, Intercepts and Slopes as Outcomes Model was applied. In this model, the coefficients (slopes) of the factors will be modeled to account for the variability of the regression equations across classes. The coefficient refers to the amount of influence a factor has on the endogenous factor. The Level-2 factors that are significantly associated with Level-1 factors are described as cross-level interactions. In this model there will be only one Level-2 equation for each Level-1 Beta value.

This research question includes three previous research questions. The first model was the Analysis of Variance Model which was explained the differences in students' Imagination and Creativity views among schools (Research Question 3). The variability of students' Imagination and Creativity views was modeled with school level factors in the Means as Outcomes Model (Research Question 4). None of the student level factor or coefficient science achievement factor was observed to be randomly varying in the Random Coefficient Model (Research Question 5). Therefore, this coefficient could not be modeled with school level factors. Therefore, only the intercept is modeled. The equations for the first model in this analysis are:

Level 1(Students level):

$Y_{ij} = \beta_{0j} + \beta_{1j}(\text{GRADE8}) + \beta_{2j}(\text{SELFEFFI}) + \beta_{3j}(\text{MEANINGF}) + \beta_{4j}(\text{ROTELEAR}) + r_{ij}$

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{01} (\text{ABILITYG}) + \gamma_{02} (\text{QUALITYE}) + u_{0j}$

$\beta_{1j} = \gamma_{10}$

$\beta_{2j} = \gamma_{20}$

$\beta_{3j} = \gamma_{30}$

$\beta_{4j} = \gamma_{40}$

Of the two school level factors, one of these factors, *Ability grouping between science classes* was found as non-significant and removed from the model. Thus, the other factor (*Quality of school's educational resources*) was significantly related to students' Imagination and Creativity views.

Finally, the full final Intercepts and Slopes as Outcomes Model was analyzed and the equations for the final full model are:

The equations for the second model in this analysis are:

Level 1(Students level):

$Y_{ij} = \beta_{0j} + \beta_{1j}(\text{GRADE8}) + \beta_{2j}(\text{SELFEFFI}) + \beta_{3j}(\text{MEANINGF}) + \beta_{4j}(\text{ROTELEAR}) + r_{ij}$

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{02}$ (QUALITYE) + u_{0j}

$\beta_{1j} = \gamma_{10}$

$\beta_{2j} = \gamma_{20}$

$\beta_{3j} = \gamma_{30}$

$\beta_{4j} = \gamma_{40}$

Table 4.25 Final Estimation of Fixed Effects of Final Full Model for Intercepts and Slopes as Outcomes Model for Imagination and Creativity

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Overall mean Imagination and Creativity[1], γ_{00}	2.248	0.017	126.008	0.000
QUALITYE, γ_{01}	0.068	0.022	3.062	0.006
GRADE8, γ_{10}	-0.127	0.042	-3.010	0.003
SELFEFFI, γ_{20}	0.095	0.019	4.785	0.000
MEANINGF, γ_{30}	0.055	0.021	2.563	0.011
ROTELEAR, γ_{40}	-0.075	0.016	-3.584	0.001

The results of the final estimation of fixed effects obtained from the full final Intercepts and Slopes as Outcomes Model were presented in Table 4.25. As stated before, the results from Means as Outcomes Model are reported in the final full Intercepts and Outcomes Model.

The results revealed significant and positive relationship between *quality of school's educational resources* and Imagination and Creativity views (γ_{01}= 0.068, se= 0.022).

In addition to these, the results from the Random Coefficient Model are reported in the final full Intercepts and Slopes as Outcomes Model. *Eight grade level*, *students' self efficacy, students' meaningful learning and rote learning approach* are significantly related to students' Imagination and Creativity views.

The Grade-Imagination and Creativity *slope* coefficients indicates that students from different grades had significantly different understanding on the Imagination and Creativity. Students from eight grades (γ_{10}= -.127, se= .042) performed significantly lower than the students from sixth grades on the Observation and Inferences. There is no statistically significant difference between seven graders and other grade levels.

The Students' self efficacy - Imagination and Creativity slope coefficients (γ_{80}= .095, se= .019) indicates that students' self efficacy is significantly and positively related to students' Imagination and Creativity understanding. Students having high self efficacy had better Imagination and Creativity understanding.

The Meaningful learning approach - Imagination and Creativity slope coefficients (γ_{110}= .055, se= .021) indicates that students' Meaningful learning approach is significantly and positively related to students' Imagination and

Creativity understanding. Students having meaningful learning approach had higher Imagination and Creativity understanding.

The Rote learning approach - Imagination and Creativity slope coefficients (γ_{110}= -.057, se= .020) indicates that students' Rote learning approach is significantly and negatively related to students' Imagination and Creativity understanding. Students having rote learning approach had lower Imagination and Creativity understanding.

It can be seen that the coefficients have very slight differences in their magnitude, but the directions and the interpretations are same with the Random Coefficient Model because of the reduction of the number of students analyzed in the final full model.

The results of the final estimation of variance components obtained from the full final Intercepts and Slopes as Outcomes Model were presented in Table 4.26. The degrees of freedom for this model (Intercepts and Slopes as Outcomes Model) is based on the number of schools with sufficient data, and the number of school level factors included in the model.

Degrees of Freedom = J – Q – 1, where

J = the number of schools with sufficient data

Q = number of school level factors included in the model

There were 23 schools with sufficient data.

df = J – Q – 1 = 23 – 1 – 1 = 21 (df for *School Mean*)

Table 4.26 Final Estimation of Variance Components for Intercepts and Slopes as Outcomes Model for Imagination and Creativity

Random Effect	*Variance Component*	*df*	*Chi-square* χ^2	**p-value**
School mean, u_{0j}	0.00390	21	53.63255	0.000
Level-1 Effect, r_{ij}	0.29903			

The proportion of variance explained for each Imagination and Creativity slope model with significant school level factors could be examined. For this study, that would be the *Science achievement* and *Imagination and Creativity*. The equation is:

The proportion of variance explained in β_{0j}

$$= \frac{\tau_{00}\text{(Random Coefficien t)} - \tau_{00}\text{(Intercepts and Slopes as Outcomes)}}{\tau_{00}\text{(Random Coefficien t)}}$$

β_{0j} = Imagination and Creativity or the slope coefficient for a given factor

The proportion of variance explained in Imagination and Creativity =

$$\frac{0.00674 - 0.00390}{0.00674} = 0.421$$

It can be concluded that 42.1 % of the variance in the between school differences in mean Imagination and Creativity is accounted for by quality of school's educational resources However, significant differences still remains (χ^2= 53.632, p< .005) between schools.

4.3.4 HLM Analyses for Empirical NOS.

4.3.4.1 Results of Research Question III (One-Way ANOVA with Random Effects)

With respect to Empirical NOS, in order to answer the third research question of if there are any differences in students' NOS views among schools one-way ANOVA with random effects model was conducted.

For i= 1, …, nj students in school j, and j = 1, …, 23 schools, equations at two levels are:

Level 1 (Students level) Model:

$Y_{ij} = \beta_{0j} + r_{ij}$

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + u_{0j}$

where

Y_{ij} = the endogenous factor, Empirical NOS for i^{th} students in j^{th} school

β_{0j} = the intercept (the mean Empirical NOS for the j^{th} school)

r_{ij} = the student level error

γ_{00} = the grand mean

u_{0j} = the random effect associated with unit j (school)

The final estimation of fixed effects obtained from analysis of variance model of Empirical NOS is represented in the Table 4.27.

Table 4.27 Final Estimation of Fixed Effects for One-Way ANOVA with Random Effects for Empirical NOS

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Average school mean, γ_{00}	2.576098	0.017526	146.983	0.000

The analysis of variance indicates that average school mean of Empirical NOS, the grand-mean of Empirical NOS (γ_{00}), is statistically different from zero. That means there are significant differences among schools.

The grand-mean of Empirical NOS is 2.576 with a standard error of 0.017, indicating a 95% confidence interval of:

Confidence Interval = 2.576 ± 1.96 (0.017) = (2.542, 2.609)

Table 4.28 Final Estimation of Variance Components for One-Way ANOVA with Random Effects for Empirical NOS

Random Effect	*Variance Component*	*df*	*Chi-square*	**p-value**
School mean, u_{0j}	0.00485	22	79.12822	0.000
Level-1 Effect, r_{ij}	0.21396			

The final estimation of variance components obtained from the one-way ANOVA with random effects model is represented in the Table 4.28.

The findings indicated significant (p< .005) variation does exist among schools in their Empirical NOS (χ^2 = 79.12822, df = 22). The result also revealed that school level factors might account for the differences in the students' Empirical NOS understanding.

At the student level $Var(r_{ij}) = \sigma^2 = 0.21396$. At the school level, τ_{00} is the variance of the true school means, β_{0j}, around the grand-mean, γ_{00}. $Var(u_{0j}) = \tau_{00} = 0.00485$.

The intraclass correlation (ICC), which represents proportion of variance in Y (Empirical NOS) among schools, is

$ICC = \tau_{00} / (\tau_{00} + \sigma^2) = 0.00485 / (0.00485 + 0.21396) = 0.022$

indicating that about 2.2 % of the variance in Empirical NOS is among schools. HLM also provides an estimate of the reliability of the sample mean in any school. The reliability is an estimate of the true school mean and is affected by the sample size within each school. The overall estimate of reliability is the average of the school reliabilities. $\rho = .721$ indicating that the sample means tend to be a reliable indicator of true school means.

The equation for determining reliability of the mean Empirical NOS within each school is: $\rho = \tau_{00} / [\tau_{00} + (\sigma^2 / nj)]$. Therefore, the reliability of the sample mean varies from school to school because the sample size, nj, varies.

4.3.4.2 Results of Research Question IV (Means as Outcomes Model)

In order to answer the forth research question of which of the school level factors are associated with students' NOS views with respect to Empirical NOS , means-as-outcome model was applied.

Equations at two levels are:

Level 1 (Students level) Model:

$Y_{ij} = \beta_{0j} + r_{ij}$

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{01}$ (LOWINCSC) + γ_{02} (FEMALESC) + γ_{03} (ABILITYG) + γ_{04} (PHYSICAL) + γ_{05} (QUALITYE) + u_{0j}

for j = 1, 2, …, n schools

where

β_{0j} = the school mean on Empirical NOS

γ_{00} = the intercept (the grand mean for Empirical NOS , that is the average of the school means on Empirical NOS scores across the population of schools)

γ_{01} = the differentiating effect of low level school socio economic status on the school mean on Empirical NOS.

γ_{02} = the differentiating effect of proportion of female science teachers on the school mean on Empirical NOS.

γ_{03} = the differentiating effect of ability grouping between science classes on the school mean on Empirical NOS.

γ_{04} = the differentiating effect of quality of school's physical infrastructure on the school mean on Empirical NOS.

γ_{05} = the differentiating effect of quality of school's educational resources on the school mean on Empirical NOS.

τ_{00} = the conditional variance or school level variance in β_{0j} after controlling for these school level factors.

u_{0j} = the residual

The model was first run with all five factors, but *Ability grouping between science classes, Quality of school's physical infrastructure,* and *Quality of school's physical infrastructure* were not significant and were removed from the final analysis. The final estimation of fixed effects obtained from means as outcomes model of Empirical NOS is represented in the Table 4.29.

The results revealed significant and negative relationship between low level school socio economic status and Empirical NOS (γ_{01}= -0.003, se= 0.0008); significant and positive relationship between proportion of female science teachers and Empirical NOS (γ_{01}= 0.001, se= 0.0005).

Table 4.29 Final Estimation of Fixed Effects for Means as Outcomes Model for Empirical NOS

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Model for School Means[1]				
Intercepts, γ_{00}	2.571	0.0119	214.641	0.000
LOWINCSC, γ_{01}	-0.003	0.0008	-4.398	0.000
FEMALESC, γ_{02}	0.001	0.0005	2.564	0.019

[1] The student level factors were Grand Mean Centered before analysis.

The final estimation of variance components obtained from means as outcomes model is represented in the Table 4.30. The degrees of freedom for this model (Means as Outcomes Model) is based on the number of schools with sufficient data, and the number of school level factors included in the model.

Degrees of Freedom = J – Q – 1, where

J = the number of schools with sufficient data

Q = number of school level factors included in the model

Thus, all schools were used in this analysis and degrees of freedom for this model is:

df = J – Q – 1 = 23 – 2 – 1 = 20

Table 4.30 Final Estimation of Variance Components for Means as Outcomes Model for Empirical NOS

Random Effect	*Variance Component*	*df*	*Chi-square* χ^2	**p-value**
School mean, u_{0j}	0.00126	20	35.75200	0.016
Level-1 Effect, r_{ij}	0.21380			

The residual variance between schools (τ_{00} = 0.00126) is substantially smaller than the original variance (τ_{00} = 0.00485) resulting from the analysis of variance model. This reduction is due to the inclusion of school level factors. proportion of variance explained at

$$\text{level } 1 = \frac{\tau_{00}\,(\text{ANOVA}) - \tau_{00}\,(\text{Means as Outcomes})}{\tau_{00}\,(\text{ANOVA})}$$

$$\text{proportion of variance explained at level } 1 = \frac{0.00485 - 0.00126}{0.00485} = 0.740$$

This result indicates that 74.0% of the true between school variance in Empirical NOS is accounted for by *Low level school socio economic status, and Proportion of female science teachers.*

Finally, in order to examine whether the school Empirical NOS means vary significantly when high level school socio economic status and quality of school's educational resources are controlled chi-square statistic was conducted. Chi-square statistic χ^2 is found as 35.75200 (df=20, p< .05). This finding indicated that these two school level factors did not account for all the variation in the intercepts. However, even after controlling for low level school socio economic status, and proportion of female science teachers, schools still vary significantly in their average Empirical NOS views.

4.3.4.3 Results of Research Question V (Random Coefficient Model)

In order to answer the fifth research question of which of the student level factors help to explain the difference in understanding the Empirical NOS views Random Coefficient Model was conducted.

The equations to answer this question are:

Level 1(Students level):

$$Y_{ij} = \beta_{0j} + \beta_{1j}(\text{GRADE7}) + \beta_{2j}(\text{GRADE8}) + \beta_{3j}(\text{SCIENGRA}) + \beta_{4j}(\text{GENDER}) + \beta_{5j}(\text{INCOMEME}) + \beta_{6j}(\text{INCOMEHI}) + \beta_{7j}(\text{DUMMYCOL}) + \beta_{8j}(\text{DUMMYGRA}) + \beta_{9j}(\text{PARENTOC}) + \beta_{10j}(\text{LIKINGSC}) + \beta_{11j}(\text{DUMMYLIK}) + \beta_{12j}(\text{READINGB}) + \beta_{13j}(\text{INTERNET}) + \beta_{14j}(\text{DOCUMENT}) + \beta_{15j}(\text{SHARINGI}) + \beta_{16j}(\text{PERFGOAL}) + \beta_{17j}(\text{LEARNGOA}) + \beta_{18j}(\text{SELFEFFI}) + \beta_{19j}(\text{MEANINGF}) + \beta_{20j}(\text{ROTELEAR}) + r_{ij}$$

Level 2(School level):

$\beta_{0j} = \gamma_{00} + u_{0j}$

$\beta_{qj} = \gamma_{q0} + u_{qj}$

where

Y_{ij} = Empirical NOS of student *i* in class *j*

β_{0j} = the school mean on Empirical NOS

β_{1j} = the differentiating effect of 7th grade level in school j

β_{2j} = the differentiating effect of 8th grade level in school j

β_{3j} = the differentiating effect of science achievement in school j

β_{4j} = the differentiating effect of gender in school j

β_{5j} = the differentiating effect of medium level income in school j

β_{6j} = the differentiating effect of high level income in school j

β_{7j} = the differentiating effect of college education level as a highest educational level of parents in school j

β_{8j} = the differentiating effect of graduate education level as a highest educational level of parents in school j

β_{9j} = the differentiating effect of highest parental occupational status in school j

β_{10j} = the differentiating effect of student attitude toward science in school j

β_{11j} = the differentiating effect of the course student like most in school j

β_{12j} = the differentiating effect of if students reads articles or books regarding science in school j

β_{13j} = the differentiating effect of if students benefit from internet sites regarding science in school j

β_{14j} = the differentiating effect of if students watch documentary film in school j

β_{15j} = the differentiating effect of if students share their ideas about science subjects with their families in school j

β_{16j} = the differentiating effect of students' performance goal orientation in school j

β_{17j} = the differentiating effect of students' learning goal orientation in school j

β_{18j} = the differentiating effect of students' self efficacy in school j

β_{19j} = the differentiating effect of students' meaningful learning approach in school j

β_{20j} = the differentiating effect of students' rote learning approach in school j

βqj = the coefficient for factor q for class j after accounting for other factors

γ_{00} = the average of school mean on Empirical NOS across the population of schools

γ_{q0} = the average *q* factor- Empirical NOS slope across those schools

u_{0j} = the unique increment to the intercept associated with school *j*

u_{qj} = the unique increment to the slope associated with school *j*

The building strategy recommended by Raudenbush and Bryk (2002) was used. A randomly varying coefficient or factor is defined as a slope whose value varies significantly among schools, or slope effects are allowed to randomly vary across schools. Student background characteristics were first examined (*INCOMEME, INCOMEHI, DUMMYCOL, DUMMYGRA, PARENTOC*) to determine whether they were significantly related to Empirical NOS and whether or not they were randomly varying. Among these factors high level income, college education level as a highest educational level of parents, and graduate education level as a highest educational level of parents (*INCOMEHI,DUMMYCOL, DUMMYGRA)* were found to be significant, and non-randomly varying. The other factors, medium level income, and highest parental occupational status (*INCOMEME, PARENTOC*), were found to be non-significant and non-randomly varying, thus, they were removed from the model.

After, factors related to students characteristics (*GRADE7, GRADE8, SCIENGRA, and GENDER*) were examined along with the student background characteristics examined before. Except from gender (GENDER) all of the factors were found to be significant, but only science achievement factor

(*SCIENGRA*) were found randomly varying factors among factors related to students characteristics.

Then, factors related to student feelings and outside activities (*LIKINGSC, DUMMYLIK, READINGB, INTERNET, DOCUMENT, SHARINGI*) were added to the model. Except for students' benefit from internet sites regarding science and course student like most in school (*INTERNET*, *DUMMYLIK),* all of the other factors (students' attitude toward science, students' reading articles or books regarding science, students' watch documentary film and students' sharing their ideas about science subjects with their families) (*LIKINGSC, READINGB, DOCUMENT, SHARINGI*) were all significant, and non-randomly varying. Therefore, these factors will be examined as non-randomly varying factor in the model.

Lastly, learning and motivational factors (PERFGOAL, LEARNGOA, SELFEFFI, MEANINGF, ROTELEAR) were added to the model. From the learning and motivational factors, students' learning goal orientation, self efficacy, students' meaningful learning approach and students' rote learning approach (LEARNGOA, SELFEFFI, MEANINGF, ROTELEAR) were found to be significant and non-randomly varying. Therefore, these factors will be examined as non-randomly varying factor in the model. The other factor about learning and motivational factors, performance goal orientation (PERFGOAL), was not significant and non-randomly varying, so it was removed from the model. In this step, *LIKINGSC, READINGB, DOCUMENT, and SHARINGI* became non-significant and they were removed from the model.

Therefore, the final Random Coefficient Model includes nine student level factors: *college education level as a highest educational level of parents, graduate education level as a highest educational level of parents* (student background), *seventh grade level, eight grade level, science achievement, (*student characteristics), *students' learning goal orientation, self efficacy, students' meaningful learning and students' rote learning approach,* (learning and motivational factors). Among these nine student level factors, only one factor science achievement (SCIENGRA) was found as randomly varying. Therefore, the other eight factors found as non-randomly varying, were included in the model as fixed.

The final random coefficient model included the factors significantly related to Empirical NOS and the factors both significantly related to Empirical NOS and randomly varying. The final estimation of fixed effects obtained from random coefficient model of is displayed in the Table 4.31.

Table 4.31 Final Estimation of Fixed Effects for Random Coefficient Model for Empirical NOS

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Overall mean Empirical NOS[1], γ_{00}	2.481	0.019	124.987	0.000
GRADE7, γ_{10}	0.108	0.016	6.509	0.000
GRADE8, γ_{20}	0.094	0.034	2.716	0.007
SCIENGRA, γ_{30}	0.050	0.010	4.870	0.000
DUMMYCOL, γ_{40}	0.080	0.018	4.421	0.000
DUMMYGRA, γ_{50}	0.091	0.024	3.740	0.000
LEARNGOA, γ_{60}	0.112	0.018	6.115	0.000
SELFEFFI, γ_{70}	0.064	0.016	4.001	0.000
MEANINGF, γ_{80}	0.092	0.019	4.666	0.000
ROTELEAR, γ_{90}	-0.076	0.016	-4.665	0.000

[1] The student level factors were Group Mean Centered before analysis.

The Grade-Empirical NOS *slope* coefficients indicates that students from different grades had significantly different understanding on the Empirical NOS. Students from seventh grades (γ_{10}= .108, se= .016) and eighth grades (γ_{20}= .094, se= .034) performed significantly higher than the students from sixth grades on the Empirical NOS.

The Science grade-Empirical NOS slope coefficients (γ_{30}= .050, se= .010) indicates that students' science achievement is significantly and positively related to students' Empirical NOS understanding. Students having higher achievement had better Empirical NOS understanding than the other students.

The college education level as a highest educational level of parents - Empirical NOS slope coefficients (γ_{40}= .080, se= .018) and the graduate education level as a highest educational level of parents-Empirical NOS slope coefficients (γ_{50}= .091, se= .024) indicates that highest educational level of parents is significantly and positively related to students' Empirical NOS understanding.

The Learning goal orientation- Empirical NOS slope coefficients (γ_{60}= .112, se= .018) indicates that students' learning goal orientation is significantly and positively related to students' Empirical NOS understanding. Students having learning goal orientation had higher Empirical NOS understanding.

The Self efficacy- Empirical NOS slope coefficients (γ_{70}= .064, se= .016) indicates that students' self efficacy is significantly and positively related to students' Empirical NOS understanding. Students having high self efficacy had better Empirical NOS understanding.

The Meaningful learning approach - Empirical NOS slope coefficients (γ_{80}= .092, se= .019) indicates that students' Meaningful learning approach is significantly and positively related to students' Empirical NOS understanding. Students having meaningful learning approach had higher Empirical NOS understanding.

The Rote learning approach - Empirical NOS slope coefficients (γ_{90}= -.076, se= .016) indicates that students' Rote learning approach is significantly and negatively related to students' Empirical NOS understanding. Students having rote learning approach had lower Empirical NOS understanding.

The final estimation of variance components obtained from random coefficient model is displayed in Table 4.32.

Table 4.32 Final Estimation of Variance Components for Random Coefficient Model for Empirical NOS

Random Effect	*Variance Component*	*df*	*Chi-square* X^2	**p-value**
School mean, u_{0j}	0.00376	22	75.51624	0.000
SCIENGRA, u_{1j}	0.00081	22	40.55828	0.009
Level-1 Effect, r_{ij}	0.17917			

Variance among the school means τ_{00}= 0.003 with a chi-square statistic of 75.51624 is found to be statistically significant (p< .005). This significant difference (variability) in 23 schools might be explained by incorporating school level factors in to the model. The variances of the science grade slope τ_{11}= .000 (χ^2= 40.558, p< .005) are found to be significant. This significant difference indicates that in some schools, the slopes are much steeper than for other schools, namely, relationship with Empirical NOS is much stronger in some schools than in other schools. The variability among schools also suggests that school level factors might account for some of the differences.

The variances in the Analysis of Variances Model and Random Coefficient Model will be compared to calculate the variance explained at the student level. It can be compared by creating an index of the proportion of reduction in variance at the student level by comparing the σ^2 estimates from these two models.

Proportion of variance explained at

$$\text{level 1} = \frac{\sigma^2(\text{ANOVA}) - \sigma^2(\text{Random Coefficient})}{\sigma^2(\text{ANOVA})}$$

$$\text{Proportion of variance explained at level 1} = \frac{0.21396 - 0.17917}{0.21396} = 0.162$$

By including these student level factors (college education level as a highest educational level of parents, graduate education level as a highest educational level of parents, seventh grade level, eight grade level, science achievement, students' learning goal orientation, self efficacy, students' meaningful learning approach and students' rote learning approach) as predictors of Empirical NOS within school variance was reduced by 16.2 %. Therefore, these factors account for about 16.2 % of the student level variance in Empirical NOS.

Findings related to reliability estimates of intercepts and randomly varying slopes indicate that the reliability of intercepts is 0.71 the reliability of randomly varying slopes are, 0.36 for Science achievement. According to

Raudenbush and Bryk (2002) the primary reason for the lower reliability of the slopes is that the true slope variance across schools is much smaller than the variance of the true means and many schools are relatively homogenous on the randomly varying factors (e.g. SCIENGRA).

4.3.4.4 Results of Research Question VI (Intercepts and Slopes as Outcomes)

In order to answer sixth research question of whether school level factors predict student NOS views and the strength of associations between students NOS views and student level factors in terms of Empirical NOS, Intercepts and Slopes as Outcomes Model was applied. In this model, the coefficients (slopes) of the factors will be modeled to account for the variability of the regression equations across classes. The coefficient refers to the amount of influence a factor has on the endogenous factor. The Level-2 factors that are significantly associated with Level-1 factors are described as cross-level interactions. In this model there will be only one Level-2 equation for each Level-1 Beta value.

This research question includes three previous research questions. The first model was the Analysis of Variance Model which was explained the differences in students' Empirical NOS views among schools (Research Question 3). The variability of students' Empirical NOS views was modeled with school level factors in the Means as Outcomes Model (Research Question 4). One student level factor or coefficient science achievement factor (*SCIENGRA*) were observed to be randomly varying in the Random Coefficient Model (Research Question 5). Therefore, this coefficient can be modeled with school level factors. The school level factors which are significantly related to the random coefficients are termed as cross-level interactions that mean school level factor influences a student level slope. First of all, the intercept is modeled, and then randomly varying coefficient is modeled.

The equations for the first model in this analysis are:

Level 1(Students level):

$Y_{ij} = \beta_{0j} + \beta_{1j}(\text{GRADE7}) + \beta_{2j}(\text{GRADE8}) + \beta_{3j}(\text{SCIENGRA}) + \beta_{4j}(\text{DUMMYCOL}) + \beta_{5j}(\text{DUMMYGRA}) + \beta_{6j}(\text{LEARNGOA}) + \beta_{7j}(\text{SELFEFFI}) + \beta_{8j}(\text{MEANINGF}) + \beta_{9j}(\text{ROTELEAR}) + r_{ij}$

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{01}\ (\text{LOWINCSC}) + \gamma_{02}\ (\text{FEMALESC}) + u_{0j}$

$\beta_{1j} = \gamma_{10}$

$\beta_{2j} = \gamma_{20}$

$\beta_{3j} = \gamma_{30} + u_{3j}$

$\beta_{4j} = \gamma_{40}$

$\beta_{5j} = \gamma_{50}$

$\beta_{6j} = \gamma_{60}$

$\beta_{7j} = \gamma_{70}$

$\beta_{8j} = \gamma_{80}$

$\beta_{9j} = \gamma_{90}$

Both of the school level factors, low level school socio economic status and proportion of female science teachers (*LOWINCSC and FEMALESC*) were significantly related to students' Empirical NOS views. Then, these two factors were included in the science achievement factor (*SCIENGRA*) coefficient model with the previous results.

The equations for the second model in this analysis are:

Level 1(Students level):

$Y_{ij} = \beta_{0j} + \beta_{1j}$(GRADE7) + β_{2j}(GRADE8) + β_{3j}(SCIENGRA) + β_{4j}(DUMMYCOL) + β_{5j}(DUMMYGRA) + β_{6j}(LEARNGOA) + β_{7j}(SELFEFFI) + β_{8j}(MEANINGF) + β_{9j}(ROTELEAR) + r_{ij}

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{01}$ (LOWINCSC) + γ_{02} (FEMALESC) + u_{0j}

$\beta_{1j} = \gamma_{10}$

$\beta_{2j} = \gamma_{20}$

$\beta_{3j} = \gamma_{30} + \gamma_{31}$ (LOWINCSC) + γ_{32} (FEMALESC) + u_{3j}

$\beta_{4j} = \gamma_{40}$

$\beta_{5j} = \gamma_{50}$

$\beta_{6j} = \gamma_{60}$

$\beta_{7j} = \gamma_{70}$

$\beta_{8j} = \gamma_{80}$

$\beta_{9j} = \gamma_{90}$

Of the two school level factors, one of these factors, *proportion of female science teachers* (*FEMALESC*) was not significantly related to the science achievement (*SCIENGRA*) slope and removed from the model. Thus, the other factor was significantly related to students' Empirical NOS views.

Finally, the full final Intercepts and Slopes as Outcomes Model was analyzed and the equations for the final full model are:

Level 1(Students level):

$Y_{ij} = \beta_{0j} + \beta_{1j}(\text{GRADE7}) + \beta_{2j}(\text{GRADE8}) + \beta_{3j}(\text{SCIENGRA}) + \beta_{4j}(\text{DUMMYCOL}) + \beta_{5j}(\text{DUMMYGRA}) + \beta_{6j}(\text{LEARNGOA}) + \beta_{7j}(\text{SELFEFFI}) + \beta_{8j}(\text{MEANINGF}) + \beta_{9j}(\text{ROTELEAR}) + r_{ij}$

Level 2 (School level) Model:

$\beta_{0j} = \gamma_{00} + \gamma_{01}\ (\text{LOWINCSC}) + \gamma_{02}\ (\text{FEMALESC}) + u_{0j}$

$\beta_{1j} = \gamma_{10}$

$\beta_{2j} = \gamma_{20}$

$\beta_{3j} = \gamma_{30} + \gamma_{31}\ (\text{LOWINCSC}) + u_{3j}$

$\beta_{4j} = \gamma_{40}$

$\beta_{5j} = \gamma_{50}$

$\beta_{6j} = \gamma_{60}$

$\beta_{7j} = \gamma_{70}$

$\beta_{8j} = \gamma_{80}$

$\beta_{9j} = \gamma_{90}$

Table 4.33 Final Estimation of Fixed Effects of Final Full Model for Intercepts and Slopes as Outcomes Model for Empirical NOS

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Overall mean Empirical NOS, γ_{00}	2.481	0.017	142.000	0.000
LOWINCSC, γ_{01}	-0.003	0.000	-3.445	0.003
FEMALESC, γ_{02}	0.001	0.000	2.356	0.029
GRADE7, γ_{10}	0.104	0.016	6.320	0.000
GRADE8, γ_{20}	0.100	0.033	2.959	0.004
SCIENGRA, γ_{30}	0.052	0.010	5.078	0.000
LOWINCSC, γ_{31}	-0.001	0.000	-2.638	0.016
DUMMYCOL, γ_{40}	0.074	0.018	4.033	0.000
DUMMYGRA, γ_{50}	0.086	0.024	3.503	0.001
LEARNGOA, γ_{60}	0.112	0.018	6.130	0.000
SELFEFFI, γ_{70}	0.064	0.016	4.003	0.000
MEANINGF, γ_{80}	0.091	0.019	4.658	0.000
ROTELEAR, γ_{90}	-0.077	0.016	-4.722	0.000

The results of the final estimation of fixed effects obtained from the full final Intercepts and Slopes as Outcomes Model were presented in Table 4.33. As stated before, the results from Means as Outcomes Model are reported in the final full Intercepts and Outcomes Model.

The results revealed significant and negative relationship between low level school socio economic status and Empirical NOS (γ_{01}= -0.003, se=

0.0008); significant and positive relationship between proportion of female science teachers and Empirical NOS (γ_{01}= 0.001, se= 0.0005).

In addition to these, the results from the Random Coefficient Model are reported in the final full Intercepts and Slopes as Outcomes Model. *College education level as a highest educational level of parents, graduate education level as a highest educational level of parents*, *seventh grade level, eight grade level, science achievement, students' learning goal orientation, self efficacy, students' meaningful learning and students' rote learning approach,* are significantly related to students' Empirical NOS views.

The Grade-Empirical NOS *slope* coefficients indicates that students from different grades had significantly different understanding on the Empirical NOS. Students from seventh grades (γ_{10}= .104, se= .016) and eighth grades (γ_{20}= .100, se= .033) performed significantly higher than the students from sixth grades on the Empirical NOS.

The Science grade-Empirical NOS slope coefficients (γ_{30}= .052, se= .010) indicates that students' science achievement is significantly and positively related to students' Empirical NOS understanding. Students having higher achievement had better Empirical NOS understanding than the other students.

The college education level as a highest educational level of parents - Empirical NOS slope coefficients (γ_{40}= .074, se= .018) and the graduate education level as a highest educational level of parents-Empirical NOS slope coefficients (γ_{50}= .086, se= .024) indicates that highest educational level of parents is significantly and positively related to students' Empirical NOS understanding.

The Learning goal orientation- Empirical NOS slope coefficients (γ_{60}= .112, se= .018) indicates that students' learning goal orientation is significantly and positively related to students' Empirical NOS understanding. Students having learning goal orientation had higher Empirical NOS understanding.

The Self efficacy- Empirical NOS slope coefficients (γ_{70}= .064, se= .016) indicates that students' self efficacy is significantly and positively related to students' Empirical NOS understanding. Students having high self efficacy had better Empirical NOS understanding.

The Meaningful learning approach - Empirical NOS slope coefficients (γ_{80}= .091, se= .019) indicates that students' Meaningful learning approach is significantly and positively related to students' Empirical NOS understanding. Students having meaningful learning approach had higher Empirical NOS understanding.

The Rote learning approach - Empirical NOS slope coefficients (γ_{90}= -.077, se= .016) indicates that students' Rote learning approach is significantly and negatively related to students' Empirical NOS understanding. Students having rote learning approach had lower Empirical NOS understanding.

It can be seen that the coefficients have very slight differences in their magnitude, but the directions and the interpretations are same with the Random

Coefficient Model because of the small reduction of the number of students analyzed in the final full model.

In the final full Intercepts and Slopes as Outcomes Model, only one school level factors was significantly related to a student level slope. As previously stated, the *science achievement* (SCIENGRA) had one significant school level factors; low level school socio economic status (*LOWINCSC)* (γ_{40}= -.001, se= .0006). That means *science achievement* has negatively related to students' Empirical NOS understanding in schools with low level school socio economic status.

The results of the final estimation of variance components obtained from the full final Intercepts and Slopes as Outcomes Model were presented in Table 4.34. The degrees of freedom for this model (Intercepts and Slopes as Outcomes Model) is based on the number of schools with sufficient data, and the number of school level factors included in the model.

Degrees of Freedom = J – Q – 1, where

J = the number of schools with sufficient data

Q = number of school level factors included in the model

There were 23 schools with sufficient data.

df = J – Q – 1 = 23 – 2 – 1 = 20 (df for *School Mean*)

df = J – Q – 1 = 23 – 1 – 1 = 21 (df for Science Achievement (SCIENGRA))

Table 4.34 Final Estimation of Variance Components for Intercepts and Slopes as Outcomes Model for Empirical NOS

Random Effect	*Variance Component*	*df*	*Chi-square* χ^2	**p-value**
School mean, u_{0j}	0.00190	20	46.30597	0.001
SCIENGRA, u_{3j}	0.00078	21	40.70894	0.009
Level-1 Effect, r_{ij}	0.17910			

The proportion of variance explained for each Empirical NOS slope model with significant school level factors could be examined. For this study, that would be the *Science achievement* and *Empirical NOS.* The equation is:

The proportion of variance explained in β_{0j}

$$= \frac{\tau_{00}\text{(Random Coefficien t)} - \tau_{00}\text{(Intercepts and Slopes as Outcomes)}}{\tau_{00}\text{(Random Coefficien t)}}$$

β_{0j} = Empirical NOS or the slope coefficient for a given factor

The proportion of variance explained in Empirical

$$\text{NOS} = \frac{0.00376 - 0.00190}{0.00376} = 0.494$$

The proportion of variance explained in Science achievement (SCIENGRA);

$$\beta_{3j} = \frac{0.00081 - 0.00078}{0.00081} = 0.037$$

It can be concluded that 49.0 % of the variance in the between school differences in mean Empirical NOS is accounted for by *Low level school socio* *economic status and proportion of female science teachers*. 3.7 % reduction in the variances was accounted for by *Low level school socio economic status* for Science Achievement (SCIENGRA). However, significant differences still remains (χ^2= 46.305, p< .005) between schools. All of these proportions showed that substantial amount of variation had been accounted for.

CHAPTER V

DISCUSSION

This chapter is divided in to three sections. The first section deals with the validity and reliability of NOSI; the second section is related to elementary students' general views about NOS; the third section is about factors related to students' NOS views.

5.1 Validity and Reliability of NOSI

When constructing and developing a scale, it is most crucial to be certain that the scale measures what is intended to measure. This issue ensures the instrument validity. Thus, in this study assessing what is intended to be measured regarding students' NOS views was the main validity focus for developing NOSI. To ensure that whether we addressed a common understanding of the NOS aspects with NOSI items we conducted several pilot studies when the need occurred during the instrument development. Throughout development of the NOSI previous results of the qualitative studies (Akerson & Volrich, 2006; Khishfe, 2008; Khishfe & Abd-El-Khalick, 2002; Khishfe & Lederman, 2006-2007) provided valuable information to us to see how elementary students perceived, understand, and the NOS aspects. During pilot studies, we observed that slight changes in the item structure caused big differences in the factor structure. We based all of our item revisions based on these changes on teachers' and students' responses, observed during the pilot studies. Satisfactorily at the end of the all pilot studies exploratory and confirmatory factor analyses showed that the final version of NOSI indeed measured the elementary students' NOS views.

Regarding the reliability of NOSI, the findings of this study revealed that NOSI has a significant level of reliability (α=.76). According to Kline (1999) and DeVellis (1991), the alpha value for cognitive tests between .70 and .80 is in accordance with accepted standards. When we compared our dimensions' reliability values with NOS scales developed previously, we observed that the reliability values found for total NOSI and its dimensions were generally higher (Table 5.1).

The Empirical dimension of NOSI has a moderate level of reliability (α=.63), which is still a reasonable value for social studies, as argued by (Hatcher & Stepanski, 1994; Liang et al., 2008; Tsai & Liu , 2005) and a higher reliability value compared to VOSE. These comparisons suggest that NOSI has high reliability indices and may have potential to determine the elementary students' NOS views.

Table 5.1 Comparing Reliability Values of NOSI with other NOS Instruments and their Dimensions

NOSI (for Elementary Students)		SUSSI (for College Students) (Liang, Chen, Kaya, Adams, Macklin & Ebenezer, 2008)		VOSE (for College Students) (Chen, 2006)		SEVs (for High School Students) (Tsai & Liu, 2005)	
Dimensions	**α**	**Dimensions**	**α**	**Dimensions**	**α**	**Dimensions**	**α**
Observation and Inference	.74	Observation and Inferences	.61	Nature of observations	.47		
Tentative NOS	.76	Tentativeness	.56	Tentativeness	.34	The changing and tentative feature of science knowledge	.60
Imagination and creativity	.80	Creativity and Imagination	.89	Use of imagination	.71	The invented and creative nature of science	.60
Emprical NOS	.63			Validation of scientific knowledge	.44		
Total α	.76	Total α	.69	test–retest correlation coefficient	.82	Total α	.67

5.2 Elementary Students' General Views about NOS

In terms of the Tentative NOS and Imagination and Creativity dimensions of NOSI, elementary students had difficulty in representing their views. Regarding Tentative NOS, they generally had a *close* to support, but did not accept, the idea that scientists are always correct, everything scientists say in books is correct, and scientists are 100 % sure about the knowledge they generate. The students' views about Tentative NOSI items revealed that they did not clearly understand the changing nature of both science and the knowledge scientists generate. These findings were in agreement with earlier studies in which researchers argued that students in elementary and high school had a naïve understanding about the tentative NOS (Ryan & Aikenhead, 1992; Stein & McRobbie, 1997).

Regarding Imagination and Creativity findings, this study reveals that students had a *close* to support, but did not accept the idea, that scientists use their imagination and creativity during their investigations and that imagination and creativity do not result in flawed conclusions in scientific investigations. Not appreciating the place of imagination and creativity in the NOS was also reported by earlier studies (e.g. Khishfe & Abd-El-Khalick, 2002). In terms of a Turkish context, similar findings were presented by Celikdemir (2006), regarding the tentativeness of NOS, and the role of imagination and creativity.

Among all the qualities tested, the students' views regarding the "empirical dimension of the NOS" were found to be the most developed. Generally, students accepted that scientists may interpret the same data differently and that in light of new scientific knowledge, our scientific understanding can be enhanced. Similar to our findings, Sadler et al. (2004) found that 80% of high school students in their sample could define data, but 17% of those had difficulty in understanding the empirical nature of NOS. In that study, the majority of the students had a sound understanding regarding both the definition of data and the empirical views of the NOS.

The least developed views were found for the Observation and Inferences dimension of NOSI. The students generally believed that scientists could only be certain about their findings if they actually visualize the results. Moreover, they stated that if scientists make inferences based on their data, then their findings cannot be certain. Griffiths and Thompson (1993) conducted a study with students who were the same age as those in our study. They found that, related to observation, most students believed that observation is done by visualization. Like the students studied by Griffiths and Thompson (1993), in this study students also gave credit to scientists' sense of sight, rather than their ability to make inferences.

New science and technology curriculum was applied in a short time after previous program had been implemented, therefore science teachers tried to adapt two science and technology curriculum in a short time. Literature on NOS support the idea that implementation of NOS aspects in classroom environments can be a challenging task for teachers as well as students to master. The data from this study support that one or two year implementation of new curriculum does not reach the stage of actually developing student more accurate views of NOS. In the previous science curriculum, students centered activities and scientific method was emphasized. The students in this study were familiar with the investigation, collecting data, and evidence. Moreover, student centered activities could further improve students' understanding of the empirical nature of scientific knowledge included in the new curriculum.

5.3 Factors Related to Students' NOS Views

In this part, Student-Level factors and School-Level factors are discussed with respect to Tentativeness of NOS, the role of observation and Inferences, Empirical NOS, and Imagination and Creativity.

In literature, quantitative studies regarding elementary students' NOS understanding have not been paid much attention. Most of the research focusing on factors at the student level ignored the nested structure of the data which caused bias in estimating the coefficients and standard errors. This study eliminated these problems by using a multilevel analysis technique taking into consideration the nested structure of the data to get more precise coefficients. In this study, student and school level factors related to student NOS understanding were investigated through Hierarchical Linear Modeling (HLM) as a multilevel analysis technique. Student and school level factors were determined with the aid of a theoretical framework provided in the previous literature. Student level factors included: students' socio-economic status, parents' education level, parents' occupational status, grade level, previous semester science grades (science achievement), gender, student attitude toward science, the courses they liked most, whether they read articles or books regarding science, whether they benefit from internet sites regarding science, whether they watch documentary films, whether they share their ideas about science subjects with their families, performance goal orientation, learning goal orientation, self efficacy, rote learning approaches and meaningful learning approaches. School level factors included school socio-economic status, proportion of female science teachers, ability grouping between science classes, the quality of the school physical infrastructure, and the quality of the school educational resources. Tentative NOS, Observation and Inferences, Empirical NOS, Imagination and Creativity were the outcome factors of this study. The final full models from the Intercepts and Slopes as Outcomes Model were constructed separately for each dimension of NOS, and the results were obtained accordingly.

5.3.1 Student Level Factors

Science Achievement (SCIENGRA), and Grade Level (GRADE) were the only factors which were varying randomly across schools involved in this study. Science achievement of the students was significantly and positively related to Tentative NOS and Empirical NOS and randomly varied across schools. Science achievement was also significantly related to Observation and Inferences but this variable non-randomly varied across schools. In other words students with higher science grades had a more comprehensive understanding about Tentative NOS, Empirical NOS, and Observation and Inferences. These results are consistent with the findings of the study of Yore et al. (2002) in that students' awareness of NOS had positive influences on 3rd and 6th grade students' achievement.

Grade Level was significantly and positively related to students NOS understanding. Besides, Grade Level randomly varied across schools with respect to Observation and Inferences. Direct proportional relationship was obtained between 6^{th} and 7^{th} grade student understanding of all aspects of NOS. Prolonged exposure to a new curriculum might have increased these students' understanding. In terms of Tentative and Empirical NOS, 8^{th} graders scored significantly higher than 6^{th} graders. These results may be associated with student experiences about learning science in the schools such as carrying out investigations. This finding has been supported by other researchers. The more experiences the elementary students have in school, the more informed NOS understanding they possess (Kang, Scharmann & Noh, 2005; Solomon et al., 1996). Stein and McRobbie (1997) and Huang et al. (2005) also asserted that student understanding of NOS improves as grade level increases. Beside these, there were no significant differences between 7^{th} and 8^{th} graders understanding NOS. Also, it is interesting to note that students at 8^{th} grade level had lower mean scores than 6^{th} graders in terms of imagination and creativity aspects of NOS. This may reflect the national exam system in Turkey, where, generally, students take exams at the end of elementary school in previous exam system (i.e.,the 8th grade) that enable them to enroll in one of the prestigious high schools and again at the end of high school, to allow them to enter a university. As recognized by Berberoglu and Hei (2003), rote learning may be reflected in both the format and content of these exams. Since students in 8th grade spend most of their time studying for this exam, they may have a tendency to merely memorize concepts. This study habit may be the reason for the low mean scores of imagination and creativity aspects of NOS as compared to other grade levels.

Due to having randomly varying slopes, magnitude of the relationships regarding science achievement, and grade level vary from school to school. That means in some schools, these factors correlate with students understanding regarding NOS dimensions which are much stronger than they are in other schools. However, to understand the reason why these slopes are randomly varied one needs more sensitive analyses. The differences among schools might be explained by the association of the other factors, such as classroom learning environment, factors relating to parents, school and students' characteristics, learning and motivational factors. The findings of other studies reveals the influence of teaching approaches of teachers on students' NOS views (Scharmann & Harris, 1992; Lederman, 1999), influence of teachers practices and instruction in the classroom (Zeidler & Lederman, 1989; Gallagher, 199; Walters-Adams, 2006) might provide sources of the differences among schools. In this study, we could not get any evidence about such issues. Further research is needed to explain the interrelation of these factors with students' NOS views. When we examined the other student level variables, non-randomly varied findings revealed that there were not only some common and but also different factors influencing each dimension of NOS investigated in this study since they had different views regarding each sub-dimensions as supported by Tsai (2002) and Huang et al. (2005).

The significant and positive association between Gender of the students and student Tentative NOS understanding indicate that females had better Tentative NOS understandings than males. There was no gender differences regarding other aspects of NOS. Different from this study, Huang et al. (2005) found that eighth grade male Taiwanese students had more contemporary views of tentative NOS. Sixth and seventh grade female students had more favorable understandings of empirical NOS. In terms of the sixth graders, females had significantly higher empirical NOS scores than males. Moreover, seventh grade female students distinguished between imagination and creativity more easily than males did. This gender difference may result from types of activities implemented in the class, student previous background information, gender of the teacher, and teacher biases.

In the literature there have been very limited studies which investigate the relationship among factors that are mentioned below regarding student NOS views directly. Therefore, it will be discussed with the help of possible indirect relationships. With respect to the association of student background variables, positive relationships between high level income and Tentativeness of NOS revealed that students with high level income parents had more complete understanding about Tentativeness of NOS than the students whose parents had low incomes. Considering the socio-economic conditions in Turkey, it is reasonable to state that students from families with high income are provided with additional educational opportunities, such as special courses after school, personal computers at home, books and materials in rich and comfortable home environments. Thus, in our study these opportunities might help the advantageous students improve their understanding about science concepts and nature of science. On the contrary, students from families with low incomes study their courses at home by themselves. And, some of these students need to work after school to provide financial support for their families' income. Most of the time it is difficult for these working students to find time to study their school courses at home.

Parents' education level was also found to be an important factor influencing student NOS understanding. Findings indicated that college and graduate education level of parents is significant and positive indicators of student tentative NOS and empirical NOS understanding. In addition students whose families' had experienced graduate level education held more informed NOS understanding than students having families with college level of education. For example, Ercikan, McCreith, and Lapointe (2005) found that parents' education level had strong effects on student achievement. Based on this finding, it can be argued that parents with higher educational degrees may be better in comprehending and responding to the difficulties their children have in science learning. Based on their knowledge and experiences, they could better coach their children's learning. However, Hortaşsu (1995) found that in Turkey, mothers' education level was a significant predictor of students' general achievement rather than that of fathers' education level. The author argued that in Turkey mothers take more responsibility for their children and devote more time to their children's lessons and homework; thus, mothers with higher level of education can be more helpful in the learning of children. The study of Hacieminoglu et al. (2009) revealed that this situation might have changed over the last decade. Both fathers and mothers have started to take turns to help their children regarding their academic success. Parents' efforts for improving the academic success of students also help to improve student NOS views.

Whether students watch documentary films was another student level factor influencing students and Tentative NOS views positively. Additionally in this study, there is an open-ended part in the student questionnaire reflecting which type of documents they watch. Most of the students reported that they watch discovery channel. Moreover they reported that they like documentaries, about animals, science, nature, forest, undersea, plants, the living and their characteristics, space, people, inquiry, discovery and inventions. Dhingra (2003) supported this finding explaining that television shows is like explicit teaching; therefore, it has positive associations with student NOS understanding.

The other student level factors related to students NOS views learning and motivational factors such as learning approach, motivational goals and self-efficacy in ways they were examined in this study.

From these factors student self-efficacy was positively related to student NOS views except for observations and inferences. Students having higher levels of self-efficacy gained more complete understanding on tentative NOS, empirical NOS and imagination and creativity. Beside this, while these three dimensions of NOS had negative relationships between rote learning approaches, imagination and creativity and empirical NOS had positive relationships between meaningful learning. With respect to goal orientation, performance goal orientation was negatively related to student Tentative NOS views, and learning goal orientation was positively related to student Empirical NOS views. The study of Cavallo et al. (2003), Cavallo et al. (2004), Hacieminoglu et al. (2009) and Kizilgunes et al. (2009) revealed similar and supportive relationships regarding these results. Similarly Kizilgunes et al. (2009) found negative relationships between performance goal orientation and certainty of knowledge. Contrary to our findings, Kizilgunes et al. (2009) found negative relationships between self-efficacy and certainty of knowledge. Most literature mentioned support the idea that student achievement is positively correlated with self-efficacy. On the other hand, meaningful learning and negatively correlated with rote learning and performance orientation. Students who had high achievement preferred to do meaningful learning rather than rote learning. Performance-oriented students, who study for receiving higher grades, had lower achievement and naïve views of NOS. These students were not interested in learning the concepts for their interest and achieving meaningful learning. Good science achievement also enables these students to be aware of their capabilities to better learn new science concepts as well as nature of science. Hacieminoglu et al. (2009) suggest that in order to get better science achievement, students should be encouraged to do meaningful learning rather than rote learning. Attaining meaningful learning may also increase self-efficacy toward learning science with more complete understanding of NOS. Rote learning and studying for higher grades are neither helpful in retaining the learned science concepts in the long term (Cavallo et al., 2003; Cavallo et al., 2004) nor improving NOS. In other words, it was argued that the direction of the relationship among these factors could be stated in the following order: parents' socioeconomic status → meaningful learning →learning goal orientation →students' achievement→ students' NOS views.

5.3.2 School Level Factors

The Science Grade-Tentative NOS slope and Science Grade-Empirical NOS slope were the coefficients in the Hierarchical linear model of NOS dimensions with one significant school level factors (cross-level interaction).

With respect to Tentative NOS as an outcome variable, the interaction revealed that high socio economic status of schools is positively related to the science achievement. These results indicated that in schools that enroll students from higher socio-economic levels, science grades have more of an impact on tentative NOS (steeper slopes). That means the relationship between the science achievement and Tentative NOS in schools having high socio-economic status may be stronger than the relations of which in schools having low socio-economic status with similar science achievement. Moreover, low socio-economic status of schools is negatively related to the Science grade. These results show that in schools that have low socio-economic status, science grade has less of an impact on empirical NOS (steeper slopes). That means the relationship between the science achievement and Empirical NOS in schools with low socio-economic status may be slighter than the relations of which in schools having high socio-economic status with similar science achievement. The findings also reveal positive relationships between schools with high socio-economic status and Tentative NOS, negative association between schools with low socio-economic status and Empirical NOS. These results are related to educational opportunities in schools such as types of activities (science club, science festival, science computation) since schools having high socio-economic status experience more science activities than the ones with low socio-economic status.

There are some other school level factors influencing student NOS understanding. One of them is proportion of female science teachers affecting positively students empirical NOS understanding. This result might be related to the fact that students having female teachers feel themselves more comfortable and confident or female teachers are more tolerant and pleasant than male teachers as supported in the literature (as cited in Gilmartin, Denson, Li, Bryant & Aschbacher, 2006). The other one was quality of school educational resources such as instructional materials, science laboratory equipment and materials, computers for instruction, library materials and audio-visual resources. Quality of school educational resources was positively associated with student understanding of imagination and creativity in science. Student views about imagination and creativity were higher in schools where the quality of school educational resources was better. Another factor is quality of the school physical infrastructure which related to student understanding of observation and inferences positively. The more complete understanding the students have, the better school buildings and grounds, heating/cooling and lighting systems, and instructional space the schools are. In the literature there are some contradictory findings about effectiveness of these factors on students' achievement. In the early years findings of the meta-analyses study (Fuller, 1987) revealed the positive influence of instructional materials on students' achievement. On the other hand recent meta-analyses study meta-analysis study conducted by Hanushek (1997) indicated that there is no consistent result about the effectiveness of availability of laboratories, the size and presence of a library, and the property of the school on student performance. These inconsistent results might be associated with utilization of these resources and facilities. Some of the school principal in this study reported that even if they had sufficient educational resources in their schools, teachers did not use them effectively during their instructions.

CHAPTER V

CONCLUSION, IMPLICATIONS and RECOMMENDATIONS

6.1 Conclusion

In many countries, exploring student views about the NOS has been considered an important focus for science educators and researchers. These studies help both to provide students with contemporary perspectives regarding the NOS and to develop their understandings about these perspectives (Abd-El-Khalick et al., 1998; Lederman, 1992). Moreover, researchers also argue that it is important to improve student views of the NOS at early grade levels. According to Bruer (1993), the elementary level is a pivotal time when students gain an understanding of the world around them. Moreover, Bruer (1993) contends that they use knowledge gained from formal science education experiences to clarify the other experiences gained outside and inside the school environment. It is now supported that elementary students may improve their own views about the NOS (Kang, Scharmann & Noh, 2005; Meichtry, 1992); thus, determining and developing student NOS views constitutes an important goal for elementary school science teachers and researchers. Therefore in this study it was focused on elementary student NOS views.

This study presents an instrument for measuring elementary student views of the NOS regarding four dimensions (the tentative NOS, the empirical NOS, observations & inferences, and imagination and creativity). Based on the reliability and validity evidence, it can be concluded that this new instrument can be used for elementary school students of different cultural backgrounds; however, researchers must be careful when adapting this instrument because students' views are influenced by the wording the items employ.

This instrument could also provide a useful tool for researchers who wish to make cross-cultural comparisons and evaluate how well the NOS objectives are attained in a particular science curriculum. For future research, the number of items in each NOSI dimension can be increased and also some dimensions not included in this study can be added and considered. For example, new items related to scientific theories, laws, and facts might be added, because these concepts play an important role in the growth of scientific knowledge as reported by (Abd-El-Khalick et al., 1998; Bell et al., 2000; Duschl, 1990; Lederman, 1992; Lederman et al., 2001).

Tsai (2002) and Huang et al. (2005) have argued that students may have different views concerning different sub-dimensions of the NOS. In our study descriptive analyses supported this argument and indicated that students had more accurate views on some dimensions of NOSI than other dimensions. These findings enabled us to conclude that views regarding different dimensions of the NOS developed "more or less independently" from each other (Schommer, 1994, p.300). In other words, developing better views in one dimension does not necessarily result in a better understanding of the other dimension(s). Thus, teacher awareness of students' views regarding different dimensions of the NOS is crucial when one desires improvement in less sophisticated views of NOS held by elementary students.

Because of the distinction among student views regarding NOS, different factors related to school and student level have been observed. Many factors have been related to different dimensions of NOS. This study has established the importance of student socio-economic status experiences with varying learning approaches, self-efficacy, and motivational goals in forming their NOS views. It can be concluded that parent educational levels, student achievement, self efficacy, experience with meaningful learning, and learning goal orientation are indeed positively related to student NOS views in many different dimensions. On the other hand, it can be also concluded that performance goal orientation and rote learning approaches are negatively related to different dimensions of student NOS views. With respect to school level factors, quality of physical infrastructure of school such as instructional space in classrooms, quality of educational resources such as instructional materials, science laboratory equipment and materials, computers for instructions, library materials, and audio-visual resources, high school socio-economic status, proportion of female science teacher are important factors for improving student NOS views in many different dimensions. Describing characteristics of high performing schools and successful students is an important issue and should help educators and policy-makers to attain high levels of student performance. NOSI can aid these teachers in determining their student NOS views and enable them to organize their teaching plans accordingly. Moreover, research supports indicate the use of an explicit approach rather than an implicit approach when improving students views of the NOS (Abd-El-Khalick & Lederman, 2000; Akerson & Volrich, 2006; Khishfe & Abd-El-Khalick, 2002; Khishfe & Lederman, 2006; Khishfe & Lederman, 2007; Khishfe, 2008). These teaching approaches may also be valuable for students whose desire is to be successful in standardized test. Since these students focus on learning and memorizing a substantial amount of information, they may not have time to consider the NOS through implicit instruction.

6.2 Implications

One of the main focuses of training scientifically literate students is the development of contemporary understanding of the nature of science. Our study supports the importance of the developing students' NOS in early ages. Therefore first mission should be the raising the awareness of in-service teachers and pre-service teachers about the importance of the developing students' NOS views in early ages and factors related to students' NOS views. Secondly, school principals and teachers should make parents conscious about these factors and how they should help their children effectively. Additionally, our study support the relationship between parents' education and income level and student NOS understanding. It should be noted that there is a difference between students' parent education and income level. To overcome this individual difference, school principals and teachers should provide poor students with free courses and their educational materials such as textbook. Also some counseling facilities should be provided for both students and their parents when they needed it.

With respect to classroom activities, teachers should give importance to use audiovisual resources, for instance they could bring documentaries related to the topics to the class and make students watch them. They should encourage students to use meaningful learning strategies, and to be learning goal oriented therefore teachers should make students give up following rote learning approach. Teachers should avoid using or emphasizing memorization strategies in the classroom. Teachers should use performance based assessment strategies and questions which students utilize and improve their critical thinking skills. Teachers should not emphasize the science grades in classroom and in this manner they should make students give up being performance goal oriented.

Students' self-efficacy is also important factors to improve students NOS views, therefore teachers should endeavor for increasing students' self-efficacy. For this purpose teachers should ask question to each student considering their level so that they can answer and they should give positive encouragement to the students. Teachers also avoid making gender discriminations in classroom; they should give similar duties without emphasizing their sex.

Reason for the observed differences among schools should be investigated and necessary arrangements should be provided to supply equal opportunities among schools for students. Quality of the physical infrastructure of schools and quality of educational recourses of schools should be set to enhance student learning in schools and improve generally the quality of education. School principals should report any of the deficiencies regarding these resources such as instructional materials, science laboratory equipment and material, computers for instruction, library materials and audiovisual resources. Teachers should use science laboratory effectively. Learning environments should be designed to encourage student self-efficacy, meaningful learning, and learning goal orientation. These issues should be emphasized in teacher education programs and for in-service teacher training programs.

6.3 Limitations and Recommendations

This study has some limitations that researchers should consider while generalizing and using the findings. Firstly, the study was limited by its reliance on self-reported data. Follow-up studies verifying consistency and accuracy of the findings of this study are needed for examining the different methods and measures. Secondly, the subject of this study was limited to the 6^{th}, 7^{th} and 8^{th} grade Turkish public school students which were selected in Cankaya district, one of the largest urban areas in Ankara. Therefore, results may not be reliable in different situations and cultural contexts. Researchers should be careful about the generalizations of the findings of this study. Same research should be conducted again in different cities and regions in both public and private schools to generalize results confidently. Thirdly, because of the nature of the hierarchical linear modeling technique, model specification as in the structural equation modeling is not possible. Since hierarchical linear modeling technique does not examine bi-directional relationships, more in-depth studies are needed to understand the causes of the relationship obtained in this study.

Although a great deal of variances were accounted for or reduced by the student and school level variables, a great deal of variances still existed. This issue is another limitation for this study. This means there are some other factors explaining the variability among schools. Classroom level factors and factors related to teachers, such as activities used in the classroom and teacher practices, should also be investigated in further research. The literature used to consider with this research supports that naïve views of student understanding of NOS aspects may be a result from lack of student understanding of epistemology of science and the concrete operational thought as supported the study by Kang, Scharmann and Noh (2005). Since NOS understanding by students is very connected to the epistemology of science, there is a need to study some epistemological development further (Kang, Scharmann & Noh, 2005; Larochelle & Desautels 1991). Moreover, the teaching approach used by teachers indicates that their behaviors and explanations in the classrooms may be affecting their own NOS understanding. These views, like teachers' naïve views and lack of knowledge regarding NOS, may affect student NOS conceptions (Brickhouse, 1990; Clough, 1997; Dogan & Abd-El-Khalick, 2008; Eichinger, Abell, & Dagher, 1997; Lederman & Zeidler, 1987). Student understanding NOS conceptions may be influenced by not only teacher understandings and behaviors but also other classroom factors such as teacher characteristics, teacher attitudes, student characteristics, and classroom atmosphere as indicated in the studies reported by Lederman and Druger (1985) and Lederman (1986). Furthermore, teacher language in science instruction, the instructional materials used, (such as some deficiencies found in the textbooks) may affect student views of the nature of science understandings as reported by Meichtry (1993). We could not provide any evidence about these variables; therefore, relationships between these factors and student NOS views should be investigated further to determine accurately the relationships in a wide perspective for further research.

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APPENDIX A

HIERARCHICAL LINEAR MODEL ASSUMPTIONS

A.1 Assumption Tests for the Model with Observation and Inferences as Outcome

A.1.1 Assumption of Normal Distribution of Level-1 Errors

Figure A.1 displays a normal Q-Q plot of the level-1 residuals based on the final fitted model. The plot is approximately linear, suggesting that there is not a serious departure from a normal distribution and that this assumption is tenable.

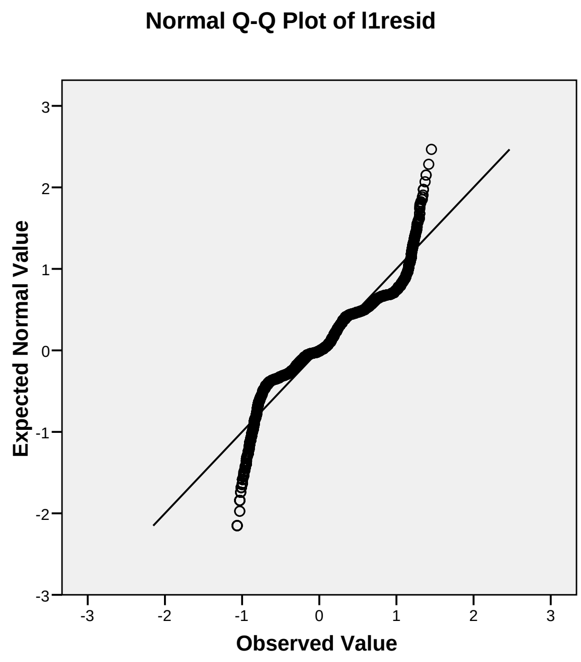


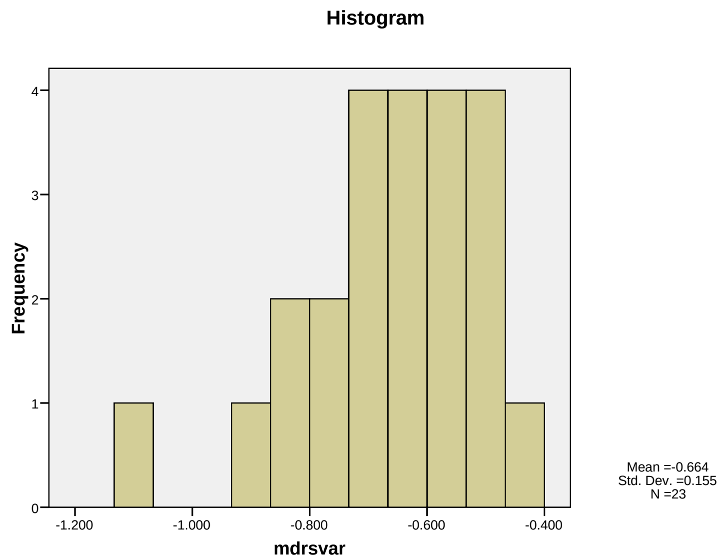
Figure A.1 Q-Q Plot of the Level-1 Residuals

A.1.2 The Homogeneity of Variance Assumption

The homogeneity of variance assumption was tested by using the H statistic analyzing equal variance across schools. The H statistic was not significant (χ^2 = 25.83545, df = 22, p-value = 0.258) that means the variances across schools were equal to each other.

```
Test of homogeneity of level-1 variance
 ----------------------------------------
 Chi-square statistic         =     25.83545
 Number of degrees of freedom =      22
 P-value                      =     0.258
```

However an examination of the residual dispersion was needed. A histogram revealed that some schools had lower than expected residual dispersion. Some groups might have extreme values, therefore students within these schools are very homogeneous but violation of the homogeneity of variance assumption is not a serious problem for estimating the school level coefficients or their standard errors (Raudenbush & Bryk, 2002).



A.1.3 Normality Assumption of Level-2 Residuals

In order to check normality assumption the units in the residual file namely, CHIPCT and MDIST were used. "If *q* level-1 coefficients were modeled MDIST would be the Mahalanobis distance (i.e., the standardized squared distance of a unit from the center of a v-dimensional distribution, where v is the number of random effects per unit). Essentially, MDIST provides a single, summary measure of the distance of a unit's EB estimates, β^*_{qj} from its "fitted value", $\gamma_{q0} + \sum \hat{\gamma}_{q0} W_{sj}$. If the normality assumption is true, then the mahalanobis distances should be distributed approximately $\chi^2_{(v)}$. Analogous to univariate normal probability plotting, a Q-Q plot of MDIST versus CHIPCT will be constructed. CHPICT are expected values of the order statistics for a sample of size J selected from a population that is distributed $\chi^2_{(v)}$. If a Q-Q plot of MDIST against CHIPCT resembles a 45 degree line, there is evidence that the random effects are distributed *v*-variate normal. In addition, the plot helps to detect outlying units (i.e., units with large MDIST values well above the 45 degree line)"(Rauenbush et al., 2004, pp. 41-42). Figure A.2 represent Q-Q plot of MDIST against CHIPCT approximating a 45 degree line, and that the assumption is tenable.

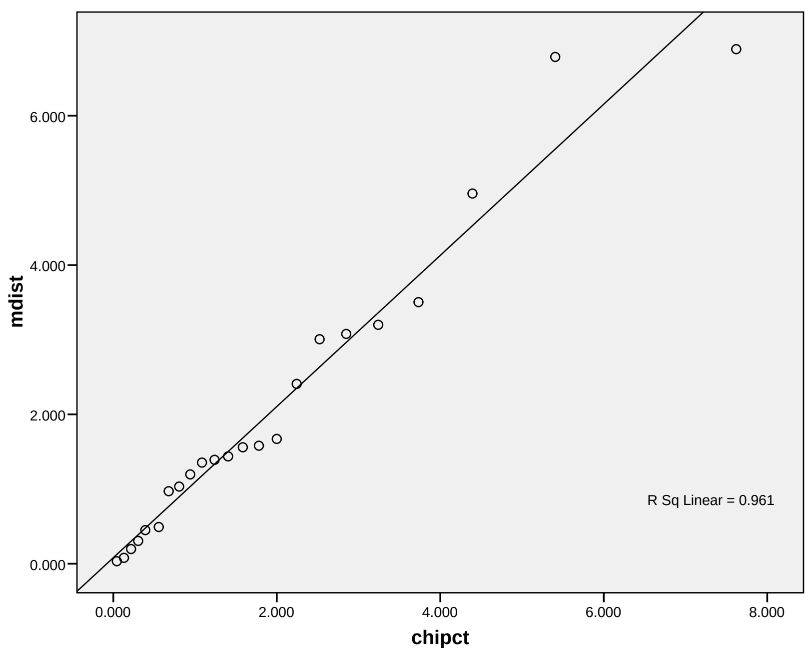


Figure A. 2 Plot of MDIST vs CHIPCT

A.2 Assumption Tests for the Model with Tentative NOS as Outcome

A.2.1 Assumption of Normal Distribution of Level-1 Errors

Figure 2.1 displays a normal Q-Q plot of the level-1 residuals based on the final fitted model. The plot is approximately linear, suggesting that there is not a serious departure from a normal distribution and that this assumption is tenable.

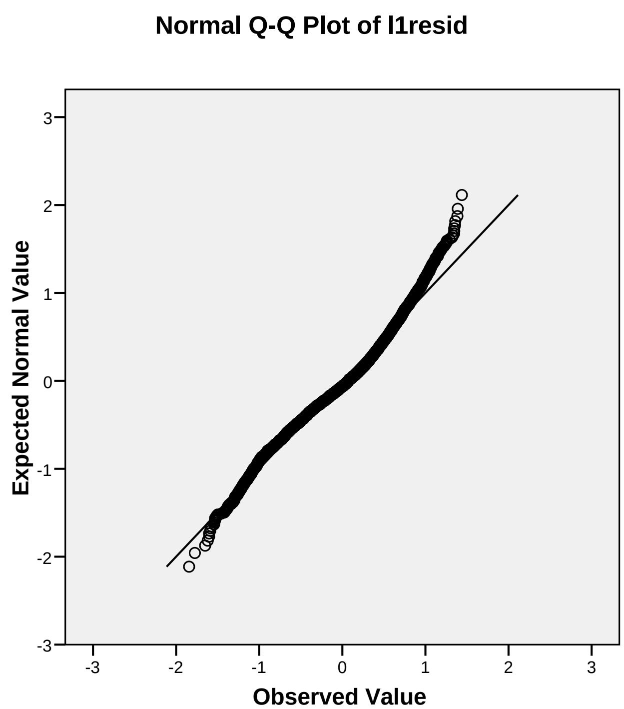


Figure A.3 Q-Q Plot of the Level-1 Residuals

A.2.2 The Homogeneity of Variance Assumption

The homogeneity of variance assumption was tested by using the H statistic analyzing equal variance across schools. The H statistic was not significant (χ^2 = 34.98209, df = 22, p-value = 0.039) that means the variances across schools seems to be equal to each other. However an examination of the residual dispersion was needed. Some groups might have extreme values but a violation of the homogeneity of variance assumption is not a serious problem for estimating the school level coefficients or their standard errors (Raudenbush & Bryk, 2002).

```
Test of homogeneity of level-1 variance
 ----------------------------------------
 Chi-square statistic         =     34.98209
 Number of degrees of freedom =      22
 P-value                      =     0.039
```

A.2.3 Normality Assumption of Level-2 Residuals

In order to check normality assumption the units in the residual file namely, CHIPCT and MDIST were used. "If *q* level-1 coefficients were modeled MDIST would be the Mahalanobis distance (i.e., the standardized squared distance of a unit from the center of a v-dimensional distribution, where v is the number of random effects per unit). Essentially, MDIST provides a single, summary measure of the distance of a unit's EB estimates, β^*_{qj} from its "fitted value", $\gamma_{q0} + \sum \hat{\gamma}_{q0} W_{sj}$. If the normality assumption is true, then the mahalanobis distances should be distributed approximately $\chi^2_{(v)}$. Analogous to univariate normal probability plotting, a Q-Q plot of MDIST versus CHIPCT will be constructed. CHPICT are expected values of the order statistics for a sample of size J selected from a population that is distributed $\chi^2_{(v)}$. If a Q-Q plot of MDIST against CHIPCT resembles a 45 degree line, there is evidence that the random effects are distributed *v*-variate normal. In addition, the plot helps to detect outlying units (i.e., units with large MDIST values well above the 45 degree line)"(Rauenbush et al., 2004, pp. 41-42). Figure A.4 represent Q-Q plot of MDIST against CHIPCT approximating a 45 degree line, and that the assumption is tenable.

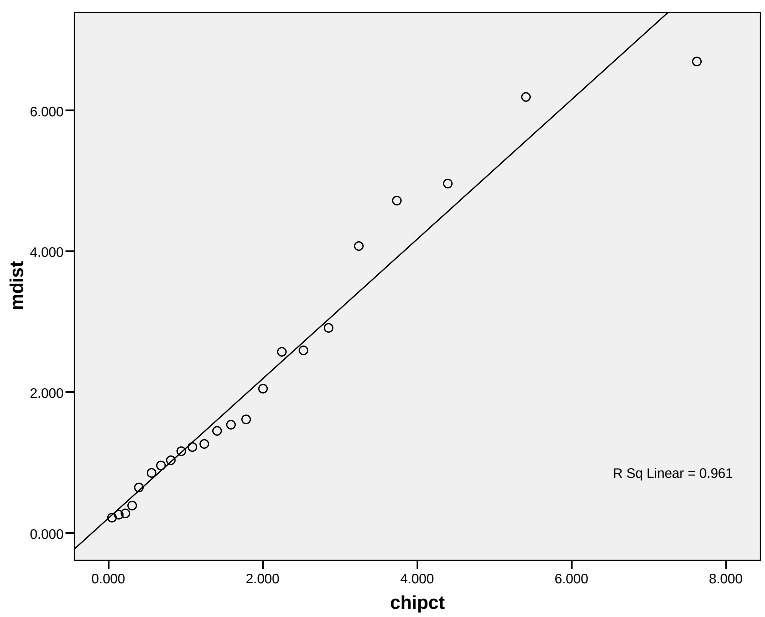


Figure A. 4 Plot of MDIST vs CHIPCT

A.2.4 Normality Assumption of Random Coefficients

Skewness and Kurtosis values for Empirical Bayes (EB) residuals of the slopes for SCIENGRA showed that Skewness and Kurtosis values are within acceptable range. Histograms of the random coefficients EB estimates (Figure X) showed normal distribution.

Table A.1 Skewness and Kurtosis Values of the EB Estimates of Random Coefficients

	EBSCIENG
Skewness	.073
Kurtosis	-.975

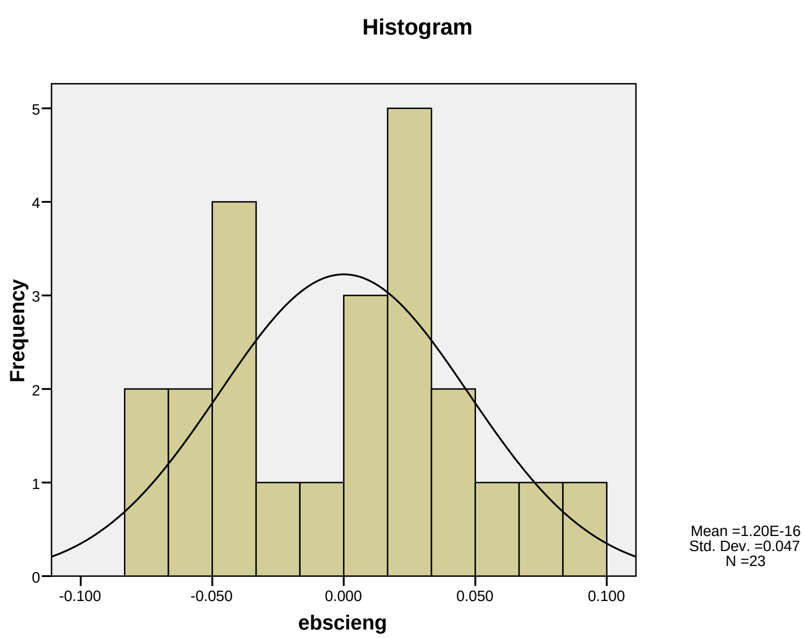


Figure A.5 Histogram of EB Residuals of the slope for SCIENGRA

A.2.5 Assumption of Linear Relationship between Level-2 Predictors and an Outcome

Plots of EB residuals for SCIENGRA slope against HIGHINCS and QUALITYE (level-2 predictor) were needed. Assumption of linear relationships between SCIENGRA slope against HIGHINCS and QUALITYE are tenable because residuals randomly distributed around zero line without regard to values of level-2 predictor. Results were shown in Figure A.6 and Figure A.7.

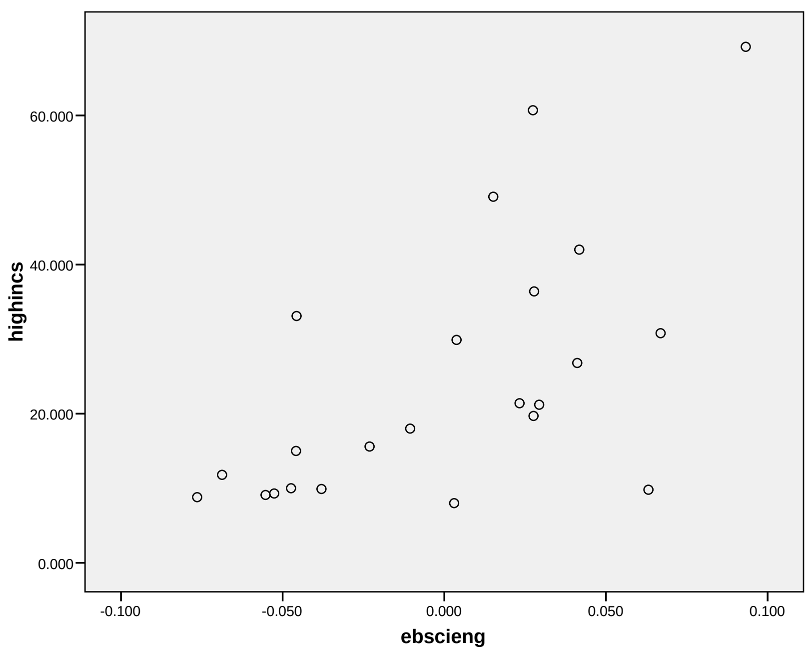


Figure A.6 EB residuals for SCIENGRA slope against HIGHINCS.

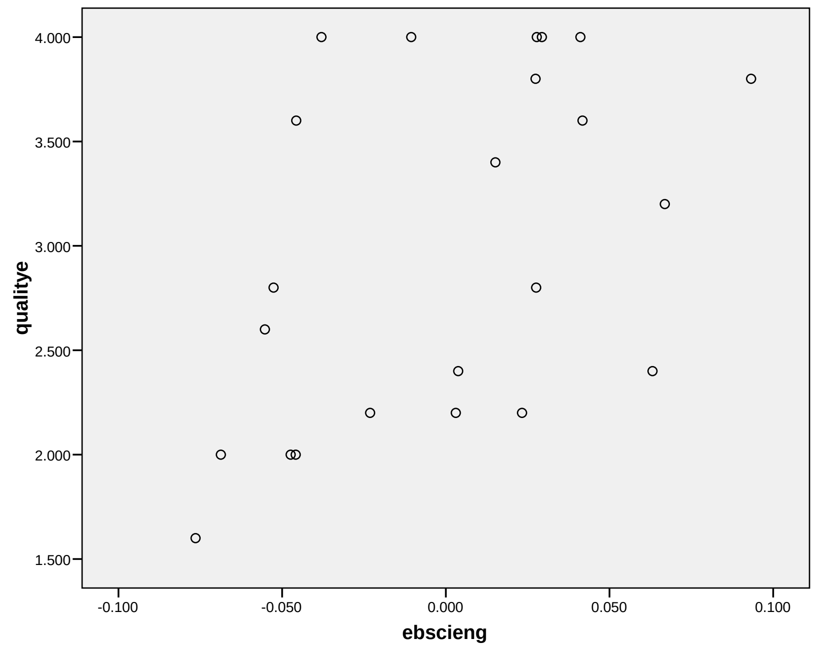


Figure A.7 EB residuals for SCIENGRA slope against HIGHINCS.

A.3 Assumption Tests for the Model with Imagination and Creativity as Outcome

A.3.1 Assumption of Normal Distribution of Level-1 Errors

Figure A.8 displays a normal Q-Q plot of the level-1 residuals based on the final fitted model. The plot is approximately linear, suggesting that there is not a serious departure from a normal distribution and that this assumption is tenable.

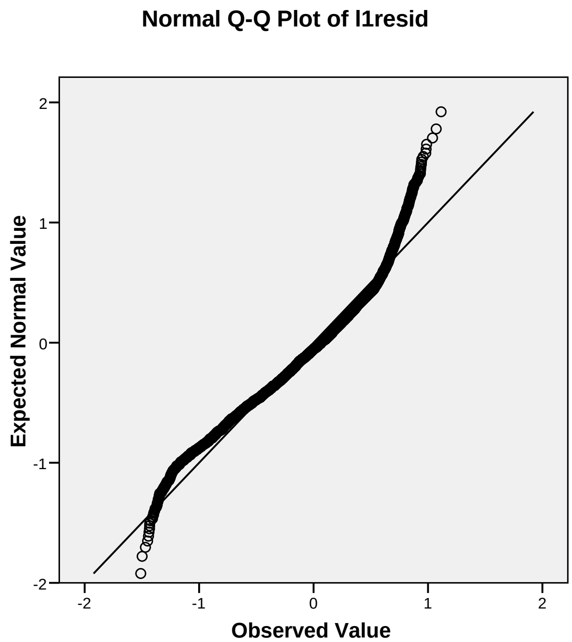


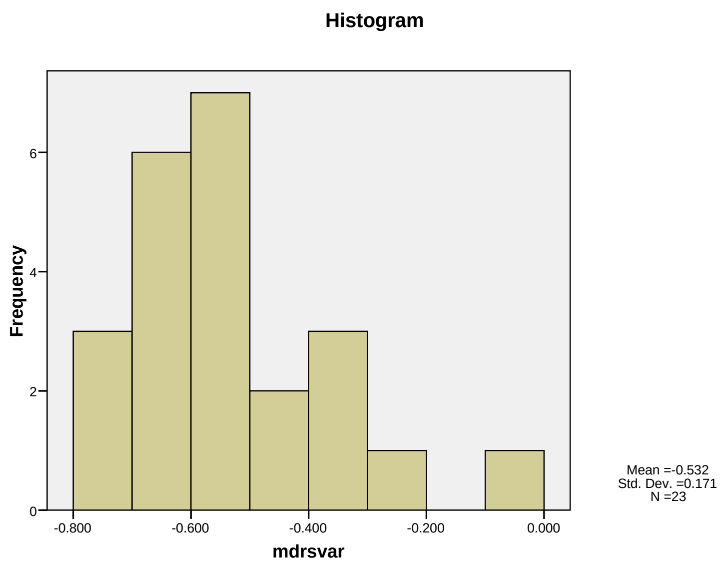
Figure A.8 Q-Q Plot of the Level-1 Residuals

A.3.2 The Homogeneity of Variance Assumption

The homogeneity of variance assumption was tested by using the H statistic analyzing equal variance across schools. The H statistic was not significant (χ^2 = 35.08206, df = 22, p-value = 0.038) that means the variances across schools seems to be equal to each other.

```
Test of homogeneity of level-1 variance
 ----------------------------------------
 Chi-square statistic         =     35.08206
 Number of degrees of freedom =      22
 P-value                      =     0.038
```

However an examination of the residual dispersion was needed. A histogram revealed that some schools had lower than expected residual dispersion. Some groups might have extreme values, therefore students within these schools are very homogeneous but violation of the homogeneity of variance assumption is not a serious problem for estimating the school level coefficients or their standard errors (Raudenbush & Bryk, 2002).



A.3.3 Normality Assumption of Level-2 Residuals

In order to check normality assumption the units in the residual file namely, CHIPCT and MDIST were used. “If *q* level-1 coefficients were modeled MDIST would be the Mahalanobis distance (i.e., the standardized squared distance of a unit from the center of a v-dimensional distribution, where v is the number of random effects per unit). Essentially, MDIST provides a single, summary measure of the distance of a unit's EB estimates, β^*_{qj} from its "fitted value", $\gamma_{q0} + \sum \hat{\gamma}_{q0} W_{sj}$. If the normality assumption is true, then the mahalanobis distances should be distributed approximately $\chi^2_{(v)}$. Analogous to univariate normal probability plotting, a Q-Q plot of MDIST versus CHIPCT will be constructed. CHPICT are expected values of the order statistics for a sample of size J selected from a population that is distributed $\chi^2_{(v)}$. If a Q-Q plot of MDIST against CHIPCT resembles a 45 degree line, there is evidence that the random effects are distributed *v*-variate normal. In addition, the plot helps to detect outlying units (i.e., units with large MDIST values well above the 45 degree line)"(Rauenbush et al., 2004, pp. 41-42). Figure A.9 represent Q-Q plot of MDIST against CHIPCT approximating a 45 degree line, and that the assumption is tenable.

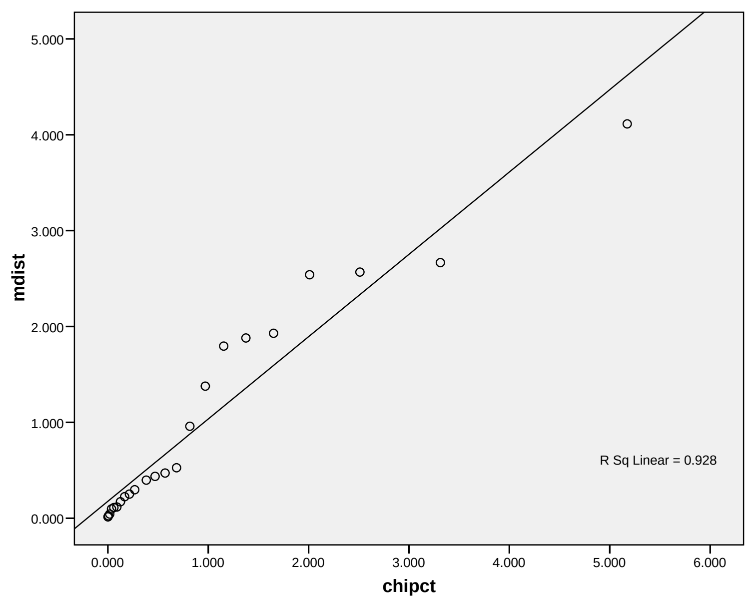


Figure A. 9 Plot of MDIST vs CHIPCT

A.4 Assumption Tests for the Model with Empirical NOS as Outcome

A.4.1 Assumption of Normal Distribution of Level-1 Errors

Figure 2.1 displays a normal Q-Q plot of the level-1 residuals based on the final fitted model. The plot is approximately linear, suggesting that there is not a serious departure from a normal distribution and that this assumption is tenable.

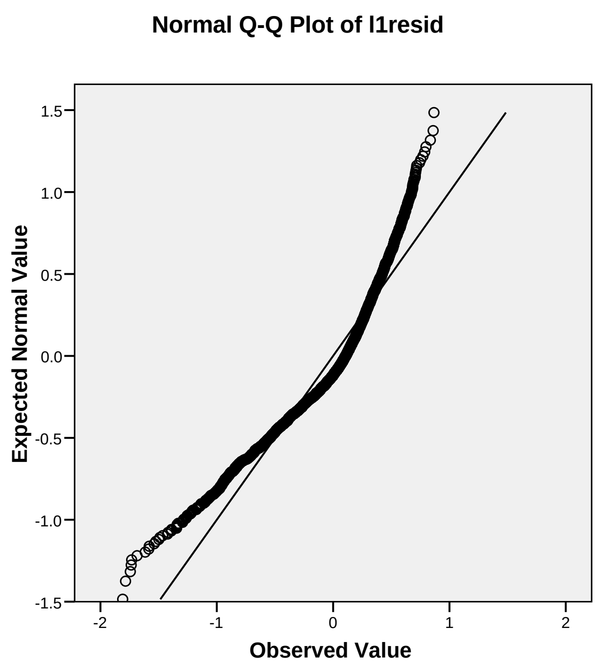


Figure A.10 Q-Q Plot of the Level-1 Residuals

A.4.2 The Homogeneity of Variance Assumption

The homogeneity of variance assumption was tested by using the H statistic analyzing equal variance across schools. The H statistic was not significant (χ^2 =

31.28230, df = 22, p-value = 0.090) that means the variances across schools seems to be equal to each other. However an examination of the residual dispersion was needed. Some groups might have extreme values but a violation of the homogeneity of variance assumption is not a serious problem for estimating the school level coefficients or their standard errors (Raudenbush & Bryk, 2002).

```
Test of homogeneity of level-1 variance
 ----------------------------------------
 Chi-square statistic         =     31.28230
 Number of degrees of freedom =      22
 P-value                      =     0.090
```

A.4.3 Normality Assumption of Level-2 Residuals

In order to check normality assumption the units in the residual file namely, CHIPCT and MDIST were used. “If *q* level-1 coefficients were modeled MDIST would be the Mahalanobis distance (i.e., the standardized squared distance of a unit from the center of a v-dimensional distribution, where v is the number of random effects per unit). Essentially, MDIST provides a single, summary measure of the distance of a unit’s EB estimates, β^*_{qj} from its “fitted value”, $\gamma_{q0} + \sum \hat{\gamma}_{q0} W_{sj}$. If the normality assumption is true, then the mahalanobis distances should be distributed approximately $\chi^2_{(v)}$. Analogous to univariate normal probability plotting, a Q-Q plot of MDIST versus CHIPCT will be constructed. CHPICT are expected values of the order statistics for a sample of size J selected from a population that is distributed $\chi^2_{(v)}$. If a Q-

Q plot of MDIST against CHIPCT resembles a 45 degree line, there is evidence that the random effects are distributed *v*-variate normal. In addition, the plot helps to detect outlying units (i.e., units with large MDIST values well above the 45 degree line)"(Rauenbush et al., 2004, pp. 41-42). Figure A.11 represent Q-Q plot of MDIST against CHIPCT approximating a 45 degree line, and that the assumption is tenable.

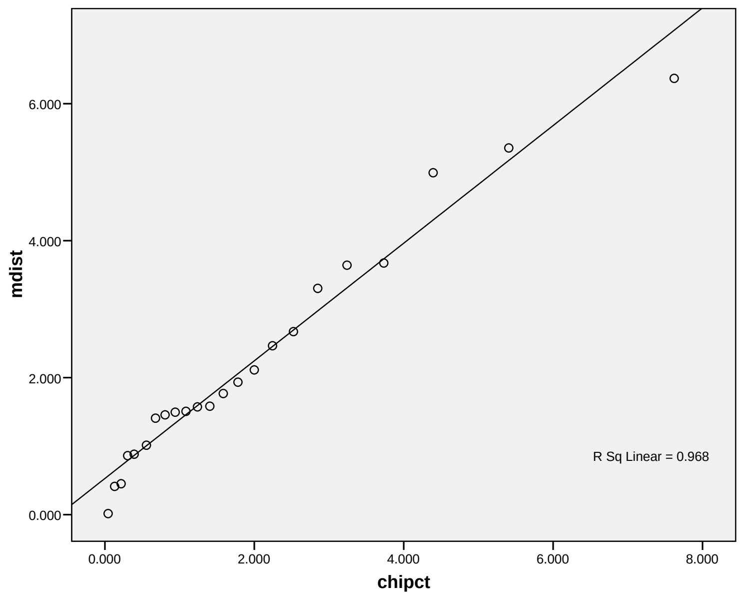


Figure A. 11 Plot of MDIST vs CHIPCT

A.4.4 Normality Assumption of Random Coefficients

Skewness and Kurtosis values for Empirical Bayes (EB) residuals of the slopes for SCIENGRA showed that Skewness and Kurtosis values are within acceptable range. Histograms of the random coefficients EB estimates (Figure A.12) showed normal distribution.

Table A.2 Skewness and Kurtosis Values of the EB Estimates of Random Coefficients

	EBSCIENG
Skewness	-.137
Kurtosis	-.935

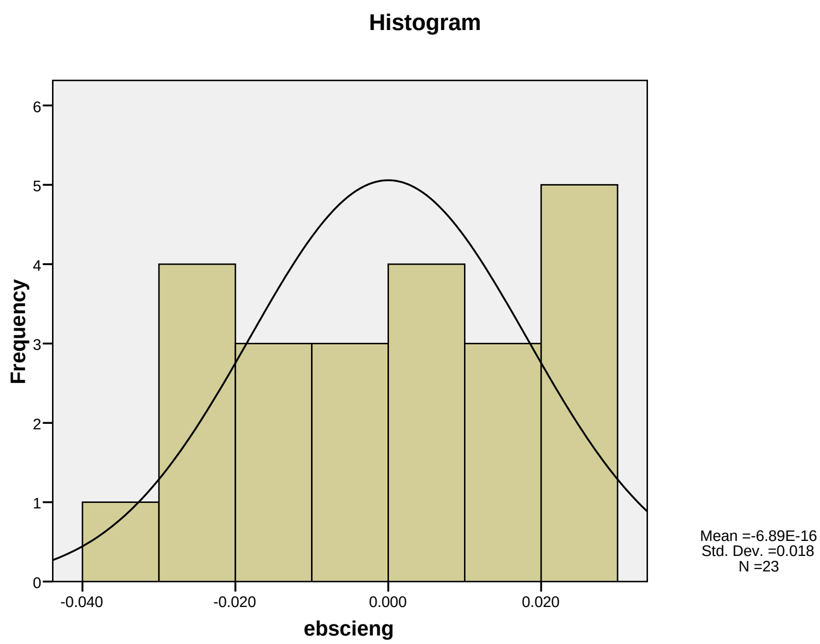


Figure A. 12 Histogram of EB Residuals of the slope for SCIENGRA

A.2.5 Assumption of Linear Relationship between Level-2 Predictors and an Outcome

Plots of EB residuals for SCIENGRA slope against LOWINCSC and FEMALESC (level-2 predictor) were needed. Assumption of linear relationships between SCIENGRA slope against LOWINCSC and FEMALESC are tenable because residuals randomly distributed around zero line without regard to values of level-2 predictor. Results were shown in Figure A.13 and Figure A.14.

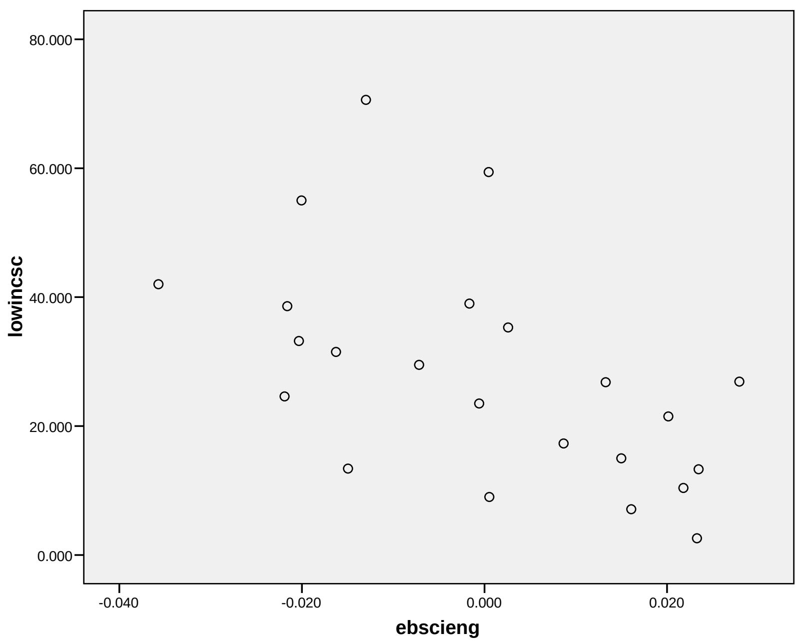


Figure A.13 EB residuals for SCIENGRA slope against LOWINCSC

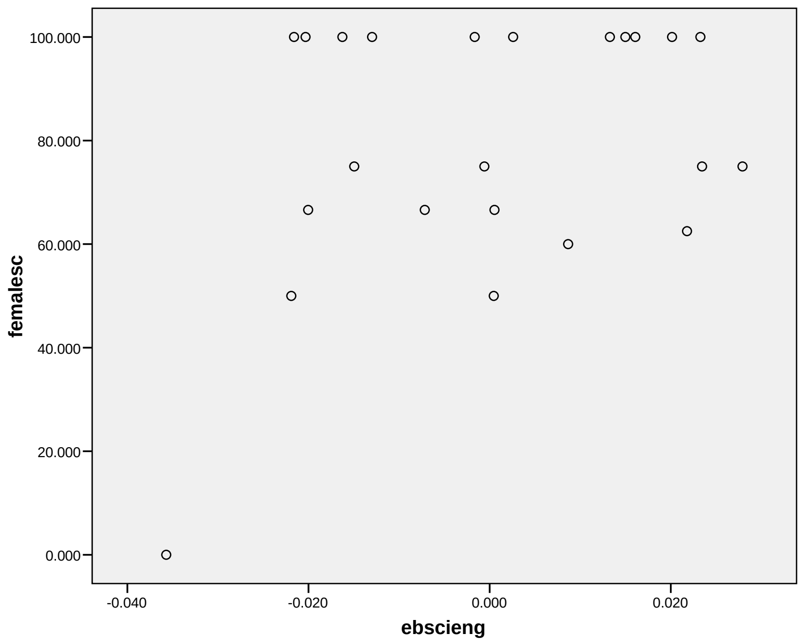


Figure A.14 EB residuals for SCIENGRA slope against FEMALESC.

APPENDIX B

B.1 BİLİMİN DOĞASI ANKETİ

	Doğru	Bilmiyorum	Yanlış
1. Bilim adamlarının bulduğu bilgiler **değişmez**, eğer değişseydi bilim adamları bu bilgileri kitaplara koymazlardı.	☐	☐	☐
2. Bilim adamlarının kitaplarda söyledikleri bilgiler hiç bir zaman **değişmez**.	☐	☐	☐
3. Fen ve teknoloji dersinde öğrendiğimiz bilgiler yeni elde edilen bilgiler ışığında değişebilir.	☐	☐	☐
4. Bilim adamları kabul ettikleri gerçeklere yeni bilgiler ekleyebilir fakat bu gerçekleri **değiştiremezler**, çünkü bu gerçeklerden yüzde yüz emindirler.	☐	☐	☐
5. Bilim adamları gerçekleri bulurken hayal güçlerini **kullanmazlar**.	☐	☐	☐
6. Bilim adamları gerçekleri bulurken yaratıcılıklarını **kullanmazlar**.	☐	☐	☐
7. Bilim adamlarının atomun yapısı hakkındaki bilgileri kesindir çünkü atomla ilgili bilgileri onları mikroskop altında görerek elde etmişlerdir.	☐	☐	☐
8. Bilim adamlarının atomun yapısı hakkındaki bilgileri kesin değildir çünkü atomla ilgili bilgileri onları görerek değil varolduklarını varsayarak elde etmişlerdir.	☐	☐	☐
9. Atomun yapısı hakkında bilim adamları yeni bilgiler elde ettikçe bugünkü kabul edilen modern atom teorisi değişebilir.	☐	☐	☐
10. Bilimde insanın hayal gücüne ve yaratıcılığına asla yer yoktur, çünkü bu durum yanlış ya da hatalı bulgu ve bilgilere yol açar.	☐	☐	☐
11. Fen bilgisi dersinde öğrendiğimiz bilimsel gerçekler, bilim adamlarının hayal gücü ve yaratıcılığından etkilenebilir.	☐	☐	☐
12. Bilimsel bilgi ancak kontrollü deneylerle elde edilen kanıtlar sonrasında ortaya çıkar, bilim adamının hayal gücü ve yaratıcılığına **bağlı değildir**.	☐	☐	☐
13. Bilim adamları aynı bulgulara bakarak bir olay hakkında farklı yorumlar yapabilir.	☐	☐	☐

B.2 ÖĞRENME YAKLAŞIMI ANKETİ

	Asla	Bazen	Genellikle	Her zaman
1. Genellikle başlangıçta zor görünen şeyleri anlayabilmek için çok çaba sarf ederim.	☐	☐	☐	☐
2. Yeni bir konuyu okurken, o konu ile ilgili daha önce bildiğim şeylerle ilişkilendirmeye çalışırım.	☐	☐	☐	☐
3.Çalışırken genellikle çalıştığım konunun uygulanabileceği gerçek durumları düşünürüm.	☐	☐	☐	☐
4. Konuyu en iyi, öğretmenin verdiği sırayla hatırlarım.	☐	☐	☐	☐
5. Öğrenmek zorunda olduğum çoğu şeyi ezberlemeye çalışırım.	☐	☐	☐	☐
6. Önemli konuları iyice anlayıncaya kadar tekrar ederim.	☐	☐	☐	☐
7. Öğretmenler, sınavda çıkmayacağı bilinen konular üzerinde öğrencilerin çok fazla vakit harcamasını **beklememelidir.**	☐	☐	☐	☐
8. Bir kez içine girdikten sonra hemen hemen her konu ilgimi çekebilir.	☐	☐	☐	☐
9. Derste öğrendiğimiz konuları yada kitaplarda okuduklarımı sorgularım.	☐	☐	☐	☐
10. Benim için yeni olan bir konu hakkında, fikirlerin nasıl birbirleriyle uyuştuğunu görerek genel bir bakış açısı edinmenin faydalı olduğunu düşünüyorum.	☐	☐	☐	☐
11. Bir dersten yada laboratuar dersinden sonra anladığımdan emin olmak için notlarımı tekrar okurum.	☐	☐	☐	☐
12. Bence bir konu hakkında çok fazla araştırma yapmak vakit kaybı, bu yüzden sadece sınıfta yada ders notlarında anlatılanları ciddi bir şekilde çalışırım.	☐	☐	☐	☐
13. Okumam için verilen materyali, anlamını tam olarak kavramak amacıyla okurum.	☐	☐	☐	☐
14. Teorik konulardan çok pratiğe dayalı uygulamalı içeriği olan konuları severim.	☐	☐	☐	☐
15. Bir konuda öğrendiğim bir şeyi başka bir konuda öğrendiğimle ilişkilendirmeye çalışırım.	☐	☐	☐	☐
16. Benim için teknik terimlerin ne anlama geldiğini öğrenmenin en iyi yolu bu terimlerin kitaptaki tanımlarını hatırlamaktır.	☐	☐	☐	☐

17. Bulmacalar ve problemler, özellikle elinizdeki materyali mantıklı bir sonuca varmak için kullandığınız durumlar bana çekici gelir.	☐	☐	☐	☐
18. Okumam için verilen materyalin gerçekte ne gibi anlamlar içerdiği konusunda pek fazla düşünmem.	☐	☐	☐	☐
19. Konuları genellikle ezberleyerek öğrenirim, hepsi aklımda kalana kadar tekrar ederim.	☐	☐	☐	☐
20. Genellikle okuduğum şeyleri gerçekten anlamadan okurum.	☐	☐	☐	☐
21. Bir konu hakkında gereğinden fazla okumak kafa karıştıracağı için yalnızca derste öğrendiklerimiz ya da laboratuarda yaptıklarımıza paralel olarak tavsiye edilen birkaç kitaba bakarım.	☐	☐	☐	☐
22. Ders çalışırken genellikle verilen bilgiye odaklanırım, fazlasını yapmak bence gereksizdir.	☐	☐	☐	☐

B.3 BAŞARI MOTİVASYONU ANKETİ

	Kesinlikle Katılmıyorum	Katılmıyorum	Katılıyorum	Kesinlikle Katılıyorum
1. Bu dersteki ana hedeflerimden birisi yaptığımız bilimsel etkinlikleri anlamaktır.	☐	☐	☐	☐
2. Bu derste öğrendiğimiz konularla ilgili fen bilgisi problemlerini çözeceğim konusunda kendime güveniyorum.	☐	☐	☐	☐
3. Bu dersteki ana hedeflerimden birisi diğer öğrencilerden daha başarılı olmaktır.	☐	☐	☐	☐
4. Derste gördüğümüz problemlere benzer problemleri çözmek için gerekli beceriye sahibim.	☐	☐	☐	☐
5. Ana hedeflerimden birisi sınıftaki fen bilgisi etkinliklerinde aptal yada beceriksiz **görünmemektir.**	☐	☐	☐	☐
6. Bu dersteki ana hedeflerimden birisi diğerlerinden daha zeki görünmektir	☐	☐	☐	☐
7. Bu dersteki ana hedeflerimden birisi çalıştığımız konuları anlamaktır.	☐	☐	☐	☐
8. Bu derste tek başıma bir deney yapacak olsam, eminim sorun yaşarım.	☐	☐	☐	☐

9. Bu dersteki ana hedeflerimden birisi bilgimi arttırmaya çalışmaktır.	□	□	□	□
10. Bu dersteki ana hedeflerimden birisi bu işi beceremeyen tek kişi olmamaktır.	□	□	□	□
11. Bu dersteki ana hedeflerimden birisi yaptığımız fen etkinlikleri sırasında gerçekte neler olduğunu anlamaktır.	□	□	□	□
12. Diğer öğrencilere kıyasla, sınıfta yaptığımız fen etkinliklerinde diğerleri kadar iyi değilim.	□	□	□	□
13. Bu dersteki ana hedeflerimden birisi, yeni bir şeyler öğrenmesem bile iyi bir not almaktır.	□	□	□	□
14. Bu dersteki ana hedeflerimden birisi aldığım not her ne olursa olsun yeni bir şeyler öğrenmektir.	□	□	□	□

APPENDIX C

C.1 CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Hacieminoglu, Esme
Nationality: Turkish (TC)
Date and Place of Birth: 01 January 1981, Antalya
email: ehacieminoglu@gmail.com

EDUCATION

Degree	Institution	Year of Graduation
BS	Hacettepe University Science Education	2003
High School	Isparta Gürkan High School	1998

WORK EXPERIENCE

Year	Place	Enrollment
2004-Present	METU Department of Elementary Education	Research Assistant

FOREIGN LANGUAGES

Advanced English

PUBLICATIONS

PAPERS PUBLISHED AT JOURNALS

1. **Hacieminoglu, E.,** Tuzun Yilmaz, O., & Ertepinar, H. (2009). Investigating elementary students' learning approach, motivational goals and achievement in science. *Hacettepe University Journal of Education, 37,* 72-83.

2. Yager, R. E., Ali, M. M. & **Hacieminoglu, E.,** (2010). Real Reform Takes More than "Stirring the Pot". *Science Educator,* (In press**).**

PAPERS PRESENTED AT INTERNATIONAL CONFERENCES

1. Alp, E., **Hacieminoglu, E.,** & Ertepinar, H. (2007). Pre-service Teachers' Intended Emphasis on Teaching Environmental Issues. *National Association for Research in Science Teaching (NARST),page:152, April 15 – 18, 2007, New Orleans,USA.*

2. Ertepinar, H., & **Hacieminoglu, E.** (2007). Effect of Gender and Socio Economic Status on Students' Achievement, Learning Approach, and Motivational Goals. *European Science Education Research Association, page:111, August 21-25, 2007, Malmö, Sweden.*

3. **Hacieminoglu, E.,** Ozgelen S., & Tuzun Yilmaz, O. (2007). Investigating Pre-service Teachers' Learning Approach and Epistemological Beliefs in Inquiry Learning Environment. *European Science Education Research Association, page:220, August 21-25, 2007, Malmö, Sweden.*

4. Ozgelen S., **Hacieminoglu, E.,** & Tuzun Yilmaz, O. (2007). Investigation the Effect of Inquiry Method for Student's Science Process Skills through Word Association Test. *European Science Education Research Association, page:221, August 21-25, 2007, Malmö, Sweden.*

5. **Hacieminoglu, E.,** Tuzun Yilmaz, O., & Ertepinar, H. (2007). Exploring relationships among students' learning approach and motivational goals. *234th American Chemical Society National Meeting & Exposition (ACS), August 19-23, 2007, Boston, USA.*

6. **Hacieminoglu, E.,** Alp, E., & Ertepinar, H. (2007). Investigation on the relationships between gender, mental capacity, reasoning ability, and chemistry achievement. *234th American Chemical Society National Meeting & Exposition (ACS), August 19-23, 2007, Boston, USA.*

7. Ozgelen S., **Hacieminoglu, E.,** & Tuzun Yilmaz, O. (2008). Investigation of pre-service teachers' reasoning abilities and learning approaches in inquiry based learning environment. *National Association for Research in Science Teaching (NARST) page:211, March30-April2, 2008, Baltimore MD, USA.*

8. **Hacieminoglu, E.,** Ozgelen S., & Tuzun Yilmaz, O. (2008). Pre-servıce teachers' perceptions and motivations toward a science laboratory course. *XIII. IOSTE Symposium, The Use of Science and Technology Education for Peace and Sustainable Development, page:494, September 21-26, 2008, Kuşadası, Turkey.*

9. Sahin, E. Ulutas, O. **Hacieminoglu, E.,** & Ertepinar, H. (2008). An Investigation of Turkish pre-service elementary teachers' scientific literacy. *XIII. IOSTE Symposium, The Use of Science and Technology Education for Peace and Sustainable Development, page:494, September 21-26, 2008, Kuşadası, Turkey.*

10. **Hacieminoglu, E.** (2009). Evaluating science learning: Students and teachers in Turkey. *The Association for Science Teacher Education (ASTE),page: 58, January 8-10, 2009, Hartford, CT, USA.*

11. **Hacieminoglu, E.** (2009). STS Initiatives in Turkish middle school curriculum. *Intnational Association Science Technolgy and Society (IASTS), April 2-4, 2009, Rochester, NY, USA.*

12. **Hacieminoglu, E.,** Tuzun Yılmaz, O., & Ertepinar, H. (2009). Investigating elementary students' nature of science views. *National Association for Research in Science Teaching (NARST), page;221, April 17-21, 2009, Garden Grove, CA, USA.*

13. **Hacieminoglu, E.,** Tuzun Yılmaz, O., & Ertepinar, H. (2009). Pre-service science teachers perceptions related to nature of science and their instructions. *European Science Education Research Association, (ESERA), page;438, August 31st - September 4th 2009, Istanbul, Turkey.*

14. Yager, R. E., **Hacieminoglu, E.,** & Ali, M. M. (2010). Visions for reform of science teacher education: Realizing the potential. *Associations of Teacher Educators (ATE) Annual Meeting, page; 101, February 13-17, 2010, Chicago, USA.*

15. **<u>Hacieminoglu, E.,</u>** Ertepinar, H., & Tuzun Yılmaz, O. (2010). Effect of student level variables on elementary students' nature of science views. *National Association for Research in Science Teaching (NARST), page;85, March 20-24, 2010, Philedelphia, Pennsylvania, USA.*

<u>PAPERS PRESENTED AT NATIONAL CONFERENCES</u>

1. **<u>Hacieminoglu, E.,</u>** Alp, E., & Ertepinar, H. (2006). Pre-service teachers' attitudes towards environment and teaching environmental issues. VII. Science and Mathematics Conference, page.113, Ankara, TURKEY.

2. Dogruoz, P., Ertepinar, H., Alp, E., & **<u>Hacieminoglu, E.</u>** (2007). Effect of science process skill oriented lesson on understanding of fluid force concepts. I. National Chemistry Education Conference, page. 54, İstanbul, TURKEY.

3. Ozsoy, I. S., Ertepinar, H., **<u>Hacieminoglu, E.,</u>** & Alp, E., (2007). Effect of inquiry oriented lesson on students' understanding of atom concepts, learning approaches, motivation, self efficacy, and epistemological beliefs, I. National Chemistry Education Conference, page. 55, İstanbul, TURKEY.

4. **<u>Hacieminoglu, E.,</u>** Ozgelen S., & Tuzun Yılmaz, O. (2007). Investigation of preservice science teachers perceptions towards science laboratory practice course. I. National Elementary Conference, page. 74, Ankara, TURKEY.

5. Ozgelen S., **Hacieminoglu, E.,** & Tuzun Yılmaz, O. (2007). Effect of inquiry oriented lesson on development of pre-service teachers' science process skills. I. National Elementary Conference, page. 84, Ankara, TURKEY.

POSTERS PRESENTED AT INTERNATIONAL *CONFERENCES*

1. Ozgelen S., **Hacieminoglu, E.,** & Tuzun Yılmaz, O. (2008). Effect of inquiry instruction and gender on students' science process skills, epistemological beliefs and learning approaches in Turkish context. *XIII. IOSTE Symposium, The Use of Science and Technology Education for Peace and Sustainable Development, page:1266, September 21-26, 2008, Kuşadası, Turkey.*

PROJECTS

1. Scientific Research Project (BAP-2007-05-06-01). "Preservice science teachers' perceptions toward history of science and nature of science." (As a Researcher)
2. Scientific Research Project (BAP-08-11-DPT-2002K120510)."Student and School characteristics related to elementary students nature of science views" (As a Researcher)

WORKSHOPS

1. Hierarchical Linear and Nonlinear Modeling with the HLM for Windows program. Scientific Software International professional development training session (by Steve Raudenbush, & Tony Bryk). September 17-19, 2008, Chicago, Illinois.

2. Hierarchical Linear and Nonlinear Modeling with the HLM for Windows program. Scientific Software International professional development training session (by Ann O'Connell and Betsy McCoach). June 8-12, 2009, Hartford, Connecticut.

3. Structural Equation Modeling with LISREL (by Ralph O. Mueller and Gregory Hancock), September 1-3, 2009, Chicago, Illinois.

TURKISH SUMMARY

İlköğretim Öğrencilerinin Bilimin Doğasına Yönelik Algıları ile İlişkili Öğrenci ve Okul Değişkenleri

Giriş

Öğrencilerin bilimin doğasına yönelik algıları ile ilgili çalışmalar son yıllarda fen eğitimi alanında önem kazanmıştır (Abd-El-Khalick, Bell, & Lederman, 1998; Dush, 1990; Griffiths & Barry, 1993; Huang, Tsai & Chang; 2005; Kang, Sharmann, & Noh, 2005; Khishfe & Abd-El-Khalick, 2002; Khishfe & Lederman, 2006). Bilimindoğası "bilimsel bilginin gelişiminin doğasında var olan inançlar, değerler, bilgiyi elde etme yöntemi veya bilgi epistemolojisi olarak tanımlanmıştır" (Abd-El-Khalick & Lederman, 2000, p.666). Sosyologlar ve filozoflar bilimin doğasının tanımı hakkında hemfikir olunmuş kesin bir tanım olmamasına rağmen, bilimin doğasının bazı özellikleri açısından fikir birliğine varmışlardır. Bu özellikler: bilimsel bilgi değişkendir, deneyseldir, özneldir, kısmen insanın hayal gücü ve yaratıcığının ürünüdür ve sosyal ve kültürel değerlerle iç içedir. Buna ek olarak bilimsel bir süreçte gözlem ve çıkarım arasındaki farklılıkların kavranmalı ve bilimsel teori ve kanun arasındaki ilişki anlaşılmalı (Abd-El-Khalick, Bell, & Lederman, 1998; Khishfe & Lederman, 2006; Schwartz & Lederman, 2007).

Türkiye, Lübnan, Tayvan, Venezüella ve Kanada gibi ülkelerdeki müfredat yenileme çalışmalarında öğrencilerin bilimin doğasına yönelik algılarının geliştirilmesine önem vermişlerdir. Dünya çapındaki müfredatlara bilimin doğasının entegre edilmesi sonucunda Türkiye deki yeni Fen ve Teknoloji müfredatında bireysel farklılıklar gözetilmeksizin her öğrencinin fen okuryazarı olabilmesi vurgulanmaktadır. Fen okuryazarı olmanın en önemli özelliklerinden birisi bilimsel kavramları anlamanın yanı sıra bilimin doğasını ve gelişimini anlayabilmektir (Dogan & Abd-El-Khalick, 2008; Lawson, 1995). Buradan da anlaşılacağı gibi bilimin doğasını anlayabilmek fen okuryazarlığının gelişiminde önemli bir rol oynamaktadır.

Dünya çapındaki müfredatlara bilimin doğasının entegre edilmesi sonucunda öğretmenlerin ve öğrencilerin bilimin doğasına yönelik algılarının belirlenmesine yönelik çalışmalar önem kazanmıştır. Araştırmacılar genellikle öğrencilerin bilimin doğasına yönelik algılarını inceleyen çalışmalarında nitel araştırma yöntemlerini kullanmışlardır (Griffiths & Barman, 1995; Griffiths & Barry, 1993; Moss, 2001; Sadler, Chambers, & Zeidler, 2004). Literatür incelendiğinde ilköğretim öğrencilerinin bilimin doğasına yönelik algılarını inceleyen çalışmaların da Nitel çalışmalar olduğu görülmüştür (Shiang-Yao & Lederman, 2002; Khishfe, 2008; Khishfe & Abd-El-Khalick, 2002; Khishfe & Lederman, 2006; Khishfe &

Lederman, 2007; Liu & Lederman, 2002). Bunun yanı sıra araştırmacılar bu konu üzerinde nicel araştırma yöntemleriyle literatürdeki ölçekleri kullanarak araştırmalar yapmışlardır. Literatürde var olan ölçekler incelendiğinde ölçeklerin çoğunun lise öğrencileri veya üniversite öğrencileri için hazırlanmış olduğu görülmektedir. Örnek olarak Cooley ve Klopher (1961) tarfından geliştirilen "*Test on Understanding Science (TOUS)",* Ruba ve Anderson (1978) tarfından geliştirilen "*Nature of Scientific Knowledge Scale (NSKS)*" Aikenhead, Fleming, ve Ryan (1987) tarfından geliştirilen "*Views on Science-Technology-Society (VOST)*", gösterilebilir. Bunun yanı sıra literatürde son zamanlarda geliştirilmiş olan ölçeklerde bulunmaktadır. Huang et al., (2005)tarafından geliştirilen "*Pupils' Nature of Science Scale (PNSS)*", Liang, Chen, Chen, Kaya, Adams, Macklin, ve Ebenezer (2008) tarafından geliştirilen, "*Student Understanding of Science and Scientific Inquiry (SUSSI)"* , Chen (2006) tarafından geliştirilen "*Views on Science and Education Questionnaire (VOSE)*" Tsai ve Liu (2005) tarafından geliştirilen "*Students' Epistemological Views of Science (SEVs)*" bunlardan bazılarıdır. Bu nedenle bilimin doğası ile ilgili lise düzeyinde (e.g., Chen, 2006; Griffiths & Barman, 1995; Griffiths & Barry, 1993; Lederman & O'Malley, 1990; Liang et al., 2008; Ryan & Aikenhead, 1992) ve üniversite düzeyinde (e.g., Abd-El-Khalick, et al., 1998; Bell, Lederman, & Abd-El-Khalick, 2000; Eichinger, Abell, & Dagher, 1997; Lederman, Schwartz, Abd-El-Khlick, & Bell, 2001; Pomeroy, 1993; Tsai & Liu, 2005) birçok çalışmalar yapılmış olmasına rağmen, bu konuda ilköğretim düzeyinde sınırlı sayıda çalışma bulunmaktadır ve bu çalışmaların çoğunda nitel yöntemler kullanılmıştır (Akerson & Volrich, 2006; Huang et al., 2005; Kang et al., 2005; Khishfe, 2008; Khishfe & Abd-El-Khalick, 2002; Khishfe & Lederman, 2006; Khishfe & Lederman, 2007; Shiang-Yao & Lederman 2002). Literatürdeki nitel çalışmaların bir çoğu öğrencilerin bilimin doğasının alt boyutlarına yönelik benzer sonuçlar göstermektedir. Örneğin üniversite ve lise düzeyindeki öğrencilerin bilimin doğasına yönelik algıları temel düzeydedir. İlköğretim öğrencileri ile yapılmış olan çok az çalışma bulunmakta ve bunların çoğu nitel yöntemleri içeren çalışmalrdır. Bu çalışmaların sonuçları da öğrencilerin bilimin doğasına yönelik algılarının temel düzeyde olduğunu göstermiştir. Bu sonuçlar farklı yaş gruplarında, ülkelerde aynı şekilde tutarlılık göstermektedir ve bu sonuçların geniş bir örneklemde genellenebilmesi için ilköğretim öğrencileri için geçerli ve güvenilir bir ölçek geliştirilmesine ihtiyaç duyulmaktadır.

Öğrencilerdeki bireysel farklılıklar onların fen konularını öğrenmelerinde önemli bir rol oynamaktadır (Koran & Koran, 1984). Öğrenmenin yanında bu farklılıklar öğrencilerin diğer karakterleriyle de örneğin onların öğrenme yaklaşımları, güdüleri, algıları ve kendine güvenleri gibi karakterlerle de ilgilidir

(Debacker & Nelson, 2000; Garcia & Pintrich, 1992; Lin & McKeachie, 1999; Qian, 1995; Koran & Koran, 1984; Zhang, 2000). Türkiye'de yeni Fen ve Teknoloji dersi müfredatı geliştirilirken öğrenci farklılıkları da göz önünde tutulmaya çalışılmıştır. Dolayısıyla, öğrenci farklılıklarının -öğrencilerin öğrenme yaklaşımları, güdüleri, algıları ve kendine güvenleri- fen eğitimimize olan katkıları araştırılması gereken bir konudur. Bu araştırmalara fen araştırmacılarının sık sık kullandıkları değişkenlerden olan cinsiyet ve sosyal durumların katılması daha verimli sonuçlar elde edilmesi açısından önem taşımaktadır. Daha önce yapılan çalışmalar cinsiyet yönünden kızların daha çok güdüsel başarılarının olduğunu ortaya koymuştur (Kahlee & Meece, 1994). Cinsiyetin yanı sıra diğer soysodemografik değişkenlerinde öğrenme yaklaşımlarında, güdüsel hedeflerde ve kendine güvende etkili rol oynadığı belirtilmiştir (Greenfield, 1997; Kahlee & Meece, 1994). Bilimin doğası ile ilgili bazı çalışmalarda cinsiyet ve sınıf düzeyi farklılıkları göz önünde bulundurulmuştur (e.g., Huang et al., 2005; Kang et al., 2005; Dogan & Abd-El-Khalick, 2008). Bunun yanı sıra Edmondson (1989) ve Edmondson & Novak, (1993) ün çalışmaları öğrencilerin bilimin doğasına yönelik algıları ile onların öğrenme kavramına verdikleri tanımlar, öğrenme yaklaşımları ile ilişkili olduğunu göstermiştir. Fakat öğrencilerin bilimin doğasına yönelik algılarının bireysel faktörleri yansıtan değişkenlerle olan ilişkilerinin incelenmesi önem taşımaktadır.

Bir diğer önemli nokta ise eğitim alanında ilköğretim düzeyinde öğrenci başarısı ve öğrenmesi ile ilgili çalışmalara verilen önem gün geçtikçe artmaktadır (Klinger & Ma, 2000). Bu araştırma konularıyla ilgili veriler genellikle gruplanmış verilerdir, yani okul içerisinde veya sınıf içerisinde gururlanmış şekildedirler. Bu nedenle bu gibi araştırmalarda öğrenci ile ilgili değişkenlerin yanı sıra, okul veya sınıf ile ilgili değişkenlerin birlikte incelenmesi gerektiği önerilmektedir (Klinger & Ma, 2000; Raudenbush & Bryk, 2002; Willms & Raudenbush, 1989). Bu nedenle bu çalışma bu etkenler göz önünde bulundurularak tasarlanmıştır.

Bu çalışmanın amacı ilköğretim öğrencilerinin bilimin doğasına yönelik algılarını ölçmeye yönelik bir ölçek geliştirmek ve ilköğretim öğrencilerinin bilimin doğasına yönelik algılarının hangi okul ve öğrenci ile ilgili değişkenlerle ne derece ilişkili olduğunu göstermektir.

Metodoloji

1. Yöntem, Evren ve Örneklem

Bu çalışmada betimsel tarama deseni kullanılmıştır. Bu çalışmanın ulaşılabilen evreni Ankara ili Çankaya ilçesine ait tüm 6., 7. ve 8. sınıf ilköğretim öğrencileridir.

Çankaya ilçesinde toplam 9,123 altıncı sınıf, 9,145 yedinci sınıf ve 9,448 sekizinci sınıf öğrencisi mevcuttur. Bu yüzden evren 27,716 ilköğretim öğrencisinden oluşmaktadır. Bu öğrencilerin 3,653 ünden veri toplanmıştır ve kayıp veriler olmasından ötürü 591 öğrenciye ait ölçek çalışmadan çıkarılmıştır. Çankaya ilçesi Ankara daki ilçeler arasında, sosyoekonomik özellikler bakımından en fazla çeşitlilik gösteren ilçe olduğu için çalışma bu ilçe de yapılmıştır. İlçedeki okulların seçimi sırasında ise araştırmacının elindeki alfabetik okullar listesindeki tüm okullar aranarak okul idaresinden bu çalışmaya katılım konusunda gönüllü olan okullardaki öğrencilerden veri toplanmıştır. Bu nedenle Çankaya da ki belirli okullara gidilmiştir fakat bu okullar rastgele seçilememiştir. Çankaya daki toplam 103 okuldan 23 ilköğretim okulundan veri toplanabilmiştir. Öğrencilerin demografik özellikleri ile ilgili bilgiler Tablo 1 de verilmiştir.

Table 1. *Katılımcıların Demografik Özellikleri*

Demografik Özellikler		N	%
Cinsiyet	Bayan	1567	51,2
	Bay	1495	48,8
Sınıf Seviyesi	6. sınıf	1415	46.2
	7. sınıf	1397	45.6
	8. sınıf	250	8.2
Anne Eğitim Düzeyi	Eğitim Almamış	59	1.9
	İlköğretim	721	23.5
	Ortaokul	474	15.5
	Lise	1016	33.2
	Üniversite	645	21.1
	Yüksek Lisans	130	4.2
	Doktora	17	.6
Baba Eğitim Düzeyi	Eğitim Almamış	5	.2
	İlköğretim	314	10.3
	Ortaokul	345	11.3
	Lise	837	27.3
	Üniversite	1096	35.8
	Yüksek Lisans	368	12.0
	Doktora	97	3.2
Gelir Düzeyi	500 TL ve altı	172	5.6
	501 – 1000	561	18.3
	1001 – 1500	1138	37.2
	1501 – 2000	424	13.8
	2001 – 2500	295	9.6
	2500 ve üstü	472	15.4

2. Çalışmanın değişkenleri

Çalışmada kullanılan değişkenler tablo 2 de gösterilmektedir.

Tablo 2. *Sonuç, Öğrenci ve Okul Düzeyindeki Değişkenler*

Sonuç Değişkenleri	Bilimin Doğasının Alt boyutları	Bilimin değişebilirliği	TENTATIV
		Gözlem ve Çıkarım	IMEGCRAT
		Bilimin Deneysel Olması	OBSVINF
		Hayal gücü ve Yaratıcılık	EMPIRICA
Öğrenci ile ilgili değişkenler	Öğrencinin özgeçmişi ile ilgili değişkenler	Sosyoekonomik Statü (SES)	INCOMEME INCOMEHI
		Ailenin Eğitim Düzeyi (PEL)	DUMMYCOL DUMMYGRA
		Ailenin iş sahibi olma durumu	PARENTOC
	Öğrenci Özellikleri ile ilgili değişkenler	Sınıf Düzeyi (GRADE)	GRADE7 GRADE8
		Fen Başarısı	SCIENGRA
		Cinsiyet	GENDER
	Öğrencilerin Duyguları ve Okul dışı aktiviteleri ile ilgili Değişkenleri	Fen'e yönelik tutum	LIKINGSC
		En çok sevdiği ders	DUMMYLIK
		Fen ile ilgili kitap veya dergi okuması	READINGB
		Fen ile ilgili internet sitelerinden yararlanması	INTERNET
		Belgesel izlemesi	DOCUMENT
		Fen konuları ile ilgili düşüncelerini ailesiyle paylaşımı	SHARINGI
	Öğrenme ve Motivasyonla ilgili Değişkenler	Performansa yönelik motivasyon	PERFGOAL
		Öğrenmeye yönelik motivasyon	LEARNGOA
		Öz yeterlik	SELFEFFI
		Ezberleyerek Öğrenme	MEANINGF
		Anlamlandırarak Öğrenme	ROTELEAR

Tablo 2 nin devamı

Okul ile ilgili Değişkenler	Okul özellikleri ile ilgili değişkenler	Okul un Sosyoekonomik Statüsü	HIGHINCS LOWINCS
		Bayan fen bilgisi öğretmenlerinin oranı	FEMALESC
		Sınıfların öğrencilerin yeteneklerine göre gruplanması	ABILITYG
		Okulun fiziksel altyapısı ile ilgili özellikler	PHYSICAL
		Okulun eğitsel kaynakları ile ilgili özellikler	QUALITYE

3. Kullanılan Ölçekler

Bilimin Doğası Ölçeği(NOSI)

Ölçek araştırmacılar tarafından geliştirilmiştir. Öncelikle literatürdeki elde edilen bilgiler doğrultusunda bilimin doğasına yönelik alt boyutlar ve maddeler belirlenmiştir. Bu süreçte öncelikle yurt içi ve yurtdışındaki çalışmalardan özellikle ilköğretim öğrencilerinin bilimin doğasına yönelik algısını konu alanlar incelendi. Literatür taraması sonucunda bilimin doğası hakkında literatürde kabul görmüş alt boyutlar çıkarıldı. Sonrasında araştırmacılar tarafından iyi derecede kabul görmüş dergilerde basılmış konu hakkındaki makaleler incelendi. Bu çalışmalar nitel çalışmalar olduğu için öğrencilerin bilimin doğası hakkındaki görüşlerine yönelik derinlemesine bilgi vermektedir. Bu nedenle araştırmacılar tarafından öğrencilerin çalışmalardaki uygulamadan önceki ve sonraki görüşmelerdeki cümleleri incelendi. Bu cümleler temel alınarak madde havuzu oluşturuldu, orijinal maddeler ve

Türkçeye çevrilmiş maddeler dil uzmanları ve alan uzmanları tarafından incelendi. Literatürde ilköğretim seviyesindeki öğrenciler ile ilgili yapılmış çalışmalarda ele alınan bilimin doğasının ortak alt boyutları ölçeğin alt boyutları olarak belirlenmiştir. Bu alt boyutlar; Bilimin değişebilirliği (Bilimin Değişebilirliği), bilimin deneysel olması (Bilimin Deneysel Olması) , hayal gücü ve yaratıcılığın rolü (Hayal gücü ve yaratıcılık), gözlem ve çıkarım ın farkı (Gözlem ve Çıkarım). Bu aşamalardan sonra güvenirlik ve geçerlik çalışmaları yapılmaya başlanmıştır. Bunun için dört kez pilot çalışma yapılmıştır. Her pilot çalışmada ölçeklerde öğrencilerin maddeler hakkındaki düşüncelerini belirtebilecekleri boşluklar bırakılmıştır. Bunun yanı sıra öğrencilerden ve öğretmenlerden sözlü olarak alınan geri bildirimler araştırmacı tarafından kaydedilmiştir ve bunlar ölçeği yeniden tasarlarken göz önünde bulunduruluştur. Pilot çalışmaların ardından faktör analizleri yapılmıştır ve faktör yükleri düşük olan maddeler atılmıştır. Bilimin doğası ölçeğinin son hali 5tanesi pozitif, 8 tanesi negatif olmak üzere toplam 13 maddeden oluşmaktadır. Dört pilot çalışmadan sonraki düzenlemeler sonucunda bilimin doğası ölçeğinin son hali Çankaya'daki 6., 7., ve 8. sınıflardan oluşan 782 ilköğretim öğrencisine uygulanmıştır. Bu öğrencilerin betimleyici özellikleri tablo 3 de gösterilmektedir. Bilimin doğası ölçeğinin faktör yapısı ve güvenilirlik katsayısı ise tablo 4 de gösterilmektedir.

Table 3. *Katılımcıların Demografik Özellikleri*

Demografik Özellikler		N	Percent
Cinsiyet	Female	391	50
	Male	391	50
Sınıf Düzeyi	6th grade	329	42.1
	7th grade	320	40.9
	8th grade	133	17.0

Tablo 4. *NOSI Maddelerinin Faktör Yükleri*

NOSI Altboyutları	Madde		Factor 1	Factor 2	Factor 3	Factor 4
Gözlem ve Çıkarım	7	Negatif	.990			
	8	Pozitif	.595			
Alfa değeri = .74						
Bilimin Değişebilirliği	2	Negatif		.975		
	1	Negatif		.846		
	4	Negatif		.353		
Alfa değeri = .76						
Hayal gücü ve yaratıcılık	5	Negatif			.750	
	10	Negatif			.682	
	6	Negatif			.670	
	12	Negatif			.646	
	11	Pozitif			.588	
Alfa değeri = .80						
Bilimin Deneysel Olması	9	Pozitif				.881
	3	Pozitif				.756
	13	Pozitif				.249
Alfa değeri = .63						
Aygendeğeri			3.40	2.36	1.45	1.14
Varyans (%)			26.21	18.20	11.15	8.77
Toplam Alfa değeri =.76						

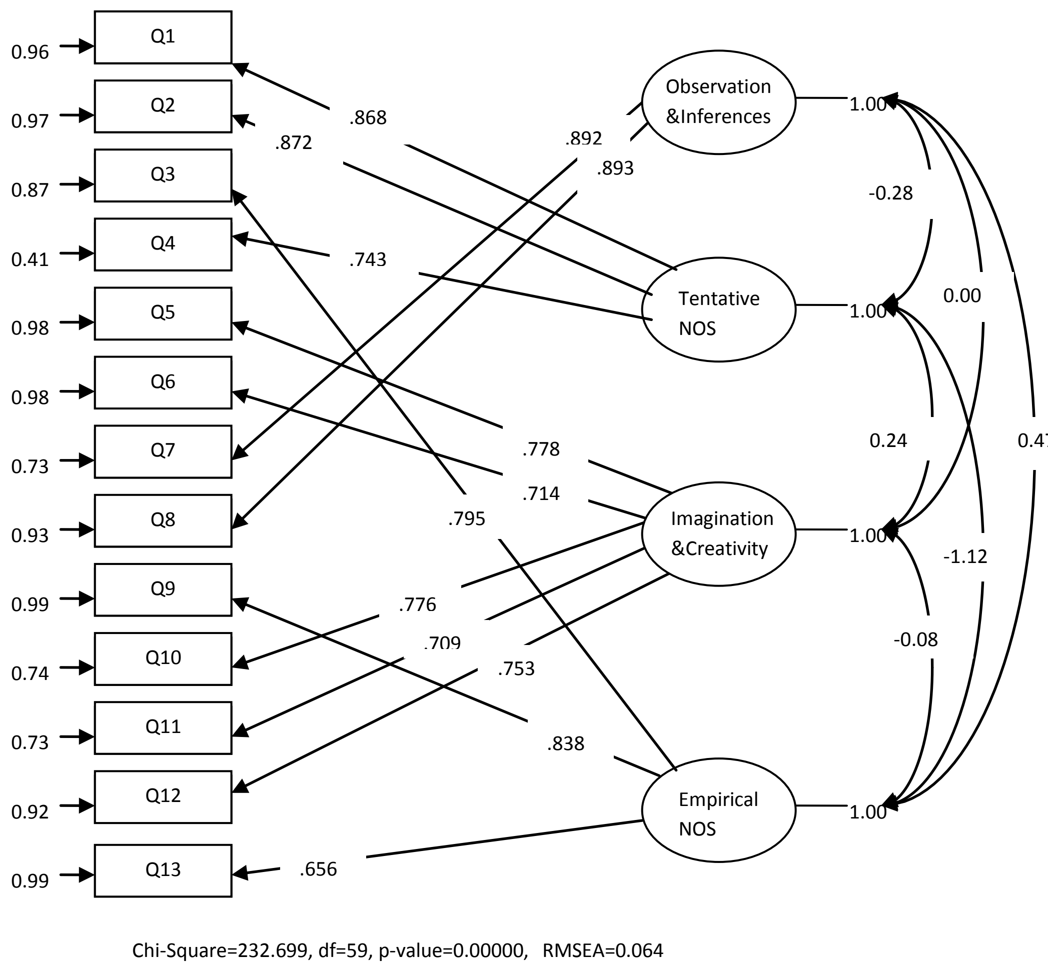


Figure 1. Doğrulayıcı Faktör Analizi Modeli

Öğrenme Yaklaşımı Ölçeği

Bou Joude (1992) ve Cavallo and Schafer (1994) in çalışmalarında kullandığı öğrenme yaklaşımı ölçeği öğrencilerin öğrenme yaklaşımlarını ölçmek için kullanılmıştır. Ölçek likert tipi 22 maddeden oluşmuştur. Bu maddelerden 11 madde anlamlandırarak öğrenme, diğer 11 madde ise ezber yoluyla öğrenme yaklaşımını ölçmektedir. Ölçeğin güvenilirlik katsayısı anlamlı öğrenme için 0.81, ezber yolluyla öğrenme alt boyutu için 0.76 olarak rapor edilmiştir (Cavallo, Rozman & Potter, 2004). Anket Caliskan (2004) tarafından lise öğrencilerin de uygulama yapmak üzere Türkçe ye çevrilmiştir. Ölçeğin ilköğretim öğrencilerine uygun olup olmadığını anlamak için araştırmacılar tarafından pilot çalışma yapılmıştır ve bu çalışmada bazı maddelerdeki kelime değişiklikleri dışında bütün maddelerin öğrenciler için uygun olduğu görülmüştür. Bazı kelime değişikliklerinden sonra ölçek Ankara da aynı bölgedeki 416 yedinci sınıf ilköğretim öğrencilerine uygulanmıştır. Ölçeğin güvenilirlik katsayısı anlamlı öğrenme için 0.77, ezber yolluyla öğrenme alt boyutu için 0.761olarak bulunmuştur.

Başarı Motivasyon Ölçeği

Cavallo, Rozman, and Potter (2004) in çalışmalarında kullandığı Başarı Motivasyon Ölçeği öğrencilerin başarı motivasyonlarını ölçmek için kullanılmıştır. Ölçek likert tipi 14 maddeden oluşmuştur. Bu maddelerden 5 madde öğrencilerin performansa yönelik motivasyonu, 5 madde öğrenmeye yönelik motivasyonu, 4 madde ise öz-yeterliklerini ölçmektedir. Ölçeğin güvenilirlik katsayısı performansa yönelik motivasyon için 0.82, öğrenmeye yönelik motivasyon için 0.94, öz-yeterlik için 0.89 olarak rapor edilmiştir (Cavallo, Rozman & Potter, 2004). Anket öğrenme yaklaşımı anketi gibi Caliskan (2004) tarafından lise öğrencilerin de uygulama yapmak üzere Türkçe ye çevrilmiştir. Ölçeğin ilköğretim öğrencilerine uygun olup olmadığını anlamak için araştırmacılar tarafından pilot çalışma yapılmıştır ve bu çalışmada bazı maddelerdeki kelime değişiklikleri dışında bütün maddelerin öğrenciler için uygun olduğu görülmüştür. Bazı kelime değişikliklerinden sonra ölçek Ankara da aynı bölgedeki 416 yedinci sınıf ilköğretim öğrencilerine uygulanmıştır. Ölçeğin güvenilirlik katsayısı performansa yönelik motivasyon için 0.75, öğrenmeye yönelik motivasyon için 0.83, öz-yeterlik için 0.75 olarak bulunmuştur.

4. Data Analizi

Veri analizinde kullanmak için aşamalı doğrusal modelleme yöntemi seçilmiştir. Çünkü çalışmadaki veriler, öğrencilerle ilgili değişkenler ve okulla ilgili değişkenler den oluşmaktadır. Aynı okullardaki öğrenciler okulun eğitsel olanakları, sosyoekonomik seviyesi gibi aynı okul değişkenlerine sahiptir. Aşamalı doğrusal modelleme yöntemi kullanılmadığı taktirde, bütün öğrenciler aynı okul değişkenlerine sahipmiş gibi analiz yapılmakta ve bütün öğrenciler için tek bir regresyon modeli oluşturulur. Veri aşamalı doğrusal modelleme yöntemi (HLM) kullanılarak analiz edildiğinde her grup kendi alt modelleri ile temsil edilmektedir. Bu alt modeller aynı seviyedeki değişkenler arasındaki ilişkilerle beraber, bu seviyedeki değişkenlerin diğer seviyedekilere olan etkisini de ortaya koymaktadır. Bu nedenle HLM aşamalı yapıdaki değişkenler arasındaki ilişkiyi belirlemek için daha iyi daha uygun bir analiz yöntemi olduğu için verilerin analizinde bu teknik seçilmiştir.

Sonuçlar ve Tartışma

Ölçek geliştirirken göz önünde bulundurulması gereken en önemli konu ölçeğin istenilen durumu ölçüp ölçmediğidir. Bu durum aynı zamanda ölçeğin geçerliliği ile ilgilidir. Bu nedenle birden fazla pilot çalışma yapılması önem taşımaktadır. Literatürdeki nitel çalışmaların sonuçları ilköğretim öğrencilerin bilimin doğası hakkındaki görüşleri yönünde bu çalışmaya büyük ölçüde öncülük etmiştir (Akerson & Volrich, 2006; Khishfe, 2008; Khishfe & Abd-El-Khalick, 2002; Khishfe & Lederman, 2006-2007). Pilot çalışmalar sırasında maddelerdeki çok küçük değişiklikler bile faktör yapılarında çok büyük değişikliklere sebep olmuştur. Pilot çalışma sürecindeki maddelerdeki değişiklikler bu süreçte öğrenciler ve öğretmenlerden alınan geri bildirimler sonucunda ortaya çıkmıştır. Bazı maddeler güvenirliklerinin düşük olması sebebiyle ölçeğin son halinden çıkarılmıştır. Açıklayıcı ve doğrulayıcı faktör analizleri sonuçları Bilimin doğası ölçeğinin ilköğretim öğrencilerinin bilimin doğasına yönelik algılarını ölçebildiğini göstermektedir. Ölçeğin alt boyutları literatürde aynı alt boyutlarla hazırlanmış diğer ölçeklerle karşılaştırıldığında güvenirlik değerinin (α=.76) diğerlerine göre daha yüksek ve literatüre göre kabul edilebilir düzeyde olduğu görülmektedir (DeVellis, 1991; Kline, 1999). Ölçeklerle ilgili değerler Tablo 5 de sunulmuştur. En düşün güvenirlik katsayısı bilimin deneysel olması (α=.63) alt boyutuna aittir fakat literatüre göre sosyal alandaki çalışmalar için hala kabul edilebilir düzeydedir (Hatcher & Stepanski, 1994; Liang et al., 2008, Tsai & Liu , 2005).

Tablo 5.

Ölçeklerin ve Alt Boyutlarının Güvenirliği

NOSI (ilköğretim öğrencieri için)		SUSSI (üniversite öğrencileri için) (Liang, Chen, Kaya, Adams, Macklin & Ebenezer, 2008)		VOSE (üniversite öğrencileri için) (Chen, 2006)		SEVs (lise öğrencileri için) (Tsai & Liu, 2005)	
Altboyutlar	**α**	**Altboyutlar**	**α**	**Altboyutlar**	**α**	**Altboyutlar**	**α**
Gözlem ve çıkarım	.74	Gözlem ve çıkarım	.61	Gözlemin Doğası	.47		
Bilimin değişebilir-liği	.76	Bilimin değişebilir-liği	.56	Bilimin değişebilir-liği	.34	Bilimin değişebilir-liği	.60
Hayalgücü ve yaratıcılık	.80	Hayalgücü ve yaratıcılık	.89	Hayal gücünün kullanımı	.71	İcat edilen yaratıcı bilimim doğası	.60
Bilim deneyselliği	.63			Bilimsel bilginin doğrulanması	.44		
Toplam α	.76	Toplam α	.69	Test-tekrartest ilişki katsayısı	.82	Toplam α	.67

Betimsel İstatistik Sonuçları

Betimsel istatistik sonuçları bilimin doğasının alt boyutları arasında en istenilen düzeyde olanının öğrencilerin bilimin deneysel oluşuna yönelik algılarının olduğu sonucunu ortaya koymuştur. Benzer şekilde Sadler, et al., (2004) lise öğrencileri ile yaptığı çalışmasında örnekleminin %80 inin data yı tanımlayabildiği, öğrencilerin birçoğunun bu boyuta yönelik algılarının gelişmiş olduğu sonucunu ortaya çıkarmıştır. Bilimin değişebilirliği ve hayal gücü ve yaratıcılık alt boyutlarına yönelik kararsız bir tutum göstermişlerdir. Bu sonuç literatürdeki bazı çalışmaların sonuçlarıyla uyumludur (Khishfe & Abd-El-Khalick, 2002; Ryan & Aikenhead, 1992; Stein & McRobbie, 1997). Bu konudaki en az düzeydeki algıları ise Griffiths and Thompson (1993) çalışmalarıyla desteklediği gibi gözlem ve çıkarım alt boyutuna aittir. Değişkenlerin betimsel istatistik değerleri tablo 6 de verilmiştir.

Tablo.6 Sonuç, Öğrenci ve Okul Düzeyindeki Değişkenlerin Betimsel Analiz Sonuçları

Düzey	Değişkenler	Çeşidi	N	M	SD
Sonuç	TENTATIV	Sürekli	3043	1.81	.71
	IMEGCRAT	Sürekli	3034	2.16	.69
	OBSVINF	Sürekli	3021	2.24	.56
	EMPIRICA	Sürekli	3044	2.59	.47
Öğrenci ile ilgili değişkenler	INCOMEME	Kategorik	3062	0.51	0.50
	INCOMEHI	Kategorik	3062	0.25	0.43
	DUMMYCOL	Kategorik	3062	0.36	0.48
	DUMMYGRA	Kategorik	3062	0.15	0.36
	PARENTOC	Kategorik	3062	0.96	0.20
	GRADE7	Kategorik	3062	0.46	0.50
	GRADE8	Kategorik	3062	0.08	0.27
	SCIENGRA	Sürekli	3062	2.59	1.19
	GENDER	Kategorik	3062	0.49	0.50
	LIKINGSC	Kategorik	3062	0.87	0.34
	DUMMYLIK	Kategorik	3062	0.36	0.48
	READINGB	Kategorik	3062	0.74	0.44
	INTERNET	Kategorik	3062	0.70	0.46
	DOCUMENT	Kategorik	3062	0.79	0.41
	SHARINGI	Sürekli	3062	0.71	0.45
	PERFGOAL	Sürekli	3021	2.70	0.72
	LEARNGOA	Sürekli	3028	3.41	0.54
	SELFEFFI	Sürekli	3024	3.04	0.59
	MEANINGF	Sürekli	3005	3.06	0.53
	ROTELEAR	Sürekli	3000	2.47	0.51
Okul ile ilgili Değişkenler	HIGHINCS	Sürekli	23	24.59	17.26
	LOWINCS	Sürekli	23	28.07	17.32
	FEMALESC	Sürekli	23	79.23	25.16
	ABILITYG	Kategorik	23	0.17	0.39
	PHYSICAL	Sürekli	23	2.85	0.54
	QUALITYE	Sürekli	23	2.98	0.83

Aşamalı Doğrusal Modelleme Sonuçları

Fen başarsı ve sınıf düzeyi bu çalışmadaki rastlantısal olarak değişebilen değişenlerdir. Öğrencilerin fen başarısı ile bilimin değişebilirliği ve deneysel olması arasında anlamlı ve pozitif bir ilişki vardır. Fen başarısı gözlem ve çıkarım alt boyutu ile de pozitif yönde ilişkilidir fakat okullar arasında rastlantısal olarak çeşitlenmemiştir. Yani yüksek fen başarısına sahip olan öğrencilerin bilimin değişebilirliği, deneysel olması ve gözlem ve çıkarım alt boyutuna yönelik algıları daha gelişmiş düzeydedir. Literatürde Yore, Anderson and Shymansky (2002) nin çalışmasının sonuçları bu bulguları destekler yöndedir.

Sınıf düzeyinin de öğrencilerin bilimin doğasına yönelik algıları ile pozitif yönde ilişkilidir. Özellikle 7. Sınıf öğrencilerinin bilimin doğasına tüm alt boyutlarına yönelik algıları 6. Sınıf öğrencilerinin algılarından daha yüksektir. Bu gelişimin nedeni yeni müfredatın etkisi şeklinde açıklanabilir. 8. Sınıfların bilimin değişebilirliği ve deneysel olması yönündeki algıları 6. Sınıf öğrencilerinin algılarından daha yüksektir. Bu sonucun öğrencilerin okulda geçirdikleri zaman ve deneyim den kaynaklandığı düşünülmektedir. Literatür öğrencilerin okulda ne kadar çok vakit geçirirlerse ve deneyim kazanırlarsa, bilimin doğasına yönelik algılarının o kadar geliştiğini desteklemektedir (Kang et al., 2005; Solomon, et al., 1996). Aynı zamanda Stein and McRobbie (1997) ve Huang et al. (2005) sınıf düzeyi arttıkça öğrencilerin bilimin doğasına yönelik algılarının geliştiğini vurgulamıştır. Farklı bir sonuç olarak 8.sınıf öğrencilerinin hayal gücü ve yaratıcılık boyutuna yönelik algıları 6.sınıf öğrencilerininkinden daha düşüktür. Bunun sebebi ise 8. Sınıf öğrencilerinin iyi bir liseye ve üniversiteye gidebilmek için girdikleri sınavlar olarak açıklanabilir. Berberoglu ve Hei (2003) ün çalışmalarında açıkladığı gibi bu sınavlar yapı ve içerik olarak ezberlemeyi gerektirmektir. Bu nedenle 8. Sınıflar zamanlarının çoğunu bu sınavlara çalışmak için bazı kavramları ezberleyerek öğrenme yönelimindedirler. Bu çalışma alışkanlığı bilimin doğasının bu alt boyutuna ait düşüncelerinin diğer sınıf düzeyindeki öğrencilerden daha düşük seviyede olmasına sebep olmuş olabilir.

Fen başarısı ve sınıf düzeyi rastlantısal olarak çeşitlendiği için bu değişkenlerin öğrencilerin bilimin doğasına yönelik algıları ile olan ilişki büyüklüğü okullar arasında değişiklik göstermektedir. Yani öğrenci başarısı ve sınıf düzeyi bazı okullarda diğer okullara nazaran öğrencilerin bilimin doğasına olan algılarıyla daha güçlü düzeyde ilişkilidir. Öğrencilerin bilimin doğasına yönelik algıları yönünden okullar arasındaki farklılıkların sebebi öğrencilerle ve okullarla ilgili çeşitli değişkenler olabilir. Bu çalışmada öğrencilerle ilgili diğer değişkenler rastlantısal olarak değişmedi şeklinde incelenmiştir ve bilimsel bilginin doğasının alt boyutlarıyla ilişkili olan bazı ortak değişkenlerin yanı sıra farklı alt boyutla ilişkili faktörlerde mevcuttur. Çünkü Tsai (2002) ve Huang et al., (2005) öğrencilerin bilimin doğasına yönelik algıları her alt boyut için farklılık gösterebileceğini vurgulamıştır, bu çalışmanın sonuçları da bu bulguyu desteklemektedir. Öğrencilerin algıları bilimin doğasının her boyutu için farklı olacağından ötürü, bu algılar la ilişkili olan faktörler her boyut için farklı olabilir. Her alt boyut ile ilişkili değişkenlerden oluşan modeller tablo 7, 8, 9, 10 da verilmiştir.

Tablo 7. Gözlem ve Çıkarım Altboyutu için Son Model

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Overall mean Observation and Inferences, γ_{00}	1.726	0.028	61.037	0.000
PHYSICAL, γ_{01}	0.143	0.038	3.670	0.002
GRADE7, γ_{10}	0.137	0.041	3.318	0.004
SCIENGRA, γ_{20}	0.034	0.011	3.020	0.003
Random Effect	*Variance Component*	*df*	*Chi-square* χ^2	**p-value**
School mean, u_{0j}	0.00960	21	50.43901	0.000
GRADE7, u_{1j}	0.01974	21	49.61615	0.001
Level-1 Effect, r_{ij}	0.49246			

Tablo 8. Bilimin Değişebilirliği Altboyutu için Son Model

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Overall mean tentative NOS, γ_{00}	1.866	0.037	49.333	0.000
HIGHINCS, γ_{01}	0.005	0.001	4.007	0.001
GRADE7, γ_{10}	0.254	0.023	10.685	0.000
GRADE8, γ_{20}	0.161	0.050	3.213	0.002
SCIENGRA, γ_{30}	0.139	0.016	8.495	0.000
HIGHINCS, γ_{31}	0.002	0.001	2.699	0.014
GENDER, γ_{40}	-0.054	0.022	-2.369	0.018
INCOMEHI, γ_{50}	0.106	0.029	3.606	0.001
DUMMYCOL, γ_{60}	0.129	0.026	4.797	0.000
DUMMYGRA, γ_{70}	0.112	0.036	3.071	0.003
DOCUMENT, γ_{80}	0.104	0.027	3.770	0.000
PERFGOAL, γ_{90}	-0.057	0.016	-3.515	0.001
SELFEFFI, γ_{100}	0.085	0.021	4.032	0.000
ROTELEAR, γ_{110}	-0.191	0.024	-7.914	0.000
Random Effect	*Variance Component*	*df*	*Chi-square* χ^2	**p-value**
School mean, u_{0j}	0.00767	21	67.32578	0.000
SCIENGRA, u_{3j}	0.00239	21	41.73255	0.005
Level-1 Effect, r_{ij}	0.36403			

Tablo 9. Hayalgücü ve Yaratıcılık Altboyutu için Son Model

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Overall mean Imagination and Creativity[1], γ_{00}	2.248	0.017	126.008	0.000
QUALITYE, γ_{01}	0.068	0.022	3.062	0.006
GRADE8, γ_{10}	-0.127	0.042	-3.010	0.003
SELFEFFI, γ_{20}	0.095	0.019	4.785	0.000
MEANINGF, γ_{30}	0.055	0.021	2.563	0.011
ROTELEAR, γ_{40}	-0.075	0.016	-3.584	0.001
Random Effect	*Variance Component*	*df*	*Chi-square* χ^2	**p-value**
School mean, u_{0j}	0.00390	21	53.63255	0.000
Level-1 Effect, r_{ij}	0.29903			

Tablo 10. Bilimin Deneysel Olması Altboyutu için Son Model

Fixed Effect	*Coefficient*	*Standard Error*	*t-ratio*	**p-value**
Overall mean Empirical NOS[1], γ_{00}	2.481	0.017	142.000	0.000
LOWINCSC, γ_{01}	-0.003	0.000	-3.445	0.003
FEMALESC, γ_{02}	0.001	0.000	2.356	0.029
GRADE7, γ_{10}	0.104	0.016	6.320	0.000
GRADE8, γ_{20}	0.100	0.033	2.959	0.004
SCIENGRA, γ_{30}	0.052	0.010	5.078	0.000
LOWINCSC, γ_{31}	-0.001	0.000	-2.638	0.016
DUMMYCOL, γ_{40}	0.074	0.018	4.033	0.000
DUMMYGRA, γ_{50}	0.086	0.024	3.503	0.001
LEARNGOA, γ_{60}	0.112	0.018	6.130	0.000
SELFEFFI, γ_{70}	0.064	0.016	4.003	0.000
MEANINGF, γ_{80}	0.091	0.019	4.658	0.000
ROTELEAR, γ_{90}	-0.077	0.016	-4.722	0.000
Random Effect	*Variance Component*	*df*	*Chi-square* χ^2	**p-value**
School mean, u_{0j}	0.00190	20	46.30597	0.001
SCIENGRA, u_{3j}	0.00078	21	40.70894	0.009
Level-1 Effect, r_{ij}	0.17910			

Modellerden görüldüğü gibi cinsiyet farklılığı sadece bilimin değişebilirliği alt boyutunda kızlar lehine çıkmıştır. Bu sonuç Huang, et al., (2005) in çalışmasıyla ters düşmektedir. Bilimin doğasının diğer alt boyutları cinsiyet farklılığı göstermemektedir. Öğrencilerin özgeçmişi ile ilgili değişkenler yönünden incelendiğinde yüksek gelir düzeyi ile bilimin doğasının değişebilirliğine yönelik algıları arasında pozitif bir ilişki vardır. Bu durum Türkiye deki sosyoekonomik durumu düşündüğümüzde ekonomik yönden ailesi iyi durumda olan çocuklar okuldaki eğitimlerinin yanı sıra aldıkları özel dersler, evde sahip oldukları olanaklar (bilgisayar, kitap, dergi) ve rahat öğrenme ortamlarının olmasından dolayı daha başarılı olma ihtimalleri çok yüksektir. Bunun yanı sıra ailelerin eğitim düzeyi öğrencilerin bilimin doğasına yönelik algılarıyla pozitif bir şekilde ilişkilidir. Ailelerin üniversite veya üniversite üzeri eğitim yapmaları öğrencilerin bilimin değişebilirliği ve deneysel olmasına yönelik algılarıyla pozitif yönde ilişkilidir. Belirli bir eğitim düzeyine sahip olan anne babalar, çocuklarının karşılaşacakları sorunları yakından bildikleri ve onlara bu süreçte gereken desteği zamanında verebildikleri için çocuklarının başarısını olumlu yönde etkilemektedirler. Hortaşsu (1995) annelerin eğitim seviyesinin öğrencilerin akademik başarısını pozitif yönde etkilediğini gösteren çalışmasında bu durumu Türkiye deki annelerin çocuklarına daha fazla zaman ayırdıkları ve onların ödevleri ile daha çok ilgilendikleri şeklinde açıklamıştır. Hacieminoglu, et al., (2009) ise yaptığı benzer çalışmada bu durumun son son 10 yıllık süre içerisinde babaların da çocuklarının kaliteli bir eğitim sürecinden geçmelerine önem verdiklerini ortaya çıkarmıştır. Anne babanın eğitim durumunun çocukların öğrenme yaklaşımlarında da önemli rol oynadığı bulunmuştur. Bu bulguda daha önceki bulgularla benzerlik göstermektedir (Ercikan, McCreith, & Lapointe, 2005; Zhang, 2000). Eğitimli anne babalar çocuklarının anlamlı öğrenmesini de daha çok teşvik etmektedirler. Bu nedenle ailelerin eğitim düzeyi yükseldikçe, çocuklarının akademik gelişimi için gösterdikleri çabalar daha etkili olmaktadır ve böylece öğrencilerin bilimin doğasına yönelik algıları gelişmektedir. Öğrencilerin belgesel izlemeleri onların bilimin değişebilirliğine yönelik algıları ile pozitif yönde ilişkili olan değişkenlerden birisidir. Dhingra (2003) çalışmasında bu bulguyu televizyon izlemenin kavramların belirgin bir şekilde öğretilmesine "*explicit teaching*" benzediğini belirterek desteklemiştir.

Öğrencilerim bilimin doğasına yönelik algıları ile ilişkili olan diğer değişkenler ise performansa yönelik motivasyon, öğrenmeye yönelik motivasyon, öz yeterlik, ezberleyerek öğrenme ve anlamlandırarak öğrenme ve motivasyonla ilgili değişkenlerdir. Bu değişkenlerden öğrencilerin öz yeterliklerinin gözlem ve çıkarım alt boyutu dışındaki tüm boyutlardaki bilimin doğasına yönelik algıları arasında pozitif bir ilişki vardır. Diğer taraftan öğrencilerin bu üç alt boyuta yönelik algıları ile ezberleyerek öğrenmeleri arasında negatif bir ilişki mevcutken, hayal gücü ve yaratıcılık alt boyutu ve bilimin deneysel olması alt boyutu öğrencilerin anlamlandırarak öğrenmesi arasında pozitif bir ilişki vardır. Performansa yönelik motivasyon, öğrencilerin bilimin değişebilirliğine yönelik algıları ile negatif yönde ilişkili iken, öğrenmeye yönelik motivasyon öğrencilerin bilimin deneysel olması ile ilgili algıları ile pozitif yönde ilişkilidir. Cavallo et al., (2003); Cavallo et al., (2004); Hacieminoglu, et al., (2009) ve Kizilgunes, et al., (2009) bu sonuçlara benzer ve destekleyici sonuçlar ortaya koymuştur. Benzer bir şekilde Kizilgunes et al. (2009) performansa yönelik motivasyon ile bilimin değişebilirliği arasında negatif bir ilişki ortaya koyarken, bizim bulgularımızın tam tersine öz yeterlik ile bilimin değişebilir olması arasında negatif bir ilişki ortaya koymuştur. Literatürde bir çok çalışma akademik başarının öğrencinin öz yeterliği ile pozitif yönde ilişkili olduğunu ortaya koymuştur. Akademik başarısı yüksek öğrenciler ezberleyerek öğrenmekten öte, anlamlandırarak öğrenmeyi tercih etmektedirler. Performansa yönelik motivasyona sahip öğrencilerin akademik başarıları daha düşük ve bilimin doğasına yönelik algılarının daha düşük düzeydedir. Hacieminoglu, et al., (2009) öğrencilerin başarılarının artması için onları anlamlandırarak öğrenme yaklaşımını kullanmaya teşvik edilmesi gerektiğini önermektedir. Anlamlandırarak öğrenme yaklaşımı öğrencilerin öz yeterliklerinin gelişmesine ve bilimin doğasına yönelik anlayışlarını geliştirmelerine yol açabilir.

Okulla ilgili değişkenler söz konusu olunca, sonuçlar okulların yüksek sosyoekonomik statüye sahip olması ile öğrencilerin bilimin değişebilirliğine yönelik algısı arasında pozitif yönde bir ilişki gösterirken, okulların düşük sosyoekonomik statüye sahip olması ile öğrencilerin bilimin deneysel olmasına yönelik algıları arasında negatif bir ilişki ortaya koymuştur. Bunun nedeni yüksek gelirli okullarda eğitsel fırsatların, sosyal aktivite çeşitlerinin (fen kulubü, bilim şenlikleri, fen yarışmaları) daha fazla olması şeklinde açıklanabilir. Bunun yanısıra fen başarısı değişkeni yüksek seviyedeki sosyoekonomik statü ile bilimin değişebilirliği yönünden pozitif bir şekilde etkileşime girmiştir. Sosyoekonomik düzeyi yüksek bir okulda fen başarısının bilimin doğası ile olan ilişkisi sosyoekonomik düzeyi düşük bir okulda aynı düzyde olan en başarısının bilimin doğası ile olan ilişkisinden daha güçlü olduğunu göstermektedir. Aynı şekilde fen başarısı değişkeni düşük seviyedeki sosyoekonomik statü ile bilimin deneysel olması yönünden negatif bir şekilde etkileşime girmiştir. Sosyoekonomik düzeyi düşük bir okulda fen başarısının bilimin deneysel olması ile olan ilişkisi sosyoekonomik düzeyi yüksek bir okulda aynı düzyde olan en başarısının bilimin deneysel olması ile olan ilişkisinden daha zayıf olduğunu göstermektedir. Diğer değişkenler arasında öğrencilerin bilimin deneysel olmasına yönelik algıları ile bayan okuldaki bayan fen öğretmeni oranı arasında pozitif bir ilişki vardır. Diğer bir faktör olan okulun eğitsel kaynalarının kalitesi öğrencilerin hayal gücü ve yaratıcılıklarına yönelik algılarıyla pozitif bir ilişki göstermektedir. Okuldaki eğitsel materyaller, fen labaratuarı materyalleri, sınıfta bilgisayarın kullanılması, kütüphane materyallerinin zenginliği ve görsel-işitsel eğitsel kaynaklar gibi kaynakların kalitesi arttıkça öğrencilerin bilimin doğasının hayalgücü ve yaratıcılık alt boyutuna yönelik algıları gelişme göstermektedir. Bir diğer okul ile igili değişken olan okulun fiziksel alt yapısı ile ilgili özellikler (okulun eğitim için kullanılabiecek boş alanları, okulun yapısı, ısıtma, soğuyma ve aydınlatma sistemi gibi özellikler) öğrencilerin gözlem ve çıkarım alt boutuna yönelik algılarını pozitif yönde etkilemektedir.

Öneriler ve Sınırlılıklar

Öğrencilerde fen okuryazarlığının gelişmesinde bilimin doğasına yönelik algılarının gelişmesi son derece önemlidir. Bu çalışma ise öğrencilerin bilimin doğasına yönelik algılarının erken yaşlarda gelişmesi gerektiğinin önemini vurgulamıştır. Öncelikle öğretmen adayları ve öğretmenler in bu konuda ve bilimin doğasına yönelik algılarını etkileyen değişkenler konusunda farkındalıkları arttırılmalıdır. Sonraki aşamada okul müdürleri ve öğretmenler aileleri bu konularda ve çocuklarına ne şekilde daha etkili yardımcı olabilecekleri konusunda bilgilendirmelidir. Bunların yanı sıra bu çalışma ailelerin eğitim seviyeleri ve gelir düzeyleri ile öğrencilerin bilimin doğasına yönelik algıları arasında anlamlı bir ilişki olduğunu ortaya koymuştur. Bu sonuç bireysel farklılıkların önemine dikkat çekmektedir. Bu farklılıkları ortadan kaldırmak için okullarda gelir seviyesi düşük öğrencilere ücretsiz kurslar ve ders materyalleri sağlanmalı. Sınıftaki etkinlikler yönünden ise öğretmenler görsel ve işitsel kaynakların kullanımına önem vermeli, sınıfa konu ile ilgili belgesellerin getirip öğrencilere izletilmeli. Öğrencileri anlamlı öğrenme yaklaşımına yöneltmeli, onları ezberleyerek öğrenme yolundan uzaklaştırmalı. Bu nedenle öğretmenin performans tabanlı değerlendirme yaklaşımlarını tercih etmeli ve öğrencilere düşünme yeteneklerini geliştirecek nitelikte sorular sormalılar. Öğretmen sınıfta not konusunda vurgu yapmamalıdır, öğrencinin öğrenmeye yönelik motivasyonunu arttırmalıdır, onları performansa yönelik motivasyondan uzaklaştırmalıdır. Öğrencilerin öz-yeterlikleri onların bilimin doğasına yönelik algılarını gelişmesinde önemli bir rol oynamaktadır. Bu nedenle öğretmenler her öğrenciye onların düzeylerine göre cevaplayabileceği şekilde sorular sorarak onları pozitif yönde güdülendirmelidir. Bunun yanı sıra öğretmenler cinsiyet ayrımcılığından kaçınmalıdır, cinsiyet farkını gözetmeksizin her öğrenciye görevler vermelidir. Öğrencilerin bilimin doğasına yönelik algıları bakımından okullar arasındaki farklılıkların sebebi dikkate alınmalıdır ve okullar arasındaki eşit şartların sağlanması için gerekli düzenlemeler yapılmalıdır. Eğitsel kaynakların kalitesi, okulun fiziksel alt yapısı öğrencilerin öğrenmelerini pozitif yönde etkileyecek şekilde düzenlenmeli. Okul müdürleri ders ile ilgili materyal, laboratuar malzemeleri, görsel işitsel kaynaklar, bilgisayar, kütüphane materyalleri gibi kaynaklarla ilgili eksikleri ilgili yerlere bildirmelidirler. Öğretmenler laboratuarlar ları etkili bir şekilde kullanmalıdırlar. Bu konuların önemi öğretmen ve öğretmen adaylarının eğitimlerinde vurgulanmalıdır.

Son olarak çalışmanın bazı sınırlılıklarından değinmek gerekmektedir. Bu çalışma örneklemi Çankaya bölgesinden seçilmiş devlet okullarındaki 6. 7 ve 8. Sınıf öğrencileri ile sınırlıdır. Sonuçlar farklı ortam ve kültürlerde farklı olabilir. Bu nedenle araştırmacılar çalışmanın sonuçlarını genellerken doğru genellemeler yapmalıdırlar. Sonuçları güvenli bir şekilde genelleyebilmek için aynı çalışma başka şehirlerde, bölgelerdeki, özel ve devlet okullarında tekrar yapılabilir. Aşamalı doğrusal modelleme yönteminde, yapısal eşitlik modelindeki gibi model belirlenemememektedir. Çünkü yapısal eşitlik modeli iki yönlü ilişkileri vermediği için çalışmada elde edilen ilişkilerin nedenlerini belirleyebilmek için daha derinlemesine analizler yapılmalıdır. Çalışmanın sonucunda okul ve öğrenciler ile ilgili değişkenler öğrencilerin bilimin doğasına yönelik algılarındaki çeşitliliğin bir kısmını açıklasa da, hala açıklanamayan kısmı da vardır. Bu sonuç okullar arasındaki farkı açıklayan başka etmenler de olabileceğini göstermektedir. Sınıftaki aktiviteler, öğretmenin öğretim yöntemi gibi sınıf ile ilgili değişkenlerin ilişkisi ileriki çalışmalarda araştırılabilir.