THE IMPACT OF SCHOOL AND STUDENT RELATED FACTORS ON SCIENTIFIC LITERACY SKILLS IN THE PROGRAMME FOR INTERNATIONAL STUDENT ASSESSMENT-PISA 2006

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ABSTRACT

THE IMPACT OF SCHOOL AND STUDENT RELATED FACTORS ON SCIENTIFIC LITERACY SKILLS IN THE PROGRAMME FOR INTERNATIONAL STUDENT ASSESSMENT-PISA 2006

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The purpose of the study was to examine the impact of school and student related factors on scientific literacy skills of Turkish students in the Programme for International Student Assessment – PISA 2006. 4942, 15 year-old Turkish students from 10 primary schools, 88 general high schools and 66 vocational high schools participated in this assessment.

Among the student factors considered were gender, student background, motivational factors, science self belief, value belief regarding science, science-related careers, science teaching and learning, scientific literacy and the environment. Some of the school factors discussed were proportions of girls at school, school size, school academic selectivity, teacher-student ratio, school activities for learning environmental topics and learning of science, quality of educational resources, teacher shortage (negative scale), general high school – vocational high school and average class size.

The responses of Turkish students and principals from the database of the PISA assessment were used in Hierarchical Linear Modeling (HLM). The result of the study showed that the impact of school and student related factors on scientific literacy skills of the Turkish students varied from school to school. It was observed that the PISA index of economic social and cultural status, general value of science and science self-efficacy impacted on every aspects of the scientific literacy. In addition, it is evident that the general high school students were more successful than the vocational high school students after adjusting for selected student and school characteristics.

Key Words: Programme for International Student Assessment (PISA 2006), Hierarchical Linear Modeling (HLM), Scientific Literacy Skills, Science and Turkey.

ÖZ

ULUSLARARASI ÖĞRENCİ DEĞERLENDİRME PROGRAMI – PISA 2006'DA OKUL VE ÖĞRENCİ İLE İLGİLİ ETKENLERİN FEN OKURYAZARLIK BECERİLERİ ÜZERİNDEKİ ETKİSİ

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Bu çalışmanın amacı, Uluslararası Öğrenci Değerlendirme Programı – PISA 2006'da okul ve öğrenci ile ilgili etkenlerin Türk öğrencilerin fen okuryazarlığı becerileri üzerindeki etkisinin incelenmesidir. PISA 2006 değerlendirmesine katılan 4942 tane 15 yaş grubu Türk öğrenci, 10 ilköğretim okulu, 88 genel lise programı ve 66 meslek lisesi programına devam etmektedir.

Dikkate alınan etkenlerden öğrenci ile ilgili olanlar: cinsiyet, öğrenci altyapısı, motivasyonla ilgili etkenler, öğrencinin kendine inancı, fen bilimlerine verdiği değer, fen ile ilgili meslekler hakkında bilgisi, fen öğretimi ve öğrenimi, fen okuryazarlığı ve çevre bilincidir. Okul ile ilgili olarak ele alınan etkenlerden bazıları: okuldaki kız öğrenci oranı, okul mevcudu, okulun akademik seçiciliği, öğretmen-öğrenci oranı, çevre ile ilgili konuları öğrenmede ve fen öğreniminde okul etkinlikleri, eğitim

kaynaklarının niteliği, öğretmen eksikliği (ters ölçek), genel lise – meslek lisesi ve ortalama sınıf mevcududur.

Hiyerarşik Lineer Modelleme (HLM)'de Uluslararası Öğrenci Değerlendirme Programı veri tabanındaki Türk öğrencilerin ve okul yöneticilerinin yanıtları kullanılmıştır. Çalışmanın sonucu okul ve öğrenci ile ilgili etkenlerin, Türk öğrencilerin fen okuryazarlığı becerileri üzerindeki etkisinin okuldan okula değişkenlik gösterdiğini ortaya koymuştur. PISA ekonomik sosyal ve kültürel statü indeksi, fen bilimlerine verilen genel değer ve fen bilimleri öz yeterliği, fen okuryazarlığı ile ilgili tüm bakış açılarını etkilediği gözlenmiştir. Ayrıca, seçilen öğrenci ve okul özellikleri düzeltildikten sonra genel lise programına devam eden öğrencilerin meslek liselerine devam eden öğrencilerden daha başarılı olduğu açıkça görülmektedir.

Anahtar Kelimeler: Uluslararası Öğrenci Değerlendirme Programı (PISA 2006), Hiyerarşik Lineer Modelleme (HLM), Fen Okuryazarlık Becerileri, Fen Bilimleri ve Türkiye.

To My Parents

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LIST OF ABBREVIATION

OECD	Organization for Economic Co-operation and Development
PISA	Programme for International Student Assessment
Level-1	Student Level
Level-2	School Level
ENVAWARE	Awareness of environmental issues ,
CARPREP	School preparation for science-related careers,
INSTSCIE	Instrumental motivation in science,
RATCOMP	Ratio of computers to school size,
SCHANDS	Science Teaching - Hands-on activities,
SCIEACT	Science activities,
URBAN	Urban-rural high school,
CARINFO	Student information on science-related careers,
CLASIZ	Class size,
CULTPOSS	Cultural possessions at home ,
DIL	Language at home,
ENVLEARN	School activities for learning environmental topics,
ENVOPT	Environmental optimism,
ENVPERC	Perception of environmental issues,
ERDD	Educational Research and Development Directorate
ESCS	Index of economic, social and cultural status ,
ESCSMEAN	Mean of index of economic, social and cultural status ,
GENDER	Gender,
GENSCIE	General value of science,
HEDRES	Home educational resources,
HOMEPOSS	Index of home possessions,
INTSCIE	General interest in learning science,
JOYSCIE	Enjoyment of science,

KAYNAK	Resources
MONE	Ministry of National Education
PCGIRL	Proportion of girls at school,
PERSCIE	Personal value of science,
RESPCURR	Responsibility for curriculum & assessment - School: Central Authority,
RESPDEV	Responsibility for sustainable development,
RESPRES	Responsibility for resource allocation - School: Central Authority,
SCAPPLY	Science Teaching -Focus on applications or models,
SCHSIZE	School size,
SCIEEFF	Science self-efficacy,
SCIEFUT	Future-oriented science motivation,
SCINTACT	Science Teaching – Interaction,
SCINVEST	Science Teaching - Student investigations,
SCIPROM	School activities to promote the learning of science,
SCMATEDU	Quality of educational resources,
SCSCIE	Science self-concept,
SELECT	School academic selectivity recoded,
STRATIO	Teacher-student ratio,
TCSHORT	Teacher shortage (negative scale)
VOCATION	Vocational-general high school,
WEALTH	Family wealth,

CHAPTER 1

INTRODUCTION

Quality of the education is the most valuable asset for the generations and countries. To achieve quality education, strong commitment from everyone, including governments, teachers, parents and students themselves is required (Gurria, OECD 2006).

The quality of education and training is considered to be of concern the highest political priority in most of the countries. High level of knowledge, competencies and skills are considered to be the basic conditions for active citizenship, employment and social cohesion. In this context, knowing our students' characteristics and our schools' characteristics with respect to other countries and monitoring student performance at national level are important means of shaping one's future as a professional. For this purpose countries need comprehensive assessment programs for the educational practices in order to make education-policy decisions for better outputs in line with the indicators related to school and students characteristics. PISA plays an important role in this respect all over the world because of its comprehensive data set that could provide information for the educational policy makers.

Thus, the goal of the study was to analyze the impacts of students and schools characteristics on students' scientific literacy skills in Turkey. The Organization for Economic Co-operation and Development (OECD)'s Programme for International Students Assessment (PISA) 2006 scientific literacy scores, selected characteristics of students and schools were taken into account in the analyses.

1.1 Organization for Economic Co-operation and Development (OECD) and Programme for International Students Assessment (PISA)

OECD was founded in 1961 to build strong economies in its member countries, improve efficiency, hone market systems, expand free trade and contribute to development in industrialized as well as developing countries. Twenty countries originally signed the Convention on the OECD on 14 December 1960; Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxemburg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. Since then a further ten countries have become members of the organization; Australia, Czech Republic, Finland, Japan, Korea, Mexico, New Zealand, Poland and Slovak Republic.

OECD works on many global issues in the areas concerning; economy, society, governance, finance, innovation and sustainability. The issues are competition, development, economics and growth, enterprise, industry and services, rural and urban development, trade, migration, health, social and welfare issues, employment, education, corporate governance, fighting corruptions, public governance and management, regulatory reform, financial markets, insurance and pensions, investment, tax, science and innovation, information and communication technologies, biotechnology, energy, environment, agriculture and fisheries, and sustainable development (OECD, 2008).

As regards to education, OECD works on many hot topics in education such as preschool and school, higher education and adult learning, human capital etc. One of the international projects of OECD is the Programme for International Student assessment (PISA).

PISA is an internationally standardized assessment that is developed together with participating countries and administered to 15-year-old individuals who are enrolled in schools. It represents a commitment by the governments of OECD Member

countries to monitor the outcomes of education systems in terms of student achievement. The aim of the PISA is to assess how far students have acquired some of the knowledge and skills that are essential for full participation in society.
It targets to answer the following questions:

i) How well are young adults prepared to meet the challenges of the future?
ii) Are they able to analyze reason and communicate their ideas effectively?
iii) Do they have the capacity to continue learning throughout life?
iv) Are some kinds of teaching and school organization more effective than others?

PISA examines the performance of students in reading literacy, mathematic literacy and science literacy and also looks at a wider range of educational outcomes that include students' motivation to learn, their beliefs about themselves and their learning strategies. It also provides insights into the factors that influence the development of skills and attitudes at home and at school, and examines how these factors interact and what the implications are for policy development (PISA, 2006).
15-year-old students are the population of PISA. National random samples of at least 4500 15-year-old students are chosen from 150 or more schools in each country to participate in the assessment. Each PISA focused on a particular subject area: reading literacy (in 2000), mathematics literacy (in 2003) and science literacy (in 2006) in the first set of the survey. The Programme for International Students Assessment will conduct second set of surveys in 2009, 2012 and 2015.

1.2 Concept of Literacy and Domains in PISA

The traditional definition of literacy is considered to be the ability to read and write, or the ability to use language to read, write, listen, and speak. In modern contexts, the word refers to reading and writing at a level adequate for communication, or at a level that lets one understand and communicate ideas in a literate society, so as to take part in that society. The United Nations Educational, Scientific and Cultural

Organization (UNESCO) has drafted the following definition during an international expert meeting in June 2003:

> Literacy is the ability to identify, understand, interpret, create, communicate and compute, using printed and written materials associated with varying contexts. Literacy involves a continuum of learning in enabling individuals to achieve their goals, to develop their knowledge and potential, and to participate fully in their community and wider society (UNESCO, 2004, p. 13).

Definition of literacy in PISA is a more explicit focus on the knowledge, understanding and skills required for effective functioning in everyday life. Literacy requires body of basic knowledge and skill to participate the society effectively. PISA assesses the literacy in three domains: reading literacy, mathematic literacy and scientific literacy.

Reading literacy is based on the ability to decode text, to interpret meanings of words and grammatical structures, and to construct meaning at least at a superficial level. It is also based on the ability to read between the lines and to reflect on the purposes and intended audiences of texts, to recognize devices used by writers to convey messages and influence readers, and the ability to interpret meaning from the structures and features of texts. Reading literacy requires an ability to understand and interpret a wide variety of text types, and to make sense of text by relating them to the context in which they appear (OECD publications, 2000).

Mathematic literacy is based on familiarity with a body of mathematical knowledge and skills, which includes basic rules, number facts and operations; working with money; fundamental ideas about space and shape, including working with measurements; notions of uncertainty, growth and change. It is also based on ability to think and work mathematically, including modeling and problem solving. These competencies include knowing the extend and limits of mathematical concepts; following and evaluating mathematical arguments; posing mathematical problems; choosing ways of representing mathematical situations; and expressing oneself on matters with a mathematical content. Mathematical literacy requires an ability to apply this knowledge, this understanding and these skills in a wide variety of personal, social and work contexts (OECD, 2000).

Scientific literacy is based on familiarity with a body of mathematical knowledge and skills. Knowledge of science includes an understanding of fundamental scientific concepts such as food chains, sustainability, energy conservation, photosynthesis, rates of reactions, adaptation, states of matter, and inheritance. It is also based on ability to use processes of scientific enquiry such as recognizing the nature limits of such enquiry; identifying evidence required to answer scientific questions; and drawing, evaluating and communicating conclusions. Scientific literacy requires ability to apply this knowledge, this understanding and these skills in a wide variety of personal, social and work contexts (OECD publications, 2000). In this context, the definitions of the mathematical literacy, reading literacy and scientific literacy of PISA 2006 are explained in the PISA 2006 Assessment Framework as following:

> *Reading Literacy:* An individual's capacity to understand, use and reflect on written texts, in order to achieve one's goals, to develop one's knowledge and potential and to participate in society.
>
> *Mathematical Literacy:* An individual's capacity to identify and understand the role that that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen.
>
> *Scientific Literacy:* An individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science related issues, understanding of the characteristics features of science as a form of human knowledge and enquiry, awareness of how science and technology shape our material, intellectual, and cultural environments, and willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen (OECD,2006, p. 12).

1.3 Implementing the PISA

PISA is a collaborative effort. The OECD Secretariat has overall responsibility for managing the Programme for International Student Assessment. The PISA

Governing Board on which each country is represented determines the policy priorities and standards for developing indicator, for establishing assessment instruments and for reporting results.

Participating countries implement PISA through National Project Managers (NPM). NPM's played a vital role in developing validating the international assessment instruments and contributed to the verification and evaluation of the survey results, analysis and reports.

The design and implementation of PISA 2006 was the responsibility of an international consortium led by the Australian Council for Educational research (ACER). The other partners were the National Institute for Educational Measurement (CITO) in the Netherlands, Westat Inc. in the United States and the National Institute for Educational Research (NIER) in Japan. In Turkey, the Ministry of National Education (MONE) - Educational Development and Research Directorate (ERDD), implements PISA. The Turkish 15 year-old student population of 665 477 is represented by the sample of 4942 students in PISA 2006.

The science proficiency levels in PISA 2006 are defined for the purpose of describing what science competencies students obtaining scores at each level demonstrate. Scores in science are grouped into six proficiency levels (Level 6 representing the highest scores hence the most difficult tasks and Level 1 the lowest scores hence the easiest tasks). The grouping into proficiency levels was undertaken on the basis of substantive considerations relating to the nature of the underlying competencies (OECD, 2007). The further details about science proficiency levels can be found in PISA 2006: Science Competencies for Tomorrow's World. In PISA 2006, Turkish students performed significantly below the OECD average on all measures, and second to last OECD countries (Mexico consistently was the lowest performing country). In science, Turkey scored 424 compared to the OECD average of 500. As seen in Figure 1.1., 12.9% of the students were not proficient at level one, the lowest of the six level of the science proficiency and there is no students at level six, the highest of the six level of the science proficiency In mathematics, Turkey 424 scored compared to the OECD average of 500. Approximately one-forth of the students were not proficient at level one in mathematics and 2% of the students were at level six, the highest of the six level of the mathematics proficiency. In reading, Turkey scored 447 compared to the OECD average of 500. Level five is the highest level of the reading proficiency. 2.5% of the students were at level five, the highest of the five level of the reading proficiency.

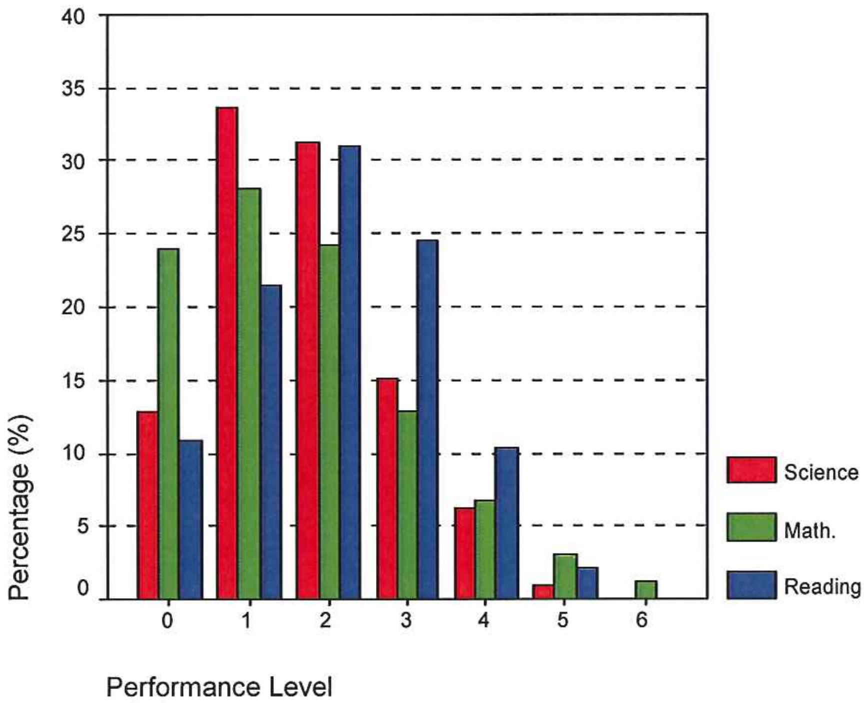


Figure 1.1. Distribution of the students to the six level of the science proficiency, the six level of the mathematics proficiency and the five level of the reading proficiency

The scientific literacy skills of the students are going to be given in terms science score (combined science) science competencies scores (i. identifying scientific issue, ii. explain phenomena scientifically and iii. using scientific evidence) and science attitudes (i. interest in learning science and support for scientific enquiry) through the thesis.

Table 1.1.

Performance of Students at Each Proficiency Level on the Combined Science Scale Identifying Scientific Issue Scale, Explain Phenomena Scientifically Scale and Using Scientific Evidence Scale.

		Average Score	Below Level 1	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
			% (se)	% (se)	% (se)	% (se)	% (se)	% (se)	% (se)
Science	Turkey	**424**	12,9 (0.8)	33,7 (1.3)	31,3 (1.4)	15,1 (1.1)	6,2 (1.2)	0,9 (0.3)	0,0 (a)
	OECD average	**500**	5,2 (0.1)	14,1 (0.1)	24,0 (0.2)	27,4 (0.2)	20,3 (0.2)	7,7 (0.1)	1,3 (0.0)
Identifying Scientific Issues	Turkey	**427**	11,2 (0.9)	31,2 (1.2)	34,2 (1.3)	18,1 (1.2)	4,9 (0.9)	0,5 (0.2)	a (a)
	OECD average	**499**	5,2 (0.1)	13,5 (0.1)	24,6 (0.2)	28,3 (0.2)	20,0 (0.1)	7,1 (0.1)	1,3 (0.0)
Explain Phenomena Scientifically	Turkey	**423**	14,3 (0.9)	33,4 (1.2)	29,8 (1.3)	14,9 (1.0)	6,1 (1.1)	1,4 (0.5)	0,1 (0.0)
	OECD average	**500**	5,4 (0.1)	14,2 (0.1)	24,0 (0.2)	27,0 (0.2)	19,7 (0.2)	8,0 (0.1)	1,7 (0.0)
Using Scientific Evidence	Turkey	**417**	19,1 (1.1)	30,3 (1.4)	27,0 (1.3)	15,2 (1.0)	6,8 (1.0)	1,6 (0.5)	0,1 (0.1)
	OECD average	**499**	7,9 (0.1)	14,1 (0.1)	21,7 (0.2)	24,7 (0.2)	19,8 (0.2)	9,4 (0.1)	2,4 (0.1)

a :The category does not apply in the country concerned. Data are therefore missing.

OECD average: OECD average takes the OECD countries as a single entity to which each country contributes with equal weight.

The distributions of Turkish and OECD countries' students combined science and science competencies are displayed in Table 1.1. 75% of Turkish students were generally under the level three in combined science and science competencies.

1.4 Purpose of the Study

The aim of the present study is to examine the mean difference in PISA 2006 combined science, science competencies and science attitudes scores among Turkish high schools when selected characteristics of students and schools were taken into account. The student level factors were student information on science-related careers, school preparation for science-related careers, cultural possessions at home, awareness of environmental issues, environmental optimism, perception of environmental issues, index of economic, social and cultural status , general value of science, home educational resources, index of home possessions, instrumental motivation in science, general interest in learning science, enjoyment of science, personal value of science, responsibility for sustainable development, science teaching -focus on applications or models, science teaching - hands-on activities, science activities, science self-efficacy, future-oriented science motivation, science teaching - student investigations, science self-concept, family wealth, language at home, vocational school and gender. The school level factors were proportion of girls at school, ratio of computers to school size, school size, school academic selectivity recoded, teacher-student ratio, school activities for learning environmental topics, responsibility for resource allocation - school: central authority, responsibility for curriculum and assessment - school: central authority, school activities to promote the learning of science, quality of educational resources, teacher shortage (negative scale), mean of index of economic, social and cultural status, vocational-general high school, class size, funding government and urban-rural high school.

In line with the purpose, the following questions were analyzed by using hierarchical linear modeling. Each question was analyzed for science knowledge, science competencies and science attitudes separately.

i) How much do Turkish high schools vary in their mean science literacy scores?
ii) Which schools characteristics are significantly related to Turkish high schools mean science literacy scores?
iii) How do vocational high schools and general high schools compare in terms of their mean science literacy scores?
iv) How do vocational high schools and general high schools compare in terms of strength of the student characteristics variables and scientific literacy scores relationship after significant school characteristics were controlled?

1.5 Significance of the Study

Nowadays economic, social, scientific and technological developments change our life styles. Globalization, international economic competition, accelerated scientific and technological developments will continue to act on our life in the future. To form high-powered future, countries are conscious of necessity to educate their citizens as science and technology literate persons. Therefore, the elementary and secondary science curricula have been updated since 2004 in Turkey. The vision of the elementary science and technology curricula is to educate all students as science and technology literate persons no matter what their individual differences are. New elementary science curriculum is based on scientific literacy. There are 7 aspects of the new elementary science curriculum. These are: i. nature of science and technology, ii. key science concepts, iii. skills for scientific processes, iv. relationships among science-technology-society-environment, v. scientific and technological psychomotor skills, vi. values which form the core of science, vii. science attitudes and values (MEB-TTK, 2006).

At first, present study is considered to be an initial benchmark to assess the performance of new science curriculum, because it is completely related to scientific literacy skills of Turkish high school students.

The purpose of the secondary education in Turkey is to give the students a minimum common culture, to acquaint them with the problems of the individual and society, to teach how to seek solutions, to raise awareness, to ensure their contribution to the socio-economic and cultural development of the country, and to prepare students for higher education, for professions, for life and for business in line with their interest and skills (OECD, 2007). Defining school and student characteristics which affect students' performance negatively or positively can help to accomplish this purpose of secondary education in Turkey. This study secondly intended to analyze many student and school level characteristics together in terms of students' scientific literacy performance. This approach will answer the question 'Is it school characteristics or student characteristics that are more effective on students' performance?' and contribute to the studies carried out to increase student performance.

Third, the secondary education system in Turkey can be broadly classified as general secondary education on the one hand and vocational and technical secondary education on the other. It will be one of the guiding principles for our education policies to provide solid proof for some issues such as the scientific literacy skill levels of students who are enrolled in different school types, if there is a significant difference among these skill levels, and which school and student characteristics cause this difference if any. This study also discusses the comparisons of Turkish general high schools and vocational high schools in terms of their scientific literacy scores. These schools are compared not only using combined science score of the students, but also using science competencies scores and attitudes scores of the students. In other words, scientific literacy of Turkish students is assessed in a multidimensional way. Consequently, this multidimensional study stands the policy makers in good stead.

Forth, it is important in terms of data which were used. PISA 2006 data were used to analyze mean science literacy in Turkish high schools since PISA study is the most comprehensive educational survey in the world. In order to be able to appreciate the significance of PISA, one needs to examine closely how the study is conducted. Many researchers, experts, administrators, managers and teachers take charge in PISA. The PISA Governing Board (PGB), OECD Secretariat, PISA Consortia, Technical Advisory Group (TAG), Subject Matter Expert Groups (SEG), National Project Managers (NPM) and National Centers (NC) are the groups that carry out the PISA project. Approximately 400,000 students in 43 languages from 57 countries took part in two hours of direct assessment of science, reading and mathematics in PISA 2006 study. 14,000 school principals also responded to a school questionnaire in the study. In Turkey, 4942 students and 160 school principals participated in PISA assessment in May 2006 (OECD, 2007). After preparing international PISA report and releasing the data, researchers conduct advanced analyses (secondary analyses) to bring light on the associations in education and educational policy of the nations. In this context, this study is a secondary analysis of Turkish PISA 2006 data to find the differences among high school types in terms of school and student characteristics. The variance in student performance between schools and within schools on the science scale is high for Turkey in PISA 2006. Therefore, the causes of the variation on the science scale are analyzed in the present study.

Fifth, this study is important in terms of analyses carried out since more complex analysis techniques allow multiple covariates to be statistically controlled within the same analyses. In the analyses, both student and school characteristics were used to predict high schools' mean science literacy. So, more powerful and precise findings are obtained by hierarchical linear modeling.

1.6 Definition of Terms

Combined science score: Science score in PISA 2006 or science achievement in PISA 2006.

Conditional or residual variance-covariance β_{0j}, β_{1j}: The values of the level-2 variances and co-variances after level-2 predictors have been added for β_{0j} and β_{1j}.

Fixed effects: These are defined as being the only levels of a variable in which an experimenter is interested in studying.

Intraclass correlation coefficient: This coefficient measures the proportion of variance in the outcome that is between groups (i.e. the schools).

$\rho = \tau_{00} / (\tau_{00} + \sigma^2)$

Means-as-outcomes regression model: One form of a random-intercept model. It has only one random level-1 coefficient.

One-way random-effects ANOVA model: There are no level-1 and level-2 predictors. The other name is *a fully unconditional model.*

Outcome variable is the level-1 dependent variable

Random-coefficients regression model: All level-1 coefficients are allowed to vary randomly. This model is unconditional at level-2.

Random effects: These are effects that are a subset of the total possible levels of a variable where the experimenter is interested in generalizing the two levels not observed.

Science competencies: The competencies of identifying scientific issue, explaining scientific phenomena and using scientific evidence.

Science knowledge domain: Knowledge about science and knowledge of science.

Unconditional variance-covariance β_{0j}, β_{1j}: The values of the level-2 variances and co-variances based on the random coefficient regression model.

Variable grand-mean centered: Independent variables are centered around a ground mean by subtracting each participant's value on the independent variable from the mean of that variable across the mean of all other participants in the study.

Variable group-mean centered: Independent variables are centered around the mean of their level-2 group.

Variable uncentered: A dummy coded variable.

CHAPTER 2

REVIEW OF THE LITERATURE

This chapter covers the aspects and theoretical basis of scientific literacy, scientific literacy in PISA, the relevant research studies about Programme for International Student Assessment (PISA), the theoretical background of Hierarchical Linear Modeling (HLM) and related studies.

2.1 Scientific Literacy

Chiappetta et al.(2006) defined the science as; it distinguishes itself from other ways of knowing from other domains of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientist strive for the best possible explanations about the natural world.

Science also defined in different sources as the way of coming to understand the world in which we live. The goal of science education is to help students achieve higher levels of scientific knowledge or scientific literacy.

The concept of scientific literacy take into account both the nature of the conceptual and language code essential for science learning and the nature of the social interaction necessary for effective participation in scientific inquiry. These include knowing science, doing science, talking science, and scientific habits of mind (Lee and Fradd, 1998, as cited in Westby et al., 2000). At first, the knowing science requires more than simply knowing vocabulary belonging to science domain. To participate in classroom discourse, students have to acquire an understanding of the materials, activities and concepts they used and observed. Second, the participation in scientific inquiry requires doing science; that is, the students must be able to participate in classroom discussions, science projects, and other class activities. They must be able to engage in a discovery approach in learning, constructing their developing knowledge through experience, class discussions, develop science projects, and contribute to science activities. Third, the participation in scientific inquiry also requires talking science; that is, students must be able to talk in scientifically literate ways. They should verbally mediate the experience by modeling scientific descriptions and explanations. Forth and last the participation in scientific inquiry also requires scientific habits of mind; that is, students' knowing doing, and talking are affected by their attitudes and values about their own abilities and about school and their cultural experiences, or worldview, about how things are done or explained (Westby et al., 2000).

Laugksch (2000) examined the published literature in English on the concept of scientific literacy in the article. The concept of scientific literacy was defined as;

> An internationally well-recognized educational slogan, buzzword, catchphrase and contemporary educational goal. The term is usually regarded as being synonymous with **public understanding of science** and scientific literacy is used in the United States, the former phrase is more commonly used in Britain, with **la culture scientifique** being used in France (p.71).

Laugksch had also examined the development of the concept of scientific literacy in the article. The cited definitions and interpretations of scientific literacy were commonly found in this review. One of the definitions in the article included the seven dimension of the scientific literacy. The dimensions of the scientific literacy were:

i) The scientifically literate person understands the nature of science knowledge.
ii) The scientifically literate person accurately applies appropriate science concepts, principals, laws, and theories in interacting with his universe.
iii) The scientifically literate person uses processes of science in solving problems, making decisions, and furthering his own understanding of the universe.

iv) The scientifically literate person interacts with the various aspects of his universe in a way that is consistent with the values that underlie science.

v) The scientifically literate person understands and appreciates the joint enterprises of science and technology and the interrelationships of these with each and with other aspect of society.

vi) The scientifically literate person has developed a richer, more satisfying, more exiting view of the universe as a result of his science education and continues to extend this education throughout his life.

vii) The scientifically literate person has developed numerous manipulative skills associated with science and technology (Laugksch, 2000 as cited in Pella, p. 77).

The importance of scientific literacy in macro and in micro level has been investigated in this article. The importance of the scientific literacy can be summarized as follows.

> There are three different reasons for advocating scientific literacy in macro level. The most common reason for advocating scientific literacy has to do with the connection between scientific literacy and the economic well-being of a nation. The second argument suggests that higher level of scientific literacy among the populace translate into greater support for science itself. The third way in which science itself may benefit from the promotion of grater scientific literacy is related to the public expectations of science.
> In micro level, the direct benefits of scientific literacy to individuals are discussed, it has been suggested that improved understanding of science and technology is advantageous to anyone living in a science-and-technology-dominant society (Laugksch, 2000, p. 84).

Harlen (2001) discussed the advantage and disadvantage of the term scientific literacy in the article: "the term 'scientific literacy' was already part of the vocabulary for discussing aims of science education; an advantage because there were plenty of starting points; a disadvantage because supporters of various perceptions expected their views to predominate" (p.10).

Hand et al. (2008) have also defined the contemporary science literacy. In their points of view, science literacy involved the abilities and emotional dispositions to construct science understanding, the big ideas of science, and the communications to inform others about these science ideas and to persuade them to take informed actions. Science literacy involved the interdependent dimensions of the nature of science and scientific inquiry, reasoning and epistemological beliefs in the construction, dissemination and application of science knowledge (Hand et al., 2008)

2.2 Scientific Literacy in PISA

Using the term of *science literacy* rather than *science* underlines the importance that the PISA 2006 science assessment places on the application of scientific knowledge in the context of life situation. The functional use of knowledge requires the application the processes that are characteristics of science and scientific enquiry (scientific competency) and is arranged by the individual's appreciation, interest, values and action relative to scientific matters (science attitudes).

The PISA-Science Expert Group (SEG) described the rationale of the scientific literacy roughly as follows

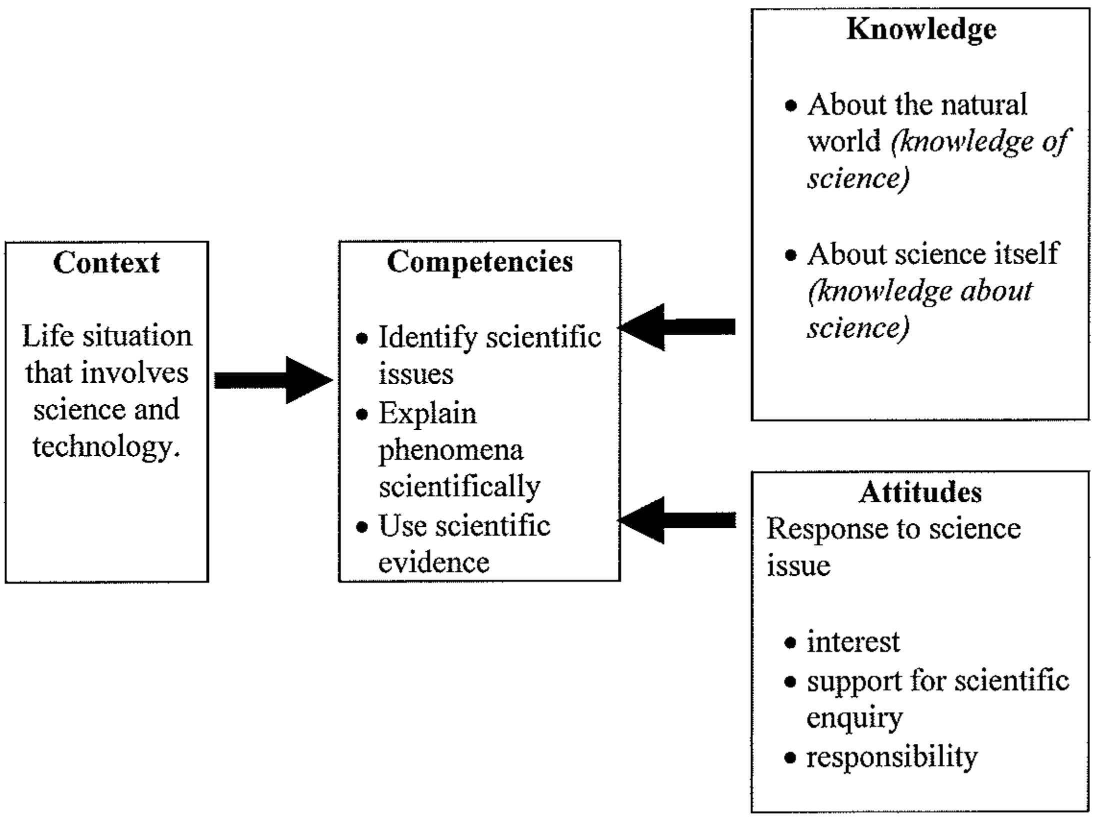
- In relation to the dual processes of science education to produce future scientists and to provide all students with understanding that will improve their future lives- there was no doubt that PISA was concerned with the latter.
- Whilst scientific literacy is something to be aimed for and developed throughout life, it is essential that it is begun in school.
- Scientific literacy is not to be equated with vocabulary; the term 'literacy' was interpreted metaphorically to mean general competence or begin 'at ease' with scientific ways of understanding things.
- A key feature was the use of evidence, which also includes knowledge of how evidence is collected in science, what makes some evidence more dependable than others, what are the shortcomings and where it can and should be applied (Haylen, 2001, p.11)

PISA 2006 assessed both cognitive and affective aspect of students' scientific literacy. The cognitive aspect includes students' knowledge and students' capacity to use this knowledge effectively. Non-cognitive or attitudinal aspect includes how students respond affectively.

The scientific literacy in PISA 2006 is not polar. In other words, it can not be categorized as being either scientifically literate or scientific illiterate. There is a progress in from less developed to more developed scientific literacy.

2.2.1 Organization of Science Domain in PISA 2006

The definition of scientific literacy in PISA 2006 was characterized as consisting of four interrelated aspects. The interrelated aspects of scientific literacy are context, competencies, knowledge and attitudes. The interrelations of the aspects of scientific literacy were characterized in PISA 2006 Assessment Framework as shown in the Figure 2.1. The aspects of scientific literacy were explained below.



*(PISA 2006 Assessment Framework)

Figure 2.1. The Framework for PISA 2006 Science Assessment

2.2.1.1 Context of Scientific Literacy

PISA 2006 science questions were framed to involve science and technology, which is health, natural resources, environment, hazard frontiers of science and technology. The context of questions was chosen in the light of relevance to students' interests and lives, representing science-related situations (OECD, 2005).

2.2.1.2 Knowledge of Scientific Literacy

PISA 2006 covers both *knowledge of science* and *knowledge about science*. Some of the science questions assess the knowledge of science the others assess knowledge about science. The questions related to knowledge of science were selected from the major fields of physics, chemistry, biology, Earth and space science and technology. The assessment material had to be relevant to real life situations, representative of important scientific concepts and appropriate to the development level of 15-year-olds. *Knowledge about science* was identified in two categories; scientific enquiry and scientific explanations (OECD, 2005). The subdimensions of the scientific literacy are given in the Figure2.2.

Scientific enquiry • Origin (e.g. curiosity, scientific question) • Purpose (e.g. to produce evidence that helps answer scientific questions, such as current ideas, models and theories to guide enquires) • Experiments (e.g. different questions suggest different scientific investigation, design) • Data (e.g. quantitative, qualitative) • Measurement (e.g. inherent uncertainty, replicability, variation, accuracy/precision in equipment and procedures)Characteristics of results (e.g. empirical, tentative, testable, falsifiable, self correcting)
Scientific explanations • Types (e.g. hypothesis, theory, model, scientific law) • Formation (e.g. existing knowledge and evidence, creativity and imagination, logic) • Rules (e.g. logically consistent, based on evidence based on historical and current knowledge) • Outcomes (e.g. new knowledge, new methods, new technologies, new investigation)

*(PISA 2006 Assessment Framework)

Figure 2.2. Knowledge of Scientific Literacy in PISA 2006.

2.2.1.3 Attitudes of Scientific Literacy

The other goals of the science education are to help students develop interest in science and support for scientific enquiry. Students' science competences include attitudes, beliefs, motivational orientation, self-efficacy and values. PISA 2006 gathered data on four areas of attitudes and engagements with science (OECD, 2005). The subdimensions of the attitudes are given in the Figure 2.3.

1. Support for scientific enquiry • Acknowledge the importance of considering different scientific perspectives and arguments • Support the use of factual information and rational explanation • Express the need for logical and careful process in drawing conclusion
2. Self-belief as science learner • Handle scientific tasks effectively • Overcome difficulties to solve scientific problems • Demonstrate strong scientific problems
3. Interest in science • Indicate curiosity in science an science-related issues and endeavors • Demonstrate willingness to acquire additional scientific knowledge and skills, using a variety of resources and methods • Demonstrate willingness to seek information and have an ongoing interest in science, including consideration of science related careers
4. Responsibility towards resources and environments • Show a sense of personal responsibility for maintain a sustainable environment • Demonstrate awareness of the environmental consequences of individual actions • Demonstrate willingness to take the action to maintain natural resources

*(PISA 2006 Assessment Framework)

Figure 2.3. Attitudes of Scientific Literacy in PISA 2006.

2.2.1. 4 Competencies of Scientific Literacy

PISA 2006 science study places emphasis on the scientific competencies. The competencies are ability to: identify scientifically oriented issues; describe, explain or predict phenomena based on scientific knowledge; interpret evidence and conclusions; and use scientific evidence to make and communicate decisions. The scientific competencies involve both knowledge of science and knowledge about science as a form of knowledge and approach to enquiry. The key cognitive abilities are inductive/deductive reasoning, critical and integrated thinking, transforming representations (data to table, table to graph), constructing and communicating arguments and explanations based on data thinking in terms of models and using mathematics (OECD, 2005). The subdimensions of the scientific competencies are given in the Figure 2.4.

Identifying scientific issues
• Recognizing issues that is possible to investigate scientifically • Identifying keywords to search for scientific information • Recognizing the key features of a scientific investigation
Explaining phenomena scientifically
• Applying knowledge of science in a given situation • Describing or interpreting phenomena scientifically and predicting changes • Identifying appropriate descriptions, explanations and predictors
Using scientific evidence
• Interpreting scientific evidence and making and communicating conclusions • Identifying the assumptions, evidence and reasoning behind conclusions • Reflecting on the societal implications of science and technological developments

*(PISA 2006 Assessment Framework)

Figure 2.4. The Scientific Competencies of Scientific Literacy in PISA 2006.

Identifying scientific issues includes recognizing questions that are possible to investigate scientifically in a given situation and identifying keywords to search for scientific information on a given topic. This competency also includes recognizing the key features of a scientific investigation, for example, what are the variables of the study, which variable should be controlled, which variable should be manipulated, what additional information is needed so that relevant data can be collected.

Identifying scientific issues requires students to have knowledge about science and knowledge of science.

The competency of explaining phenomena scientifically includes describing and interpreting phenomena and predicting changes and may involve recognizing or identifying appropriate descriptions, explanations and predictions. This competency can be assessed, for example, by presenting an investigation and asking students to identify the evidence needed or the action to be taken to obtain valid evidence (Harlen, 2001).

The competency of using scientific evidence includes accessing scientific information and producing arguments and conclusions based on scientific evidence. Selecting from alternative conclusions in relation to evidence, giving reasons for or against a given conclusion in terms of the process by which the conclusions were derived from the data and identifying the assumptions made in reaching a conclusion is also involved in this competency. In using scientific evidence, students should be able to denote logical connection between evidence and conclusions. This competency can be assessed, for example, by providing students with an account of an investigation and the conclusions drawn from it and asking for an evaluation of these conclusions, or asking for a conclusion or alternative conclusions to be drawn that are consistent with given evidence. It can also be assessed by presenting students with a situation which requires information or evidence form different sources to be brought together to support a given course of action or conclusion (Harlen, 2001).

The subdimensions of the aspects of PISA 2006 science literacy are displayed in Figure 2.5.

Summary of the Science Assessment in PISA 2006	
Definition	The extent to which an individual: • Possesses scientific knowledge and use the knowledge to identify the questions, acquire scientific knowledge explain scientific phenomena and draw evidence-based conclusions about science related issues. • Understands the characteristics features of sciences as a form of human knowledge and enquiry. • Shows awareness of how science and technology shape our material, intellectual and cultural environments. • Engage in science related issues and with the ideas of science as a reflective citizen. • Scientific literacy requires an understanding of scientific concepts as well as the ability to apply a scientific perspective and to think scientifically about evidence.
Knowledge	Knowledge of science such as: • Physical system • Living system • Earth and space system • Technology system Knowledge about science such as: • Scientific enquiry • Scientific explanation
Competencies	Type of scientific task or process: • Identifying scientific issues • Explaining scientific phenomena • Using scientific evidence
Content and situation	The area of application of science focusing on uses in relation to personal, social and global settings such as: • Health • Natural resources • Environment • Hazard • Frontiers of science and technology

*(PISA 2006 International Report)

Figure 2.5. The Summary of Assessment Framework of Scientific Literacy in PISA 2006.

The strength and weakness of the science performance of the countries were executed in the international first report of PISA 2006. The average combined science score of Turkish students in PISA 2006 is 424 points. This average score of Turkish students changes in the students' science competencies and also the science knowledge domains. The average *identifying scientific issues* score of Turkish students is 3.7 points higher than the average performance on combined science score. The average *explaining phenomena scientifically score* of Turkish students is 0.8 points lower than the average performance on combined science score. The average *using scientific evidence score* of Turkish students is 6.6 points lower than the average performance on combined science score (OECD, 2007).

2.2.2 Student-Level and School-Level Variables

This dissertation includes a great number of variables related to students and schools. Totally, 27 student level variables and 16 school level factors were used. Therefore, the student level variables were categorized to simplify the explanations and studies about the variables. The eight student level variable clusters are; 1. certain students' factors, 2. students' socio economic status, 3. motivational factors of students, 4. science self-belief, 5. value belief regarding science, 6. science related careers, 7. science teaching and learning, 8. scientific literacy and the environment.

The first cluster contains language of the students at home, gender of the students and study program type. All variables in this cluster are dichotomous. The language of the students at home was derived from "what language do you speak at home most of the time?" This variable has two codes; "1" corresponds to Turkish, "0" corresponds to the other languages. The codes of gender; "1" corresponds to female and "0" corresponds to male. The study program type was derived from "Which one of the following programme are you in?" This variable has two codes; "0" corresponds to General High Schools, "1" corresponds to the Vocational School. Considering gender the average combined science performance of Turkish female students in PISA 2006 was 11 points higher than Turkish male students (OECD, 2007).

The second cluster contains economic, social and cultural status of the students, students' home possessions, students' home educational resources, students' cultural possessions at home and index of family wealth. The effect of these variables are explained that home background influences educational success and experiences at school often appear to reinforce its effects. Although PISA shows that poor performance in school does not automatically follow from a disadvantaged socio-economic background, socio-economic background does appear to be a powerful influence on performance (OECD, 2007, p. 198). The items related to indexes of students' socio economic status can be found in Appendix A.

The third cluster contains students' general interest in science, students' enjoyment of science, students' instrumental motivation to learn science and students' future oriented motivation to learn science. The indexes in this cluster were chosen because motivation and engagement are often regarded as important driving forces of learning. The motivation can also influence whether they will successfully pursue further educational or labour market opportunities. Interest in and enjoyment of particular subjects affects both the degree and continuity of engagement in learning and the depth of understanding reached (OECD, 2007). The instrumental motivation has been found to be an important predictor for course selection, carrier choice and performance (Eccles, 1994, as cited in OECD publication, 2004, p. 123). The items related to indexes of motivational factors of students can be found in Appendix A.

The forth cluster contains students' self efficacy in science and students' self-concept. How much students believe in their own ability to handle task effectively and overcome difficulties (self-efficacy) and students' beliefs in their own academic ability (self-concept) are two ways of defining self-beliefs (OECD 2007). A strong sense of self-efficacy can affect students' willingness to take on challenging tasks

and to make an effort and persist in tackling them: it can thus have a key impact on motivation (Bandura, 1994 as cited in OECD 2007, p. 134).
Students' academic self-concept is both an important outcome of education and a trait that correlates strongly with student success. Belief in one's own abilities is highly relevant to successful learning (Marsh, 1986 as cited in OECD 2007, p: 137). Self-concept can also affect other factors such as well-being and personality development, factors that are especially important for students from less advantaged backgrounds. In contrast to self-efficacy in science, which asks students about their level of confidence in tackling scientific tasks, self-concept measures the general level of belief that students have in their academic abilities (OECD 2007). The items related to indexes of science self-belief can be found in Appendix A.

The fifth cluster contains students' general value of science, students' personal value of science and students' science activities. A strong general value of science would reflect the questions:

i) To what extent do students value the contribution of science and technology for understanding the natural and constructed world?
ii) To what extent do students value the contribution of science and technology for the improvement of natural, technological and social conditions of life? (Carstensen et al., 2003, as cited in OECD 2007, p. 127).

The personal value of science reflects to what extent the general value of science translates into science being of personal value. The index of science-related activities is the degree to which students pursue science-related activities in their free time. The items related to indexes of value belief regarding science can be found in Appendix A.

The sixth cluster contains school perception for science related careers and student information on science-related careers. In the science-related careers, any career that involves tertiary education in a scientific field is considered science-related. Therefore careers like engineer (involving physics), forecaster (involving earth science), optician (involving biology and physics), and medical doctor (involving medical sciences) are examples of science-related careers (OECD 2007). The items that indexes of science related careers were derived can be found in Appendix A.

The seventh cluster contains interaction in science teaching and learning, hands on activities in science teaching and learning, student investigation in science teaching and learning and focus on model or application in science teaching and learning. Purpose of this category is "how students learn science?" In this context, the interaction of the teachers with their students, giving opportunity to the students to express their ideas in class, using the investigation and using the models and applications in science lessons are analyzed. The teaching process is the interactive process. The evidence suggests that the main driver of the variation in student learning at school is the quality of the teachers (Mc Kinsey & Company, 2007, p.12). The items related to indexes of science teaching and learning can be found in Appendix A.

The eighth cluster contains awareness of environmental issues, level of concern for environmental issues, optimism regarding environmental issues and responsibility for sustainable development.

An individual's attitudes and behaviours with regard to the environment are likely the result of multiple factors including knowledge, awareness, attitudes and social pressure (Bybee, 2005, as cited in OECD 2007, p. 155). Because of the students' knowledge of environmental issues and their attitudes towards the environment are one of the aspects of students' scientific literacy, these indexes were included in the study. The items related to indexes of scientific literacy and the environment can be found in Appendix A.

The school level variables were also used in the dissertation. These are proportion of girls at school, ratio of computers to school size, school size, school academic selectivity recorded, teacher-student ratio, school activities for learning environmental topics, responsibility for resource allocation, responsibility for curriculum and assessment, school activities to promote the learning of science, quality of educational resources, teacher shortage, school average economic-social and cultural index, school type, describing the community in which the school is located, the percentage of schools' total funding for a typical school year comes from the government (includes departments, local, regional, state and national) and class size.

The school type, describing the community in which the school is located, the percentage of schools' total funding for a typical school year comes from the government (includes departments, local, regional, state and national) and class size are dichotomous variables.

The items related to indexes of scientific literacy and the environment can be found in Appendix B.

2.3 Studies about Programme for International Student Assessment (PISA)

The Programme for International Student Assessment (PISA) was set up in 1997 by the OECD in order to provide national governments and other with policy oriented and internationally comparable indicators of student achievement on a regular basis and in time manners. The OECD/PISA has the most reliable source of educational data. Therefore, a great number of studies conducted with PISA data, and related to PISA study can be found all over the world.

Harlen (2001) examined the PISA project in some circumstance. The rationales for the nature of the framework for assessing scientific literacy in the OECD/PISA project were discussed. The article adverted mainly; setting the PISA study in the context of international survey and overall aims of comparative research. Afterwards, it concerned with an overview of the features and management of the programme as a whole, and focused on 'literacies' and the meaning given to literacy. Then it concerned with the differences between PISA and TIMSS, the framework of scientific literacy and how it had been translated into test units. Finally, the approach taken in developing a scale for reporting scientific literacy was described. The difference between PISA and TIMSS is explained in the article as; PISA is looking at what is considered to be required to the future, whilst the main TIMSS survey studied attainment in relating to a common core of goals relating to current curricula. However, as discussed in the article, the TIMSS surveys did not match the need of governments, as the OECD saw it, for 'solid and internationally comparable evidence of educational outcomes' on a regular basis, with the explicit purpose of informing policy decisions. Therefore, the OECD set up its own assessment system to meet the need for assessments and indicators relating to the performance of 15 year old students.

Harlen (2001) discussed the essential features of the PISA project for assessing educational outcomes. The article also criticized the PISA projects since it was attempting the impossible, for there will never be completely identical opportunities for demonstrating achievement across countries. Because there were considerably differences in the motivation of the students in the national samples, since motivation depended on what meaning the testing and tasks have fun for the students. The material used was also effected the results, since test materials was translated into another language and presented to students of a different cultural background.

Kjærnsli and Lie (2004) searched the similarities and differences between the Nordic countries concerning patterns of competencies defined as scientific literacy. Kjærnsli et al. used the PISA 2000 scientific literacy score to discuss some of the main results in scientific competencies and to describe similarities and differences between the five Nordic countries, when viewed from an international perspective. The study concentrated on gender differences concerning the two types of competencies; understanding of scientific concepts versus skills in scientific reasoning and similarities and differences between countries based on item by item analyses. Correlation between each Nordic country and every other country had been looked for a Nordic pattern. In the last part cluster analyses had been used to see how countries establish clusters and whether these clusters represent meaningful groups in a geographical, cultural or political context. The result indicates that the magnitude of the gender differences in achievement varies considerably between the five Nordic countries, with a strong relative advantage for boys in Denmark.

Turmo (2004) examined the relationship between the cultural, social and economic capital of students from the Nordic countries and their level of scientific literacy, based on data from PISA 2000 study. In the study, multiple regression analyses is used. The model consists of home, cultural competence, students cultural activity, home cultural possession, home educational resources, books at home, highest family socio-economic index, and parental education. The result showed that the relationship between the home's economic capital and students' level of scientific literacy is relatively weak in all the Nordic countries. The relationship between the cultural capital of the home and the level of scientific literacy was found to be strong in several of the Nordic countries. The author recommended a need in science education for a special focus on students from lower cultural backgrounds.

İş (2003) conducted a study to investigate the factors affecting mathematical literacy of 15-year-old students in PISA 2000 across different cultural settings. In the study Brazil, Japan and Norway were selected on the basis of their rankings in PISA 2000. The proposed model was tested using structural equation modeling across three different cultures with different performance level in PISA 2000. The findings of the study show that the latent independent variable having the strongest effect on mathematical literacy is the usage of technology and facilities in Brazil, communication with parents in Japan and attitudes towards reading in Norway.

Papanastasiou (2003) conducted a study to examine how variables related to computer availability; computer comfort and educational software are associated with higher or lower levels of science literacy in the USA, Finland and Mexico, after controlling for the socio-economic status of the students. The analyses for this study were based on a series of multivariate regression models. The data were obtained from the PISA. The results of the study showed that it was not computer use itself that had a positive and negative effect on the science achievement of the students, but the way in which the computers were used within the context of each country.

2.4 Theoretical Background of Hierarchical Linear Modeling

Hierarchical linear modeling (HLM) is a particular regression technique that is designed to take into account the hierarchical structure of educational data (Raudenbush and Bryk, 2002). Opposite to the HLM techniques, the traditional regression techniques assume that all data are collected at the same level. Raudenbush and Bryk have adopted the term hierarchical linear models because the HLM conveys an important structural feature of the data. The data used in HLM have a nested or clustered structure, for example, repeated observations nested within persons. These persons also may be nested within classrooms. Further, classrooms themselves may be nested within schools, within regions and within countries. Hierarchical linear models, also called multi-level linear models, nested models, mixed linear models, or covariance components models.

The advantage of HLM is that it allows the analyst to explicitly examine the effects of the policy-relevant variables on student outcomes. It also allows for the investigation of both within-group effects and between-group effects on outcome variables. The further discussion of the advantages of hierarchical analysis appeared in the Kidwell's (1997) article.

> Traditionally, researchers testing multilevel models have had two data analysis options. The first was to assign the higher level measure to each unit at the lower level (e.g., assign group scores to individuals), and then conduct analyses strictly at the lower level. The second alternative was to aggregate measures taken at the lower level of analysis (e.g., aggregating individual-level measures to form group-level composites) and conducting analyses at the higher level only. Each of these options has potential empirical and conceptual weaknesses. With the first option, the researcher must assume that individual responses are not influenced by group characteristics. This approach yields biased estimates of the standard errors and increases the chance of Type I error "(Kidwell 1997, cited in Burstein, 1980). "With the second option, statistical power often is an issue, as is the appropriateness of inferences concerning relations among the

> aggregated variables (Kidwell 1997, cited in Klein, Dansereau & Hall, 1994, p. 5).

Hierarchical linear model comes through the conceptual and technical difficulties of multilevel data. The most commonly encountered difficulties are aggregation bias, misestimated standard errors and heterogeneity of regression.

> The aggregation bias can occur when the variable take on different meanings and therefore may have different effects at different organizational levels. Hierarchical linear modes help resolve this confounding by facilitating a decomposition of any observed relationship between variables, such as achievement social class, into separate level-1 and level-2 components.
> Misestimated standard errors occur with multilevel data when we fail to take into account the dependence among individual responses within the same organization. Hierarchical linear modes resolve this problem by incorporating into the statistical model a unique random effect for each organizational unit.
> Heterogeneity of regression occur when the relationship between individual characteristics and outcomes vary across organization. Hierarchical linear modes enable the investigator to estimate a separate set of regression coefficients for each organizational unit, and then to model variation among the organization in their sets of coefficients as multivariate outcomes to be explained by organizational factor (Raudenbush and Bryk, 2002, p.100).

The basic concepts behind hierarchical linear modeling are similar to that of OLS regression. On the base level (individual level or level 1), the analysis is similar to that of OLS regression: an outcome variable is predicted as a function of a linear combination of one or more level-1 variables (Osborne, 2000).

One of the assumptions underlying traditional regression analyses is that the observation are independent ; that is the observations of any one individual are not in any way systematically related to the observations of any other individual. This assumption is violated, for example, if some of the students are from the same family or from same classroom or from same school. Consequently, the use of traditional regression analyses yields biased estimates of the relationships among variables (Willms, 1999).The concepts related to hierarchical linear modeling will be discussed a bit more below.

2.4.1 Model Specification

The two-level hierarchical model uses two sets of regression models. The separate level-1 models are developed for each of the *j* level - 2 units. The outcome, Y (for example, chemistry achievement), and level-1 predictor or covariate, X (for example, student's age) are the dependent and independent variables of this example. The level-1 models are of the form:

$$Y_{ij} = \beta_{0j} + \beta_{1j}\,(X_{ij} - \overline{X}\,.....) + r_{ij} \qquad (2.1)$$

Where Y_{ij} is the dependent variable measured on the *i*th level-1 unit (for example, student) nested within the *j*th level-2 unit (for example, classroom), β_{0j} is the intercept for the *j*th level-2 unit (classroom), X_{ij} is the level-1 predictor or covariate (for example, student's age), $\overline{X}$.. is the grand mean of X_{ij} (for example, the mean age of all students in the sample), β_{1j} is the regression coefficient associated with level-1 predictor X for the *j*th level-2 unit (classroom) and r_{ij} is the random error associated with the *i*th level-1 unit nested within the *j*th level-2 unit .

The hierarchical linear models were outlined herein after. These models are presented in Raudenbush and Bryk. The notation and labeling convention were employed as Raudenbush and Bryk employed in the HLM.

2.4.1.1 One-way ANOVA with Random Effects.

The simplest hierarchical linear model is equivalent to a one-way ANOVA with random effects. In this case, student level (level-1) model is;

$$Y_{ij} = \beta_{0j} + r_{ij} \qquad (2.2)$$

It is assume that each level-1 error, r_{ij}, is normally distributed with a mean of zero and constant level-1 variance, σ^2.The school level (level-2) model for the one-way ANOVA with random effects is;

$$\beta_{0j} = \gamma_{00} + \upsilon_{0j} \qquad (2.3)$$

γ_{00} represents the grand-mean outcome in the population, and υ_{0j} s the random effect associated with unit j is assumed to have a mean of zero and variance τ_{00}.

2.4.1.2 Means-as-outcome Regression

The models in which the intercept is only predicted from level-2 variables are known as mean-as-outcome models because a difference in the intercept represents a difference in means in the dependent variable that can be predicted from the independent variables predicted by group characteristics.

Student level (level-1) model is:

$$Y_{ij} = \beta_{0j} + r_{ij} \tag{2.4}$$

School level (level-2) model is:

$$\beta_{0j} = \gamma_{00} + \gamma_{01} W_j + \upsilon_{0j} \tag{2.5}$$

Raudenbush and et al. (2002) stated "Similarly, the variance in υ_{0j}, τ_{00} is now the residual or conditional variance in β_{0j} after controlling for W_j "(p. 25).

2.4.1.3 One-way ANCOVA with Random Effects

In this model, the level- coefficients γ_{01} and γ_{11} and the random effects υ_{0j} (for all *j*) equal to zero. The model is named as a one-factor ANCOVA with random effects and a single level-1 predictor as a covariate.

$$Y_{ij} = \beta_{0j} + \beta_{1j} (X_{ij} - \overline{X}_{..}) + r_{ij} \tag{2.6}$$

The level-2 model is:

$$\begin{aligned} \beta_{0j} &= \gamma_{00} + \upsilon_{0j} \\ \beta_{1j} &= \gamma_{10} \end{aligned} \tag{2.7}$$

One-way ANCOVA with random effects model was not used in this dissertation.

2.4.1.4 Random- Coefficient Regression Model

In this model, both the level-1 intercept and one or more level-1 slopes vary randomly but this variation is not predicted.

$$Y_{ij} = \beta_{0j} + \beta_{1j} (X_{ij} - \overline{X}_{.j}) + r_{ij} \qquad (2.8)$$

The level-2 model is:

$$\begin{aligned} \beta_{0j} &= \gamma_{00} + \upsilon_{0j} \\ \beta_{1j} &= \gamma_{10} + \upsilon_{1j} \end{aligned} \qquad (2.9)$$

2.4.2 Assumptions

The assumptions of the hierarchical linear modeling can be explained:

1. The errors in the level-1 models are normal random variables with mean zero and common variance σ^2:

$$E (r_{ij}) = 0 \qquad Var (r_{ij}) = \sigma^2 \qquad (2.10)$$

2. In the level-2 models, it is assumed that β_{0j} and $\beta_{1}j$ are distributed as multivariate normal with means γ_{00} and γ_{10}, respectively, and variances, τ_{00} and, τ_{11}, respectively. The covariance of β_{0j} and $\beta_{1}j$ is denoted τ_{01}. In other words, it is considered the situation in which the errors are homogenous at both level-1 and level-2, although more complicated error structures are allowed. Finally, level-1 and level-2 errors are uncorrelated (Sullivan, 1999).

The assumptions were summarized as:

$$E (\upsilon_{0j}) = 0 \quad E (\upsilon_{1j}) = 0$$
$$E (\beta_{0j}) = \gamma_{00} \quad E (\beta_{1j}) = \gamma_{10}$$
$$Var (\beta_{0j}) = Var (\upsilon_{0j}) = \tau_{00} \qquad Var(\beta_{1j}) = Var (\upsilon_{1j}) = \tau_{11}$$
$$Cov(\beta_{0j}, \beta_{1j}) = Cov (\upsilon_{0j}, \upsilon_{1j}) = \tau_{01}$$
$$Cov(\upsilon_{0j}\, r_{ij},) = Cov (\upsilon_{1j}, r_{ij}) = 0 \qquad (2.11)$$

2.5 Related Studies

The hierarchical linear models were employed at many educational studies in recent years because they accommodate the nested structure of the data and facilitate the inclusion of variables derived from student and school characteristics.

National Assessment of Educational Progress (NAEP) conducted a study. The goal of the study was to examine differences in mean NEAP reading and mathematics scores between public and private schools. The selected characteristics of schools and students were taken into account. In the study, the focal parameter was the mean difference between public and private schools. NAEP 2003 assessments in reading and mathematics for grades 4 and 8 were used. Because of the nested structure of the data, hierarchical linear models were employed. The crucial finding of the study is:

- the average private schools' mean reading score was 14.7 points higher than the average public schools' mean reading score. After adjusting for selected school characteristics, the difference in means was near zero and not significant.
- the average private schools' mean mathematics score was 7.8 points higher than the average public schools' mean reading score. After adjusting for selected school characteristics, the difference in means was - 4.5 and significantly different from zero (NCES, 2006).

İş Güzel (2006) conducted a research to gain a more complete understanding of the impact of human and physical resource allocation and their interaction on students' mathematical literacy skills across Turkey, member and candidate countries of European Union through the PISA 2003. In the study, HLM techniques were used separately for three different cultural settings. The results indicated that students in Turkey, member and candidate countries of European Union who performed higher on the mathematical literacy assessment tend to have the following characteristics: (1) enrolled at higher grade levels, (2) more educational resources at home, (3) higher levels of mathematics self-efficacy, (4) lower levels of mathematics anxiety, (5) more positive self-concept in mathematics, (6) less preferences for memorization strategies, and (7) more positive disciplinary climate in mathematics lessons. As the performance of the schools were considered, the higher average mathematics self efficacy of students, the higher the mean school mathematical literacy performance. The influence on mathematical literacy assessment varied from school to school with respect to grade level and disciplinary climate in mathematics lessons in Turkey and European Union countries, with respect to grade level, mathematics self-efficacy, and disciplinary climate in mathematics in European Union candidate countries.

Akyüz (2006) employed the hierarchical linear models to examine the effects of selected teacher and classroom characteristics from Third International Mathematics and Science Study (TIMSS-R) on the student's mathematic achievement across Turkey, European Union (EU) countries and EU candidate countries. Firstly, the variations in the mathematics achievement were analyzed by using the one-way ANOVA with the random effects. Then, the effects of students and the teacher characteristics of Turkey, European Union (EU) countries and EU candidate countries were analyzed. The findings indicated that home educational resources of the students had positive significant effect on students' mathematic achievement in all the country except Romania.

Results from several international studies of student achievement have provided evidence that countries vary. There is also a significant relationship between literacy skills and socio-economic status. Understanding this relationship is a starting point for examining the distributions of educational opportunities.

One of the studies related to socioeconomic gradients and reading performance was conducted by Willms (2006). Willms designed a report to describe the performance of schools and schooling system. The hierarchical linear models were used to estimate school effects. The analyses of data from PIRLS 2001 and PISA 2000 were used. The findings of the study are;

i) Countries differed substantially in their average levels of the reading performance,

ii) In every country that participated in PIRLS 2001 and PISA 2000, there was a significant relationship between the reading performance and socio economic status,

iii) In every country there was a significant variation among schools in their performance, even after taking into account the SES of the students' families and the mean SES of the schools they attend. Countries also varied significantly in their performance, even after SES is taken into account,

iv) In some countries, the relationship between the reading performance and socioeconomic status was weaker at higher levels of socioeconomic status. However, in some other countries, particularly non-OECD countries, the relationship was stronger at higher levels of socioeconomic status.

v) Successful schools tend to be those that were successful in bolstering the performance of students from less advantaged backgrounds,

vi) In all countries there was a school "compositional effect" associated with the mean SES of the school. The average level of socioeconomic status of a community had an effect on social outcomes over and above the effects associated with individuals' socioeconomic status.

vii) Schools with a heterogeneous intake of students, in terms of their family SES, have equally high performance as those with a homogenous intake.

viii) The effects of school mean SES were to some extent mediated by school-level factors. The most important factors explaining reading performance in PIRLS were teacher experience, the disciplinary climate of the classroom, and parental support. In PISA they were student-to-staff teaching ratio, the proportion of teachers with tertiary-level qualifications, students' use of resources, teacher morale and commitment, the disciplinary climate of the classroom, and teacher-student relations. The results do not support that smaller class sizes, or lower teacher-student relations, yields better results. In PIRLS, the children in large classes fared slightly better than those in class with 20 to 30 students, while in PISA the average performance was fairly even over that range.

ix) The differences between urban and rural sectors were associated with material and human resources, such as smaller class, better quality material resources, and higher level of teacher training, and various aspects of school and classroom policy and practice.

x) Countries with high levels of segregation along socioeconomic lines tend to have lower overall performance and greater disparities in performance between students from high and low socioeconomic backgrounds.

The impact of individuals' differences and school effects on achievement in middle and high schools were studied by Ma et al (2002). Using data from the Longitudinal Study of American Youth (LSAY), hierarchical linear models (HLM) were used to model the growth of student science achievement in three areas (biology, physical science, and environmental science) during middle and high school. Results showed significant growth in science achievement across all areas. The growth was quadratic across all areas, with rapid growth at the beginning grades of middle school but show but slow growth at the ending grades of high school. At the student level socioeconomic status (SES) and age were related to the rate of growth in all areas. There were no gender differences in the rate of growth in any of the three areas. At the school levels, variables associated with school context (school mean SES and school size) and variables associated with school climate (principal leadership, academic expectation, and teacher autonomy) were related to the growth in science achievement. Initial (Grade 7) status in science achievement was not associated with the rate of growth in science achievement among either students or schools in any of the three areas.

Özdemir (2003) conducted a study to investigate the factors that are related to students' science achievement in TIMSS-R. Basically instructional activities, affective characteristics of students and socioeconomic status (SES) were taken as the variables of the model proposed within the Linear Structural Modeling (LSM) framework. Resulting path diagram showed that the largest relationship existed between science achievement and SES of students. It was also observed that student enjoyment of science did not seem to have a significant contribution on science achievement. In addition, science achievement had a negative relationship with the classroom activities considered as student-centered. On the other hand, the activities considered as teacher-centered had a positive impact on the science achievement scores. It was also observed that science achievement and perception of success/failure in science were highly related with each other.

Braun and et al. (2006) conducted a study related to the gap in academic achievement between majority and minority students by using hierarchical linear models. The goal of the study is o accumulate and evaluate evidence on the relationship between state education policies and changes in the Black-White achievement gap, while addressing some of the methodological issues that have led to differences in interpretations of earlier findings. The trajectories of Black students and White students achievement on the NEAP 8^{th} grade mathematics assessment over the period 1992 to 2000, and examine the achievement gap at three levels of aggregation: the state as a whole, groups of schools (strata) within a state defined by the SES level of the students population, and within schools within a stratum within a state were estimated. From 1992 to 2000, at every level of aggregation, mean achievement rose for both Black students and White students. Some findings of the study are: i. the achievement gaps were large for most states and changed very little at every level of aggregation, ii. there is substantial heterogeneity among states in the types of policies, iii. states' overall policy ranking correlate moderately with their record in improving Black student achievement but are somewhat less useful in predicting their record with respect to reducing the achievement gaps.

CHAPTER 3

METHODOLOGY

This chapter is devoted to the methodology of the present study. The chapter begins with the presentation of population and sample. Then, instruments, the evidence for validity and reliability of PISA 2006, scaling PISA cognitive data, sample weighting in PISA, plausible values, hierarchical linear modeling and software packages used in the dissertation are explained respectively. The chapter ends with the limitation of the study.

3.1 Population and Sample

PISA target population in each country is 15-year-old students attending educational institutions located in the country, in grades 7 and higher. The operational definition of the age population depends on the testing dates. The international target population is defined as all students who are aged from 15 years and 3 completed months to 16 years and 2 completed months at the beginning of the assessment period. A variation of up to one month in this age definition is permitted. Turkey's target population could have been defined as all students born in 1990 who were attending a school when PISA 2006 was administered in May 2006.

To select the sample, all PISA National Project Managers were required to construct a school sampling frame to correspond to their national defined target population. This frame includes any school that could have 15-year-old students, even those who might later be excluded.

Prior to the sampling Turkish schools were to be stratified. The explicit and implicit were types of PISA stratification variables. The explicit stratification consists of building separate school list, or sampling frames, according to the set of explicit stratification variables under consideration. The implicit stratification consists essentially of sorting the schools within each explicit stratum by a set of implicit stratification variables (OECD, 2003). Turkey's explicit stratification variables were the geographical region and school size. The implicit stratification variables were school level, public school/private school and urban school /rural school.

The two-stage sample was designed for Turkey's sample in PISA 2006 study. The first stage-sampling units were the individual schools having 15-year-old students. The second stage-sampling units were students within sampled schools. Thirty-five students were selected randomly from each sampled school's 15-year-old- students. 160 schools were selected randomly considering their percentage distribution in the seven geographical regions of Turkey. The distribution of the schools and the students to geographical regions is given in Table 3.1.

Table 3.1.
Turkey's Student and School Sample in PISA 2006 / Geographical Region (Unweighted).

Geographical Regions	Number of Female Students	Number of Male Students	Total Number of Students	Total Number of School
Marmara	720	718	1438	46
Ege	298	324	622	19
Akdeniz	360	348	708	23
İçanadolu	396	469	865	28
Karadeniz	220	376	596	19
Doğu Anadolu	185	169	354	12
Güneydoğu Anadolu	111	248	359	13
TOTAL	2290	2652	4942	160

The students participated to PISA 2006 from Turkey were selected from the primary schools, general high schools, anatolian high schools, science high school, vocational high schools, technical high schools, multi programme high schools, anatolian teacher training high schools, anatolian vocational high schools and Anatolian technical high schools(MEB, 2007). Turkish sample could be categorized as primary school, general high school and vocational high school, this distributions displayed in the following table.

Table 3.2.

Turkey's Student and School Sample in PISA 2006 –Programme Type (Unweighted).

Programme Type	Number of Female Students	Number of Male Students	Total Number of Students	Total Number of School
Primary School	46	70	116	10
General	1443	1416	2859	88
Vocational	801	1166	1967	62
TOTAL	2290	2652	4942	160

3.1.1 Sample Weighting in PISA

The PISA data are weighted. "Why is PISA survey weighed?" is explained in the PISA 2003 Data Analysis Manual:

> Because if the sampling units do not have the same chances to be selected and if the population parameters are estimated without taking into account these varying parameters, then results might also be biased. To compensate for these varying probabilities, data need to be weighted. Weighing consist of acknowledging that some units in the sample are more important than others and have to contribute more than others for any population estimates. A sampling unit with a very small probability of selection is considered as more important than a sampling unit with a high probability of selection. Therefore, weights are inversely proportional to the probability of selection (OECD, 2005, p. 20).

In this dissertation, all statistical analyses or procedures was weighted in student level. The variable of final student weight (W_FSTUWT) in PISA 2006 student file was used. The distribution of the weighted student sample according to the geographical regions is given in Table 3.3.

Table 3.3.
Turkey's Student and School Sample in the PISA 2006 /Geographical Region (Weighted).

Geographical Regions	Number of Female Students	Number of Male Students	Total Number of Students
Marmara	94596	100522	195118
Ege	38716	43247	81963
Akdeniz	46971	44589	91560
İçanadolu	53388	64276	117663
Karadeniz	28204	50844	79048
Doğu Anadolu	23395	26957	50352
Güneydoğu Anadolu	16168	33603	49771
TOTAL	301438	364038	665476

The distribution of the weighted student sample according to the programme type is given in Table 3.4

Table 3.4.

PISA 2006 Student and School Sample-Programme Type (Weighted).

Programme Type	Number of Female Students	Number of Male Students	Total Number of Students
Primary School	12745	22743	35488
General	173641	185954	359595
Vocational	115053	155342	270395
TOTAL	301439	364039	665478

3.2 Instruments

PISA 2006 is a paper and pencil test. The main instruments of the PISA 2006 survey are achievement tests, student questionnaire and school questionnaire.

In all PISA cycles, the domains of reading literacy, mathematical literacy and science literacy are assessed. For the PISA 2006 cycle, the focus was on the scientific literacy. The major domain is assessed in detail; therefore, science literacy took up nearly two-thirds of the total testing time. Mathematical and reading literacy were tested through the link items already used in previous PISA study. The PISA Consortium, through the test developers and expert groups, and in extensive consultation with national centers, developed the science, mathematics and reading test items.

The achievement tests are formed from science, mathematics and reading units. Each units of the PISA 2006 involved common stimulus, items assessing students' science competencies and science knowledge and items assessing students' attitudes towards science. In other word, the units comprised from common stimulus, cognitive items and attitudinal items (embedded questions). The item formats are multiple-choice, short answer and extended response. Each attitudinal item required students to express their level of agreement or level of interest on a four-point scale.

Students' support for scientific enquiry and students' interest in learning science topics were directly assessed in the test, using embedded questions that targeted personal social and global contexts. In the case students' interest in learning science topics; students were able to report on the following responses: "high interest", "medium interest", "low interest" or "no interest". For attritional questions measuring students' support for scientific enquiry, students were asked to express their level of agreement using one of the following responses: "strongly agree", "agree", "disagree" or "strongly disagree" (OECD, 2007). The released embedded attitudinal items in English and in Turkish can be found at the Appendix C and Appendix D.

To gather contextual information, PISA asks students and the principals of their schools to respond to background questionnaires. The questionnaires are central to the analysis of results in terms of a range of student and school characteristics.
The student questionnaire was administered after the literacy assessment. It took students about 30 minutes to complete the instrument. The questionnaire included items about:

i) Students themselves (age, grade, gender);
ii) Students' family and home (composition of the family; parent occupation and education; family language, ethnicity, and possessions; parental engagement in science learning activities);
iii) Students' view on science (enjoyment, self efficacy in science, value of science, science activities, interest in science)
iv) Students' views on the environment (awareness of environmental issues, environmental information, student's level of concern for environmental issue, students' optimism regarding environmental issues, environmental responsibility)
v) Careers and science (school preparation for science related careers, student information on science related careers, future-oriented science motivation)
vi) Learning time (spend time to study)

vii) Students' views on teaching and learning science (instrumental motivation to learn science, self-concept in science).

In present study 25 student level index were used. The student level indices were derived from student questionnaire in PISA 2006. An index involves multiple questions and student responses, the index was scaled using a weighted maximum likelihood estimate (WLE) and using a one-parameter item response model (a partial credit model was used in the case of items with more than two categories). The negative values for an index do not necessarily imply that students responded negatively to the underlying questions. A negative value only indicates that the respondents answered less positively than all respondents did on average across OECD countries. Likewise, the positive value for an index indicates that the respondents answered more favorably than respondents did on average across OECD countries (OECD, 2007).

The items which were constituent the student indexes can be found Appendix A.
The other questionnaire was the school questionnaire. It was administered to the school principal and took about 20 minutes to be completed. School Questionnaire was designed to gather information about:

i) The structure and organization of the school,
ii) The number of teachers and their qualifications;
iii) The school's resources
iv) Accountability and admission practices
v) Science and environment
vi) Careers and further education

The detailed description of the indices can be found at the end of this chapter and Appendix B.

3.3 The Evidence for Validity and Reliability of PISA 2006

In this section, the development of cognitive assessment instrument, development of questionnaire and quality monitoring were explained.

3.3.1 The Development of the PISA 2006 Cognitive Assessment Instruments

The development of the assessment materials in PISA was important and interactive process among the PISA Consortium, international expert group, PISA Governing Board (PGB) and national experts. A panel of international expert group led the identification of the range of skills and competencies in the respective assessment domains that were considered to be crucial for an individual's capacity to fully participate and contribute to a successful modern society. Then the assessment frameworks were developed and agreed at both scientific and policy levels. The assessment framework provided the basis for the development of the assessment instruments (OECD, 2007).

Test development teams were established in five institutions; the Australian Council for Educational Research (ACER) in Australia, the National Institute for Educational Research (CITO) in the Netherlands, University of Oslo (ILS) in Norway, University of Kiel (IPN) in Germany and National Institute for Educational Research(NIER)in Japan. At each of the centers, professional item developers wrote and developed items. In addition, cognitive items were submitted from national centers or from individuals wishing to submit items.

PISA cognitive tests were formed from "units." The units in PISA 2006 contained a common stimulus, the items assessing student achievement and embedded attitudinal items. The common stimulus included passages of text, tables, graphs and diagrams, often in combination. The item formats employed were multiple-choice, short closed-constructed response, and open (extended) constructed-response. The embedded attitudinal items in the PISA test required students to express their level of agreement on a four-point scale with two or three statements. They were related to interest in learning science or support for science.

The developed items that reflected the intentions of the frameworks were piloted in the Field Trial all participating countries. Then a final set of items was selected for the PISA 2006 Main Study.

The item included in the assessment pool was rated by each participating country i) for potential cultural, gender or other bias, ii) for relevance to 15-year-olds in school and non-school contexts and iii) for familiarity and level of interest. The consultation was undertaken two times; i) before the Field Trail ii) before the PISA 2006 main study.

Following the field trail, cognitive and attitude items were tested in all participating countries. The test developers and expert groups took into consideration a variety of aspects to select the items for the Main Study: i) the results from the Field Trail, ii) the item review from countries and iii) coding queries received during the Field Trail. They selected a final set of items for the Main Study (OECD publication, 2007).

3.3.2 The Development of the PISA 2006 Student Questionnaire and School Questionnaire

PISA 2006 context questionnaires were the Student Questionnaire, the School Questionnaire, ICT Familiarity Questionnaire and Parent Questionnaire. The questionnaires commonly collected data related to science; students' demographics, aspects of students' attitudes regarding science, information about students' experience with science, motivation for science, interest in science, concern about science and engagement with science-related activities.

The consortium and the Questionnaire Expert Group (QEG) worked together to develop the contextual questionnaire framework for PISA 2006 and the contextual instruments. The student, school and parent questionnaires were piloted in 2005 in each of the participating countries. After Field Trail, the in-depth analyses were made for PISA questionnaires.

The data analyses of the field trail PISA 2003 data included the following steps:

- An examination of non-response and response patterns for the questionnaire items,
- A comparison of different item formats between the two versions of the questionnaire,
- Exploratory and confirmatory factor analysis to review the dimensional structure of questionnaire items and to facilitate the selection construct and items,
- An analysis of cross-country validity of both dimensional item structure and item fit,
- A review of scaling properties for scaled items, using classical item statistics and IRT models.

The final selection of questionnaire material was made after an extensive review and consultations with national centers, international experts and OECD (OECD, 2005). The selection procedure of questionnaire items in PISA 2003 was the same as PISA in 2006.

3.3.3 Quality Monitoring in PISA

The "quality assurance" is not given up standard of the PISA. Therefore, quality monitoring is the process of systematically observing and recording the extent to which data are collected, retrieved and stored according to the procedures described in the field operations manuals. Quality monitoring is a continuous process that identifies potential issues and forestalling the operational problems (OECD, 2005). The main elements of the quality monitoring procedures were:

- The consortium experts systematically monitored the key processes, e.g. sampling, coding, translation, etc.

- The implementation of PISA field operations at the national level: consortium representativeness visited the participated country.
- PISA quality monitors visited a sample of schools to record the implementation of the Main Study.
- The PISA National Project Manager systematically self-reported on the implementation of key process at the national level.
- PISA test administrators completed a report after each PISA test administration.

3.3.4 Reliability of the PISA 2006

PISA 2006 Technical Report has not published yet. The reliability of PISA 2003 science scale was obtained as 0.83 for Turkey.

3.4 Scaling PISA Cognitive Data

The mixed coefficients multinomial logit model as described by Adams, Wilson and Wang (1997) was used to scale the PISA 2006 data. This model was implemented by *ConQuest®* software (Wu, Adams & Wilson, 1997). The model is a generalised form of the one-parameter Item Response Theory model (Rasch model) (OECD publication, 2005).

3.5 Plausible Values

PISA assesses the knowledge and skills of the student population. The PISA performance of the students has no impact on their school career. The goal of reducing error in making inferences about the target population is more important than the goal of reducing error at the student level in PISA.

The students who participated to PISA study did not response all items. Therefore, the student proficiencies are not observed; they are missing data that must be inferred from the observed item responses. There are several possible alternative approaches for making this inference. PISA uses the imputation methodology and reports the student performance through plausible values (PVs). PVs are a selection of likely proficiencies for students that attained each score. PISA 2006 student file contains plausible values for science, mathematics and reading. There are five for each of the science scale, (PV1SCIE to PV5SCIE) mathematics scale (PV1MATH to PV5MATH), reading scale (PV1READ to PV5READ).

The PISA 2006 assessment measured student performance on a combined science scale and three science literacy subscales. These are identifying scientific issue, explaining scientific phenomena and using scientific evidence. Therefore, there are also five for each of the science subscales; identifying scientific issue scale (PV1ISI to PV5ISI), explaining scientific phenomena scale (PV1EPS to PV5EPS) and using scientific evidence scale (PV1USE to PV5USE).
The subscales of the attitudes toward science are interest in learning science scale (PV1INTR to PV5INTR) and support for scientific enquiry scale (PV1SUPP to PV5SUPP).

The five plausible values variables were used together in the hierarchical linear modelling analyses. These scores are reported on a scale from 0 to 1 000 with mean set of 500 and standard deviation of 100. They were named as "outcome variables" displayed in Table 3.5.

Table 3.5.

Descriptive Statistics of Level-1 Outcome Variables (Weighted) / High Schools.

LEVEL-1 OUTCOME VARIABLES			*N*	*min*	*max*	*M*	*SD*
SCIENCE		PV1SCIE	629989	161,26	733,05	428,25	81,762
		PV2SCIE	629989	178,04	704,14	427,59	81,046
		PV3SCIE	629989	198,74	698,83	428,01	81,464
		PV4SCIE	629989	115,57	705,36	427,88	81,416
		PV5SCIE	629989	183,17	710,67	428,23	81,415
SCIENCE COMPETENCIES	Identifying Scientific Issues	PV1 ISI	629989	100,83	677,38	430,74	77,366
		PV2 ISI	629989	146,52	702,09	431,04	78,009
		PV3 ISI	629989	123,21	699,76	430,33	77,021
		PV4 ISI	629989	127,87	702,56	431,05	76,910
		PV5 ISI	629989	125,08	672,25	431,20	77,252
	Explaining Phenomena Scientifically	PV1 EPS	629989	156,69	735,85	426,68	85,018
		PV2 EPS	629989	155,66	747,04	426,87	85,448
		PV3 EPS	629989	129,55	739,58	426,31	84,227
		PV4 EPS	629989	194,83	742,65	426,48	84,283
		PV5 EPS	629989	106,24	715,33	426,87	84,129
	Using Scientific Evidence	PV1USE	629989	85,73	767,55	423,29	93,590
		PV2USE	629989	92,25	762,89	423,48	93,978
		PV3USE	629989	65,21	746,10	422,98	92,943
		PV4USE	629989	95,24	733,05	423,19	92,465
		PV5USE	629989	43,77	720,00	423,88	92,498
STUDENT ATTITUDES	Interest in Learning Science	PV1 INTR	629989	165,63	988,70	538,18	103,250
		PV2 INTR	629989	193,15	956,17	539,17	103,626
		PV3 INTR	629989	140,43	942,68	538,98	103,409
		PV4 INTR	629989	140,43	915,42	539,31	104,238
		PV5 INTR	629989	165,63	921,95	538,81	103,385
	Support for Scientific Enquiry	PV1SUPP	629989	165,80	963,79	568,48	123,620
		PV2SUPP	629989	20,49	969,65	568,80	123,757
		PV3SUPP	629989	145,46	971,71	568,91	123,004
		PV4SUPP	629989	121,34	1019,61	567,94	123,765
		PV5SUPP	629989	153,51	1014,79	567,67	123,723

3.6 Missing Data

There are four different missing data in PISA study.

i) *item level non-response*: if the students and school principal was expected to answer the items, but it was not answered.

ii) *multiple and invalid responses*: if the student selected more than one one alternative answers.

iii) *not applicable:* the items that were not administered to the student. (i.e. misprinted or deleted from the questionnaire by a national center).

iv) *not reached items:* all consecutive missing values clustered at the end of test session .

In this study, missing data were deleted prior to the HLM analysis. The deliation was performed at the Multivariate Data Matrix (MDM) file creation stage. Roudenbush et al. (2004) explained the handling missing data under the Help menu of HLM6 software as:

> Missing data at level-1 of the hierarchy are deleted using listwise deletion at either MDM file creation stage or when the analysis is run. If deletion at the MDM creation stage is chosen, listwise deletion is performed based on the level-1 variables selected for inclusion in the MDM file. If deletion at the analysis stage is chosen, listwise deletion is performed based on the variables included in the actual model to be run.

3.7 Hierarchical Linear Models

Behavioral and social data generally have a hierarchical (nested) structure, that is, the individual subjects of study may be classified or arranged in groups which themselves have qualities that influence the study. In this case, the individuals can be seen as level-1 units of study, and the groups into which they are arranged are level-2 units. For example, in educational research students (level 1) are nested in schools (level 2), and the schools are nested in school districts (level 3) and similarly in sociology, individuals (level 1) are nested in neighborhoods (level 2). The analysis of such data requires specialized software. Hierarchical linear have been developed to allow for the study of relationships at any level in a single analysis, while not ignoring the variability associated with each level of the hierarchy.

The submodels, running from the simpler to the more complex, include the one-way ANOVA model with random effects, a one-way analysis of covariance (ANCOVA) model with random effects, a regression model with means-as-outcomes, random-coefficients regression model, a model with intercepts-and-slopes-as-outcomes and a model with nonrandomly varying slopes.

3.7.1 One-Way ANOVA with Random Effects

The simplest hierarchical model is the one-way ANOVA model with random effects. This unconditional model provided information about if there were differences in students' proficiency among schools. This model is very similar to a one-way ANOVA model.

Student level (level 1) model is:

$$Y_{ij} = \beta_{0j} + r_{ij} \tag{3.1}$$

School level (level 2) model is:

$$\beta_{0j} = \gamma_{00} + \upsilon_{0j} \tag{3.2}$$

Mixed Model

$$Y_{ij} = \gamma_{00} + \upsilon_{0j} + r_{ij} \tag{3.3}$$

i = 1,2,3,.........,n_j students nested within j = 1,2,......., j school
where

β_{0j} = the intercept,
r_{ij} = the student level error,
γ_{00} =the grand mean (average intercept),
υ_{0j} = the random effect associated with unit j

γ_{00} is the fixed component (fixed effect) of the model. The two random components (random effects) are r_{ij} and υ_{0j}

$$r_{ij} \sim (0, \sigma^2) \tag{3.3}$$

$$\upsilon_{0j} \sim (0, \tau_{00}) \tag{3.4}$$

We assume that each level-1 error r_{ij} is normally distributed with a mean of zero and a constant level-1 variance, σ^2. This model is a random-effects model because the group effects are construed as random. Variance of the outcome is as follows:

$$\mathrm{Var}(Y_{ij}) = \mathrm{Var}(\upsilon_{0j} + r_{ij}) = \tau_{00} + \sigma^2 \tag{3.5}$$

The one-way ANOVA model is used as a preliminary step in a hierarchical data analysis. Its most important function is to provide information about the outcome variability at each of the two levels. The σ^2, parameter represents the within group variability and τ_{00} parameters represents the between-group variability.

Formally hypothesis of this model is:

$$H_0: \tau_{00} = 0 \tag{3.6}$$

The intra-class correlation coefficient can be calculated as

$$\rho = \tau_{00} / (\tau_{00} + \sigma^2) \tag{3.7}$$

It can be interpreted as the average correlation between two randomly chosen units that are in the same group (Raudenbush et al, 2002).

3.7.2 Mean-as –Outcomes Regression

This model involves the means from each of many groups as an outcome to be predicted by group characteristics.

Student level (level 1) model is:

$$Y_{ij} = \beta_{0j} + r_{ij} \tag{3.8}$$

School level (level 2) model is:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}W_{1j} + \gamma_{02}W_{2j} + \ldots\ldots + \gamma_{0Sq}W_{Sq\,j} + \upsilon_{0j} \tag{3.9}$$

$i = 1,2,3,\ldots\ldots\ldots,n_j$ students nested within $j = 1,2,\ldots\ldots,j$ school

where

β_{0j} = the intercept,
r_{ij} = the student level error,
γ_{00} = the grand mean (average intercept),
υ_{0j} = the random effect associated with unit j- deviation of unit j's mean from the grand mean, it is residual
W_S ($s= 1\ldots\ldots\ldots\ldots S_q$) = level-2 predictor

The variance in υ_{0j} (τ_{00}) is the residual or conditional variance in β_{0j} after controlling for Wj (Raudenbush et al, 2002).

i. School Level Variables Used in the Mean-as –Outcomes Model

In the present study, sixteen school level predictors were used. Eleven of the predictors were the standardized variables (school indexes) from the PISA 2006. All predictors are standardized with positive values indicating high values of the indexes except TCSHORT.

The ESCSMEAN is the average economic social cultural status of the students. This predictor is a standardized variable with positive values indicating schools that are more affluent.

The VOCATION, CLASIZ, KAYNAK and URBAN are dummy variables. The descriptive statistics of the predictors are displayed in the Table 3.6.

Table 3.6.

Descriptive Statistics of School- Level Predictors.

LEVEL-2 PREDICTORS	*N*	*min*	*max*	*M*	*SE*	*SD*
Proportion of girls at school, **PCGIRL**	150	0,00	1,00	0,43	0,018	0,220
Ratio of computers to school size, **RATCOMP**	150	0,00	0,34	0,06	0,005	0,058
School size, **SCHSIZE**	150	50	4884	1008,29	58,767	719,750
School academic selectivity recoded, **SELECT**	150	1	4	2,23	0,088	1,077
Teacher-student ratio, **STRATIO**	148	1,89	48,33	18,44	0,668	8,131
School activities for learning environmental topics, **ENVLEARN**	148	-2,27	1,39	0,17	0,081	0,985
Responsibility for resource allocation - School: Central Authority, **RESPRES**	150	-1,10	-0,26	-0,99	0,010	0,118
Responsibility for curriculum & assessment - School: Central Authority, **RESPCURR**	150	-1,40	1,27	-0,96	0,047	0,578
School activities to promote the learning of science, **SCIPROM**	149	-2,27	1,64	-0,16	0,094	1,149
Quality of educational resources, **SCMATEDU**	147	-3,43	2,14	-0,74	0,079	0,962
Teacher shortage (negative scale) **TCSHORT**	146	-1,06	3,62	1,33	0,099	1,196
Mean of index of economic, social and cultural status , **ESCSMEAN**	150	-2,43	0,75	-1,24	0,048	0,591
		Aggregated variable from student level data. Average social economic cultural status of students in school.				
Vocational-general high school, **VOCATION**	150	A dummy variable. including Vocational High School=1 (frequency=62) and General High School=0 (frequency=88)				
Class size, **CLASIZ**	148	A dummy variable. including the number of students in a class fewer than 35 or equal to 35=1 (frequency=91) and the number of students in a class more than 35 =0 (frequency=57)				
Funding government **KAYNAK**	150	A dummy variable. includes 61% and higher funding of the school by government=0 (frequency= 87) and up to 60 % funding of the school by government =1 (frequency=63)				
Urban-rural high school, **URBAN**	150	A dummy variable. includes large city(population more than 100 000)=1 (frequency=81) and small town=0 (frequency=69)				

3.7.3 Random-Coefficient Regression Model with Level-1 Covariates

In this model, the level-1 predictors and dependent variables relationships within the schools were analyzed. Each school has "its own" regression equation with an intercept and a slope. The following questions are answered by using random coefficient regression model.

i) What is the average of the schools' regression equations?

ii) How much do the regression equations vary from school to school?

iii) What is the correlation between the intercepts and the slopes?

The outcome for person **i** in school **j** is denoted as Y_{ij}. This outcome is represented as a function of individual characteristics, X_{qij}, and the model error r_{ij}.
Student level (level 1) model is;

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{1ij} + \beta_{2j} X_{2ij} + \ldots\ldots\ldots\ldots + \beta_{Qj} X_{Qij} + r_{ij} \tag{3.10}$$

School level (level 2) model is;

$$\begin{aligned} \beta_{0j} &= \gamma_{00} + \upsilon_{0j} \\ \beta_{1j} &= \gamma_{10} + \upsilon_{1j} \\ \beta_{2j} &= \gamma_{20} + \upsilon_{2j} \\ &. \\ &. \\ &. \\ B_{qj} &= \gamma_{q0} + \upsilon_{qj} \end{aligned} \tag{3.11}$$

$i = 1,2,3,\ldots\ldots\ldots,n_j$ students nested within $j = 1,2,\ldots\ldots, j$ school

where

β_{qj} = distributive effects (the mean achievement in school j) $q = 0\ldots\ldots\ldots Q$
r_{ij} = the student level error, $r_{ij} \sim N(0, \sigma^2)$

i. Centering of the Outcome Variables

The meaning of the intercept in de level-1 model depends on the location of the level-1 predictor variables (Xs).The intercept, β_{0j}, is defined as the expected outcome for a student attending school j who has the value of zero on X_{ij}. To account for variation in β_{0j}, the choice of a metric for all level-1 predictors becomes important. Two of the four possibilities for the location of the X are centering around the grand mean and centering around the group mean.

**Centering around the grand mean* is often useful to center the variable X around the grand mean. The level-1 predictors are of the form

$$(X_{ij} - \overline{X}_{..}) \qquad (3.12)$$

In this case, the intercept, β_{0j}, is the expected outcome for a subject whose value on X_{ij} is equal to grand mean $\overline{X}$...The grand mean centering yields an intercept that can be interpreted as an adjusted mean for group j.

The $Var(\beta_{0j}) = \tau_{00}$ is the variance among the level-2 units in the adjusted means.

**Centering around the group mean* is to center the original predictors around their corresponding level-2 unit means:

$$(X_{ij} - \overline{X}_{.j}). \qquad (3.13)$$

In this case, the intercept, β_{0j}, becomes the unadjusted mean for group j.

$$\beta_{0j} = \mu_{Yj} \qquad (3.14)$$

In the present study, when a covariate is introduced at the level-1, it was centered around the group mean for that variable. (Raudenbush et al, 2002).

ii. Student Level Variables of Random-Coefficient Regression Model with Level- Covariates

The twenty-seven student level outcomes were used. Twenty-four of the outcomes were the standardized variables (students' indexes) from the PISA 2006. All outcome variables are standardized with positive values indicating high values of the indexes.

The DİL, VOCATION and GENDER are dummy variables. The descriptive statistics of the predictors are displayed in the Table 3.7.a.

Table 3.7.

Descriptive Statistics of Student-Level Variables (Weighted).

LEVEL-1 VARIABLES	*N*	*min*	*max*	*M*	*SE*	*SD*
Student information on science-related careers, **CARINFO**	626866	-2,44	2,53	0,29	0,001	1,087
School preparation for science-related careers, **CARPREP**	627220	-2,92	1,96	-0,15	0,001	1,150
Cultural possessions at home , **CULTPOSS**	626816	-1,56	1,27	0,00	0,001	0,939
Awareness of environmental issues , **ENVAWARE**	628929	-3,44	3,01	0,11	0,001	0,998
Environmental optimism, **ENVOPT**	628367	-1,61	2,85	-0,10	0,002	1,260
Perception of environmental issues, **ENVPERC**	627467	-4,11	1,39	0,93	0,001	0,811
Index of economic, social and cultural status , **ESCS**	628912	-4,42	2,10	-1,22	0,001	1,082
General value of science, **GENSCIE**	628305	-3,66	2,19	0,50	0,001	1,076
Home educational resources, **HEDRES**	629039	-4,33	1,38	-0,62	0,002	1,297
Index of home possessions, **HOMEPOSS**	629859	-5,88	2,86	-1,03	0,001	1,141
Instrumental motivation in science, **INSTSCIE**	619547	-2,10	1,82	0,33	0,001	0,975
General interest in learning science, **INTSCIE**	628663	-3,14	3,29	0,24	0,001	0,954
Enjoyment of science, **JOYSCIE**	629531	-2,15	2,06	0,42	0,001	0,974

Table 3.7. a Continued).

Descriptive Statistics of Student-Level Variables (Weighted).

LEVEL-1 VARIABLES	*N*	*min*	*max*	*M*	*SE*	*SD*
Personal value of science, **PERSCIE**	628234	-3,08	2,53	0,32	0,001	1,028
Responsibility for sustainable development, **RESPDEV**	628375	-4,00	2,30	0,79	0,001	1,071
Science Teaching -Focus on applications or models, **SCAPPLY**	618472	-2,46	2,63	,07	,001	1,100
Science Teaching - Hands-on activities, **SCHANDS**	621766	-2,10	2,91	,03	,001	1,123
Science activities, **SCIEACT**	629304	-1,69	3,38	,57	,001	,915
Science self-efficacy, **SCIEEFF**	628642	-3,77	3,22	,04	,001	,991
Future-oriented science motivation, **SCIEFUT**	622550	-1,42	2,27	,65	,001	1,031
Science Teaching – Interaction, **SCINTACT**	621692	-2,51	2,47	,45	,001	,924
Science Teaching - Student investigations, **SCINVEST**	618827	-1,26	3,03	,79	,001	1,010
Science self-concept, **SCSCIE**	615033	-2,36	2,24	,15	,001	1,004
Family wealth, **WEALTH**	629859	-3,87	2,30	-1,47	,001	1,006
Language at home, **DIL**	626254	A dummy variable. including Turkish =1 (frequency=613 022) and other=0 (frequency=13 231)				
Vocational school, **VOCATION**	629989	A dummy variable. including Vocational High School=1 (frequency=270 395) and General High School=0 (frequency=359 594)				
Gender, **GENDER**	629989	A dummy variable. including Female=1 (frequency=288 694) and Male=0 (frequency=341296)				

3.8 Software Packages Used in the Dissertation

For this study, the software program HLM 6, Hierarchical Linear and Nonlinear Modeling (Raudenbush, Bryk, & Congdon, (c), 2000), which carries out the complex calculations associated with fitting HLMs was used. HLM6 program is designed to handle the PISA data structure, which incorporates five plausible values for each assessed student. The analysis procedure for each model is run five times, once for each set of plausible variable in the model. The final estimates are the averages of the results from the five different analyses (Broun et al, 2006 cited in Mislevy et al. 1992).

SPSS for Windows 11.5, 2002 was used for hierarchical linear modeling and descriptive statistics.

3.9 Limitation of the study

The present study can directly be exposed the limitation of PISA 2006 Turkish data. PISA data are subjected to two types of error: nonsampling and sampling errors. Nonsampling errors can be due to errors made in the collection and processing the data. The sources of nonsampling errors are population coverage limitations, nonresponse bias, measurement error; data collection error and data processing error (Baldi et al., 2007).

Sampling errors can take place because the data were collected from a sample rather than population. The sampling errors occur when a conflict between a population characteristics and the sample. The size of the sample relative to the population and the variability of the population characteristics might influence the magnitude of the sampling error.

A nonsampling error might be due to translation and misconception of items of index of teacher shortage-TCSHORT. This index was derived from items measuring the school principals' perceptions of potential factors hindering instruction at school

(Appendix B). The items were collected via the PISA School Questionnaire which was completed by the school principal. There are problems with the data generated in response to the items. First, teacher shortage/inadequacy conflates two different phenomena. It is impossible to discern from individual responses whether a principal answer relates to shortage, inadequacy or a combination of the two. Second, it is unclear how a principal would be able to assess whether any of these problems hindered the learning of students in their schools (White et al., 2005).

CHAPTER 4

RESULTS

This chapter of the dissertation is devoted to the presentation of the results from the Hierarchical Linear Modeling (HLM). The results of four HLM models are given for the scientific literacy skills; combined science scale, identifying scientific issues scale, explaining phenomena scientifically scale, using scientific evidence scale, interest in learning science scale and support for scientific enquiry scale.

4.1 Hierarchical Linear Modeling (HLM) Analyses

The scientific literacy skills of Turkish students were analyzed by using four different models. The models were given in four section: one -way analyses of variance with random intercept model, means-as-outcome model, random coefficient model and an intercepts- and slopes –as-outcomes model: the effects of school and students.

4.1.1 One -Way Analyses of Variance with Random Intercept Model

One-way ANOVA produces useful preliminary information about how much variation in the dependent variable lies within and between schools and about the reliability of each school's sample mean as an estimate of its true population mean.

In the present study, the one-way ANOVA model was firstly restructured for all PISA 2006 Turkish sample including primary schools, general high schools and vocational high schools. Then it was executed only for high schools data, including general high schools and vocational high schools to see the variation in the high schools. Because of the advanced regression models, the ANOVA model was executed two times. The predictor of VOCATION took part in both student level model and school level model. This dummy variable was acceptable only for high schools. It was coded "1" for vocational high school and "0" for general high school. The primary school and primary schools' students disappeared in the advance regression models as "missing data". Therefore, the ANOVA model was secondly executed for Turkish data without primary schools.

The research questions for the one-way ANOVA model are;

i) How much do Turkish schools (high schools) vary in their mean "combined science" score?

ii) How much do Turkish schools (high schools) vary in their mean "identifying scientific issues" score?

iii) How much do Turkish schools (high schools) vary in their mean "explaining phenomena scientifically" score?

iv) How much do Turkish schools (high schools) vary in their mean "using scientific evidence" score?

v) How much do Turkish schools (high schools) vary in their mean "interest in learning science" score?

vi) How much do Turkish schools (high schools) vary in their mean "support for scientific enquiry" score?

The level-1 and level-2 models are the same as previously explained equation 3.1 and equation 3.2.

The level-1 model

$$Y_{ij} = \beta_{0j} + r_{ij} \qquad (3.1)$$

The level-2 model

$$\beta_{0j} = \gamma_{00} + \upsilon_{0j} \qquad (3.2)$$

4.1.1.1 One-Way ANOVA Model for All Turkish Schools

Table 4.1 displays the results of one-way analyses of variance with random intercept models for all Turkish students. The table contains the fixed effects for science, competencies of science and altitudes towards science. The student and school fixed effects- γ_{00}, that is, estimate of the grand mean achievement, were shown in "Coeff." column. Student fixed effect is the average value of the dependent variable across all individuals. School fixed effect is the average value of the school means. In other words, the mean of Turkish students' combined science score is 423.84 and the average of mean of Turkish schools' combined science score is 413.71. All fixed effects are significant for the one-way ANOVA model. The average attitudinal scores of Turkish students are the highest of the scientific literacy skills.

Table 4.1.

Final Estimation of Fixed Effects of Scientific Literacy for All Turkish PISA 2006 Students.

			Coeff.	*SE*	*T-ratio*	*df*	*p*
	Science - Intercept,	Students	423.84	5.22	81.27	4941	0.000
		School	413.71	6.51	63.56	159	0.000
Competencies	*Identifying scientific issues-Intercept, γ_{00}*	Students	427.49	4.65	91.99	4941	0.000
		School	417.28	6.04	69.12	159	0.000
	Explaining phenomena scientifically-Intercept,	Students	423.00	5.34	79.26	4941	0.000
		School	414.55	6.87	60.30	159	0.000
	Using scientific evidence-Intercept, γ_{00}	Students	417.20	6.13	68.06	4941	0.000
		School	402.55	8.34	48.26	159	0.000
Attitudes	*Interest in learning science - Intercept, γ_{00}*	Students	539.92	2.68	201.58	4941	0.000
		School	540.60	2.84	190.09	159	0.000
	Support for scientific enquiry-Intercept, γ_{00}	Students	562.92	4.11	136.89	4941	0.000
		School	554.25	6.10	90.91	159	0.000

This unconditional model partitions variation in the dependent variable into two components: between classes (Var (υ_{0j}) = τ_{00}) and within classes (Var (r_{ij}) = σ^2) The final estimations of variance components and the intra-class correlation coefficient for this model are given in Table 4. 2. The student level variability for combined science score (σ^2) is 2862.61 and the school level variability (τ_{00}) is 3904.14. So intra-class correlation can be calculated as 0.58. Intra-class correlation coefficient indicates that 58% of the variance in combined science score explained by the grouping structure in the population. It can also be interpreted as the average correlation between two randomly chosen students in the same school. The intra-class correlation coefficients of combined science score and the intra-class correlation coefficients of science competencies are high in contrast to the intra-class correlation coefficients of attitudes of the students towards science.

Table 4.2.

Final Estimation of Variance Components and Intra-Class Correlation Coefficient of Scientific Literacy for All Turkish PISA 2006 Students.

		Sigma_ squared *(σ^2)*	*Tau* *(τ_{00})*	*Intra-class correlation coefficient* $\rho = \tau_{00} / (\tau_{00} + \sigma^2)$
	Science - Intercept,	2862.61	3904.14	0.58
Competencies	*Identifying scientific issues-Intercept,*	2874.29	3260.47	0.53
	Explaining phenomena scientifically-Intercept,	3203.12	4100.82	0,56
	Using scientific evidence-Intercept,	3806.39	5742.10	0.60
Attitudes	*Interest in learning science - Intercept,*	8899.63	634.82	0.07
	Support for scientific enquiry-Intercept,	12652.54	2175.62	0.15

The measurement of the variation among schools in their mean science literacy scores can be calculated. Under the normality assumption, 95% of the school means falls within the range:

$$\hat{Y}_{00} \pm 1.96\,(\hat{T}_{00})^{1/2} \tag{4.1}$$

Table 4.3 displays the ranges of schools' means of the combined science scores, the ranges of schools' means of the science competencies scores and the ranges of schools' means of altitudes towards science scores. The means 291.24 and 536.18 indicate a substantial range in the levels of average combined science score among schools.

Table 4.3.

The Ranges of Mean Scientific Literacy Skills of Turkish Schools.

		$\hat{Y}_{00} \pm 1.96\,(\hat{T}_{00})^{1/2}$	*95%of the school means to fall within the range*
	Science - Intercept,	$(413.71) \pm 1.96*(3904.14)^{1/2}$	(291.24, 536.18)
Competencies	*Identifying scientific issues- Intercept,*	$(417.28) \pm 1.96*(3260.47)^{1/2}$	(305.36, 529.20)
	Explaining phenomena scientifically-Intercept,	$(414.55) \pm 1.96*(4100.82)^{1/2}$	(289.04, 540.06)
	Using scientific evidence- Intercept,	$(402.55) \pm 1.96*(5742.10)^{1/2}$	(254.03, 551.07)
Attitudes	*Interest in learning science - Intercept,*	$(540.60) \pm 1.96*(634.82)^{1/2}$	(491.22, 589.98)
	Support for scientific enquiry-Intercept,	$(554.25) \pm 1.96*(2175.62)^{1/2}$	(462.83, 645.67)

4.1.1.2 One-Way ANOVA Model except Primary School

The fixed effects of one-way ANOVA model for Turkish high school students are displayed in Table 4.4.

Table 4.4.
Final Estimation of Fixed Effects of Scientific Literacy Skills of Turkish High Schools Students.

			Coeff.	*SE*	*T-ratio*	*df*	*p*
	Science - Intercept,	Students	428.00	5.15	83.04	4825	0.000
		School	424.95	5.34	79.62	149	0.000
Competencies	*Identifying scientific issues-Intercept,* γ_{00}	Students	430.88	4.65	92.71	4825	0.000
		School	427.64	5.09	84.07	149	0.000
	Explaining phenomena scientifically-Intercept,	Students	426.64	5.28	80.78	4825	0.000
		School	423.71	5.41	78.33	149	0.000
	Using scientific evidence-Intercept, γ_{00}	Students	423.37	5.87	72.07	4825	0.000
		School	420.05	6.03	69.63	149	0.000
Attitudes	*Interest in learning science - Intercept,* γ_{00}	Students	538.89	2.68	201.25	4825	0.000
		School	538.99	2.69	200.34	149	0.000
	Support for scientific enquiry-Intercept, γ_{00}	Students	568.37	3.66	155.40	4825	0.000
		School	567.62	3.63	156.16	149	0.000

The mean of students' combined science score is 428.00 and the average of mean of schools' combined science score is 424.95. All fixed effects are significant for the one-way ANOVA model. Considering combined science score and science competencies scores, the highest average of the schools' mean belonged to identifying scientific issues. The average mean of schools' interest in learning science and support for scientific enquiry are the highest, considering scientific literacy skills.

The final estimations of variance components and the intra-class correlation coefficient for high school students are given in the following table. The intra-class correlation coefficients in the Table 4.5 were smaller than all PISA 2006 Turkish samples (Table 4.2), as expected.

Table 4.5.

Final Estimation of Variance Components and Intra-Class Correlation Coefficient of Scientific Literacy Skills of Turkish High Schools Students.

		Sigma_ squared (σ^2)	*Tau* (τ_{00})	*Intra-class correlation coefficient* $\rho = \tau_{00} / (\tau_{00} + \sigma^2)$
	Science - Intercept,	3125.20	3419.02	0.52
Competencies	*Identifying scientific issues-Intercept,*	3116.72	2887.70	0.48
	Explaining phenomena scientifically-Intercept,	3510.08	3517.15	0.50
	Using scientific evidence-Intercept,	4107.90	4454.80	0.52
Attitudes	*Interest in learning science - Intercept,*	9933.71	617.56	0.06
	Support for scientific enquiry-Intercept,	13691.92	1304.19	0.09

In Table 4.6, ranges of the high schools' means, ranges of the high schools' science competencies means and ranges of the high schools' altitudes towards science means are displayed.

Table 4.6

The Ranges of Turkish High Schools Means.

		$\hat{Y}_{00} \pm 1.96\,(\hat{T}_{00})^{1/2}$	*95%of the school means to fall within the range*
	Science - Intercept,	$(424.95) \pm 1.96*(3419.02)^{1/2}$	(366.48, 483.42)
Competencies	*Identifying scientific issues-Intercept,*	$(427.64) \pm 1.96*(2887.70)^{1/2}$	(373.90, 481.38)
	Explaining phenomena scientifically-Intercept,	$(423.71) \pm 1.96*(3517.15)^{1/2}$	(364.40, 483,02)
	Using scientific evidence-Intercept,	$(420.05) \pm 1.96*(4454.80)^{1/2}$	(353.31, 486.79)
Attitudes	*Interest in learning science - Intercept,*	$(538.99) \pm 1.96*(617.56)^{1/2}$	(514.14, 563.84)
	Support for scientific enquiry-Intercept,	$(567.62) \pm 1.96*(1304.19)^{1/2}$	(531.51, 603.73)

The range between means of Turkish high schools means in the combined science is 117.94 points. The range between means of Turkish high schools means in the interest in learning science and support for scientific enquiry are 49.70 and 72.22 respectively.

4.1.1.3 The Findings from One-Way ANOVA Models

1. The performance of *schools* being enrolled 15-year-old students were significantly different in their mean combined science score, identifying scientific issues score, explaining phenomena scientifically score, using scientific evidence score, interest in learning science score and support for scientific enquiry score.

2. The performance of *high schools* being enrolled 15-year-old students were significantly different in their mean combined science score, identifying scientific issues score, explaining phenomena scientifically score, using scientific evidence score, interest in learning science score and support for scientific enquiry score.

3. The intra-class correlation coefficients of combined science and science competencies of *high schools* in Turkey are about 0.50. It indicates that 50% of the variance in combined science and science competencies explained by the grouping structure in the population.

4. The intra-class correlation coefficients of science attitudes of *high schools* in Turkey are between 0.06 and 0.09.

4.1.2 Means-As-Outcome Models

In means-as-outcome model, the students' level equation remained unchanged. The students' scientific literacy scores were viewed as varying around their school means. Each schools means were elaborated and predicted by the school level variables; *Proportion of girls at school;* ***PCGIRL,*** *Ratio of teacher-student ratio;,* ***STRATIO*** *Computers to school size;* ***RATCOMP,*** *School size;* ***SCHSIZE,*** *School academic selectivity recode;,* ***SELECT,*** *School activities for learning environmental topic;,* ***ENVLEARN,*** *Responsibility for resource allocation - School: central authority;* ***RESPRES,*** *Responsibility for curriculum & assessment - School: central authority;* ***RESPCURR,*** *School activities to promote the learning of science;* ***SCIPROM,*** *Quality of educational resources;* ***SCMATEDU,*** *Teacher shortage (negative scale);* ***TCSHORT,*** *Mean of index of economic, social and cultural status;* ***ESCSMEAN,*** *Vocational-General high school;* ***VOCATION,*** *Class size;* ***CLASIZ, KAYNAK,*** *Urban-Rural high school;* ***URBAN.***

The level-1 model and level-2 model of means-as-outcome are the application of the equations 3.8 and 3.9 respectively.

The combination of student-level model and school-level model is;

$$(Y) = \gamma_{00} + \gamma_{01}*\text{ (PCGIRL)} + \gamma_{02}*\text{(RATCOMP)} + \gamma_{03}*\text{(SCHSIZE)} + \gamma_{04}*\text{(SELECT)} + \gamma_{5}*\text{(STRATIO)} + \gamma_{06}*\text{(ENVLEARN)} + \gamma_{07}*\text{(RESPRES)} + \gamma_{08}*\text{(RESPCURR)} + \gamma_{09}*\text{(SCIPROM)} + \gamma_{10}*\text{ (SCMATEDU)} + \gamma_{11}*\text{(TCSHORT)} + \gamma_{12}*\text{(ESCSMEAN,)} + \gamma_{13}*\text{(VOCATION)} + \gamma_{14}*\text{(CLASIZ)} + \gamma_{15}*\text{(KAYNAK)} + \gamma_{16}*\text{(URBAN)} + \upsilon_0 + r \quad (4.2)$$

The means as outcome model were reconstructed for all Turkish PISA 2006 sample. However, because of the school level variable of VOCATION, primary school data were not included in the model.

The research questions for the means as outcome model are;

i) How characteristics of the school were related to "students' combined science" score?

ii) How characteristics of the school were related to "students' identifying scientific issues" score?

iii) How characteristics of the school were related to "students' explaining phenomena scientifically" score?

iv) How characteristics of the school were related to "students' using scientific evidence" score?

v) How characteristics of the school were related to "students' interest in learning science" score?

vi) How characteristics of the school were related to "students' support for scientific enquiry" score?

The models were reconstructed for the combined science scale, identifying scientific issues scale, explaining phenomena scientifically scale, using scientific evidence scale, interest in learning science scale and support for scientific enquiry scale separately. The significant school level characteristic can be found in Table E.1. for each scientific literacy skills.

4.1.2.1 Combined Science

The effects of school- level measures of *school academic selectivity recoded,* **SELECT,** *teacher shortage* (negative scale), **TCSHORT,** *mean of index of economic, social and cultural status*, **ESCSMEAN,** and *vocational-general high school*, **VOCATION** on combined science score were significant. Therefore, following equation can be written for combined science.

$$\text{Combined Science (Y)} = \gamma_{00} + \gamma_{01}*(\text{SELECT}) + \gamma_{02}*(\text{TCSHORT}) + \gamma_{03}*(\text{ESCSMEAN}) + \gamma_{04}*(\text{VOCATION}) + \upsilon_0 + r \quad (4.3)$$

Table 4.7 provides estimates for the fixed effect. There are significant association between combined science score and school academic selectivity recoded ($\hat{Y}_{01}$=13.90, *SE* =3.59), combined science score and teacher shortage ($\hat{Y}_{02}$=5.56, *SE* =2.07), combined science score and mean of index of economic, social and cultural status ($\hat{Y}_{03}$=59.65, *SE* =6.69). There is also positive effect of general high schools on combined science score- the average combined science of general high school is 25.38 units higher than the average combined science of vocational schools.
(Note: This interpretation depends on the fact that all of the level-2 predictors expect the dummy variable VOCATION were standardized. It can be seen in Chap 3).

Table 4.7.
Results from the Means-as-Outcome Model (Combined Science).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1,	β_0					
INTRCPT2,	γ_{00}	438.49	4.02	109.12	134	0.000
SELECT,	γ_{01}	13.90	3.59	3.87	134	0.000
TCSHORT,	γ_{02}	5.56	2.07	2.69	134	0.009
ESCSMEAN,	γ_{03}	59.65	6.69	8.92	134	0.000
VOCATION,	γ_{04}	-25.38	7.21	-3.52	134	0.001

Within school variance (σ^2) = 3157.64
The overall variability among the true school mean (τ_{00}) = 1094.77

After controlling for the school level effects of SELECT, TCSHORT, ESCSMEAN and VOCATION, the residual variance between schools, τ_{00}= 1094.77, is substantially smaller than the original variance, estimated in the random ANOVA model (τ_{00}= 3419.02). To compare the τ_{00} estimates across the two models, proportion reduction in variance or variance explained at school level can be calculated.

Proportion of variance
explained by in β_{0j} $= [\tau_{00\,(ANOVA)} - \tau_{00\,(OUTCOME)}] / \tau_{00\,(ANOVA)}$ (4.4)

$= (3419.02-1094.77) / 3419.02$

$= 0.68$

That is, 68% of the true between school variance in science knowledge was accounted for by the SELECT, TCSHORT, ESCSMEAN, and VOCATION.

4.1.2.2 Identifying Scientific Issues

Each school's mean of the identifying scientific issues is predicted significantly by *proportion of girls at school,* **PCGIRL,** *school academic selectivity recoded,* **SELECT,** *mean of index of economic, social and cultural status,* **ESCSMEAN** and *vocational-general high school,* **VOCATION.**
The combination of level-1 model and level-2 model is:

$$\text{Identifying Scientific Issues (Y)} = \gamma_{00} + \gamma_{01}*(\text{PCGIRLS}) + \gamma_{02}*(\text{SELECT}) + \gamma_{03}*(\text{ESCSMEAN}) + \gamma_{04}*(\text{VOCATION}) + \upsilon_0 + r \quad (4.5)$$

Table 4.8 provides estimates for the fixed effects. There are significant association between identifying scientific issues and proportion of girls at school, ($\hat{Y}_{01}$=42.38, *SE* =13.69), identifying scientific issues and school academic selectivity recoded ($\hat{Y}_{02}$=10.33, *SE* =3.35), identifying scientific issues and mean of index of economic, social and cultural status ($\hat{Y}_{03}$=46.87, *SE*=7.34). There is also positive effect of general high schools on identifying scientific issues - the average performance of identifying scientific issues of general high school is 22.22 units higher than for vocational schools.

(Note: This interpretation depends on the fact that all of the level-2 predictors expect the dummy variable VOCATION were standardized. It can be seen in Chap 3).

Table 4.8.

Results from the Means-as-Outcome Model (Identifying Scientific Issues).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1, β_0						
INTRCPT2,	γ_{00}	439.99	4.07	108.11	134	0.000
PCGIRLS	γ_{01}	42.38	13.69	3.10	134	0.003
SELECT,	γ_{02}	10.33	3.35	3.08	134	0.003
ESCSMEAN,	γ_{03}	46.87	7.34	6.38	134	0.000
VOCATION,	γ_{04}	-22.22	7.22	-3.08	134	0.003

Within school variance (σ^2) = 3149.33

The overall variability among the true school mean (τ_{00}) = 1151.05

The residual variance between schools, τ_{00}= 1151.05, was substantially smaller than the original, τ_{00}= 2887.70 estimated in the random ANOVA model. To compare the τ_{00} estimates across the two models, proportion reduction in variance or variance explained at school level can be calculated.

Proportion of variance explained by in β_{0j} $= [\tau_{00\,(ANOVA)} - \tau_{00\,(OUTCOME)}]/\tau_{00\,(ANOVA)}$ (4.4)

$= (2887.70-1151.05) / 2887.70$

$= 0.60$

That is, 60% of the true between school variance in identifying scientific issues was accounted for by the PCGIRLS, SELECT, ESCSMEAN and VOCATION.

4.1.2.3 Explaining Phenomena Scientifically

The school level model of each school's mean of explaining phenomena scientifically is predicted significantly by *school size,* **SCHSIZE,** *school academic selectivity recoded,* **SELECT,** *teacher shortage (negative scale)* **TCSHORT,** *mean of index of economic, social and cultural status* **,ESCSMEAN** and *vocational-general high school,* **VOCATION.**

The combination of level-1 model and level-2 model is:

$$\text{Explaining Phenomena Scientifically (Y)} = \gamma_{00} + \gamma_{01}*(\text{SCHSIZE}) + \gamma_{02}*(\text{SELECT}) + \gamma_{03}*(\text{TCSHORT}) + \gamma_{04}*(\text{ESCSMEAN}) + \gamma_{05}*(\text{VOCATION}) + \upsilon_0 + r \qquad (4.6)$$

Table 4.9 provides estimates for the fixed effects. There are significant association between explaining phenomena scientifically and school size, ($\hat{Y}_{01}$= -0.01, *SE* = 0.00), explaining phenomena scientifically and school academic selectivity recoded ($\hat{Y}_{02}$=14.55, *SE* = 3.84), explaining phenomena scientifically and teacher shortage (negative scale) ($\hat{Y}_{03}$=5.69, *SE* =2.12).explaining phenomena scientifically and mean of index of economic, social and cultural status ($\hat{Y}_{04}$=59.73, *SE* =7.47). There is also positive effect of general high schools on explaining phenomena scientifically - the average explaining phenomena scientifically of general high school is 28.12 units higher than for vocational schools.

(Note: This interpretation depends on the fact that all of the level-2 predictors expect the dummy variable VOCATION were standardized. It can be seen in Chap 3).

Table 4.9.

Results from the Means-as-Outcome Model (Explaining Phenomena Scientifically).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1, β_0						
INTRCPT2,	γ_{00}	437.80	4.45	98.29	133	0.000
SCHSIZE	γ_{01}	-0.01	0.00	-3.18	133	0.002
SELECT,	γ_{02}	14.55	3.84	3.78	133	0.000
TCSHORT,	γ_{03}	5.69	2.12	2.68	133	0.009
ESCSMEAN,	γ_{04}	59.73	7.47	7.99	133	0.000
VOCATION,	γ_{05}	-28.12	7.64	-3.68	133	0.001

Within school variance **(σ^2)** = 3561.52

The overall variability among the true school mean **(τ_{00})** = 1166.38

The residual variance between schools, τ_{00}= 1166.38, is substantially smaller than the original, τ_{00}= 3517.15 estimated in the random ANOVA model. To compare the τ_{00} estimates across the two models, proportion reduction in variance or variance explained at school level can be calculated.

Proportion of variance explained by in β_{0j} $= [\tau_{00\,(ANOVA)} - \tau_{00\,(OUTCOME)}] / \tau_{00\,(ANOVA)}$ (4.4)

$= (3517.15-1166.38) / 3517.15$

$= 0.67$

That is, 67% of the true between school variance in explaining phenomena scientifically was accounted for by the SCHSIZE, SELECT, TCSHORT, ESCSMEAN and VOCATION.

4.1.2.4 Using Scientific Evidence

The student-level model specified that the using scientific evidence varied among students within a school. In the second level, model each school's mean is predicted significantly by *school academic selectivity recoded,* **SELECT,** *teacher shortage* *(negative scale)* **TCSHORT,** *mean of index of economic, social and cultural status* ,**ESCSMEAN** and *vocational-general high school,* **VOCATION.**

The combination of level-1 model and level-2 model is:

$$\text{Using Scientific Evidence (Y)} = \gamma_{00} + \gamma_{01}*(\text{SELECT}) + \gamma_{02}*(\text{TCSHORT}) + \gamma_{03}*(\text{ESCSMEAN}) + \gamma_{04}*(\text{VOCATION}) + \upsilon_0 + r \quad (4.7)$$

Table 4.10 provides estimates for the fixed effect. There are significant association between using scientific evidence and school academic selectivity recoded ($\hat{Y}_{01}$=14.77, *SE* = 3.89), using scientific evidence and teacher shortage (negative scale) ($\hat{Y}_{02}$= 6.71, *SE* = 2.52), using scientific evidence and mean of index of economic, social and cultural status ($\hat{Y}_{03}$=67.48, *SE* =7.39). There is also positive effect of general high schools on using scientific evidence - the average using scientific evidence of general high school is 33.96units higher than for vocational schools.

(Note: This interpretation depends on the fact that all of the level-2 predictors expect the dummy variable VOCATION were standardized. It can be seen in Chap 3).

Table 4.10.

Results from the Means-as-Outcome Model (Using Scientific Evidence).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1, β_0						
INTRCPT2,	γ_{00}	437.04	4.28	102.166	134	0.000
SELECT,	γ_{01}	14.77	3.89	3.79	134	0.000
TCSHORT,	γ_{02}	6.71	2.52	2.66	134	0.009
ESCSMEAN,	γ_{03}	67.48	7.39	9.13	134	0.000
VOCATION,	γ_{04}	-33.96	7.88	-4.31	134	0.000

Within school variance (σ^2) = 4171.01

The overall variability among the true school mean (τ_{00}) = 1393.64

The residual variance between schools, τ_{00}= 1393.64, is substantially smaller than the original, τ_{00}= 4454.80 estimated in the random ANOVA model. To compare the τ_{00} estimates across the two models, proportion reduction in variance or variance explained at school level can be calculated.

Proportion of variance
explained by in β_{0j} $= [\tau_{00\,(ANOVA)} - \tau_{00\,(OUTCOME)}] / \tau_{00\,(ANOVA)}$ (4.4)

$= (4454.80\text{-}1393.64) / 4454.80$

$= 0.69$

That is, 69% of the true between school variance in using scientific evidence was accounted for by the SELECT, TCSHORT, ESCSMEAN and VOCATION.

4.1.2.5 Interest in Learning Science

The student-level model specified that the interest in learning science varied among students within a school. In the second level model, each school's mean was predicted significantly by mean of *index of economic, social and cultural status*, **ESCSMEAN.** The combination of level-1 model and level-2 model is:

Interest in Learning Science (Y) = $\gamma_{00} + \gamma_{01}$*(ESCSMEAN) + υ_0 + r (4.8)

Table 4.11 provides estimates for the fixed effects. There are significant association between interest in learning science and mean of index of economic, social and cultural status ($\hat{Y}_{01}$= -19.46, *SE* = 4.96).

(Note: This interpretation depends on the fact that all of the level-2 predictors were standardized. It can be seen in Chap 3).

Table 4.11.

Results from the Means-as-Outcome Model (Interest in Learning Science).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1, β_0						
INTRCPT2,	γ_{00}	539.91	2.53	213.10	137	0.000
ESCSMEAN,	γ_{01}	-19.46	4.96	-3.92	137	0.000
Within school variance (σ^2) = 10073.46						
The overall variability among the true school mean (τ_{00}) = 475.23						

The residual variance between schools, τ_{00}= 475.23, is smaller than the original, τ_{00}= 617.56 estimated in the random ANOVA model. To compare the τ_{00} estimates across the two models, proportion reduction in variance or variance explained at school level can be calculated.

Proportion of variance explained by in β_{0j} $= [\tau_{00\,(ANOVA)} - \tau_{00\,(OUTCOME)}] / \tau_{00\,(ANOVA)}$ (4.4)

$= (617.56\text{-}475.23) / 617.56$

$= 0.23$

That is, 23% of the true between school variance in interest in learning science was accounted for by the ESCSMEAN.

4.1.2.6 Support for Scientific Enquiry

The student-level model specified that the support for scientific enquiry varied among students within a school. In the second level model, each school's mean was predicted by *mean of index of economic, social and cultural status*, **ESCSMEAN.** The combination of level-1 model and level-2 model is:

Support for Scientific Enquiry (Y) = $\gamma_{00} + \gamma_{01}$ *(ESCSMEAN) + υ_0 + r (4.9)

Table 4.12 provides estimates for the fixed effect. There are significant association between support for scientific enquiry and mean of index of economic, social and cultural status ($\hat{Y}_{01}$=36.56, *SE* =7.21).

(Note: This interpretation depends on the fact that all of the level-2 predictors were standardized. It can be seen in Chap 3).

Table 4.12.

Results from the Means-as-Outcome Model (Support for Scientific Enquiry).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1, β_0						
INTRCPT2,	γ_{00}	568.22	3.28	173.23	137	0.000
ESCSMEAN,	γ_{01}	36.56	7.21	5.07	137	0.000
Within school variance (σ^2) = 13900.03						
The overall variability among the true school mean (τ_{00}) = 890.59						

The residual variance between schools, τ_{00}= 890.59, is substantially smaller than the original, τ_{00}= 1304.19estimated in the random ANOVA model. To compare the τ_{00} estimates across the two models, proportion reduction in variance or variance explained at school level can be calculated.

Proportion of variance explained by in β_{0j} $= [\tau_{00\,(ANOVA)} - \tau_{00\,(OUTCOME)}] / \tau_{00\,(ANOVA)}$ (4.4)

$= (1304.19-890.59) / 1304.19$

$= 0.32$

That is, 32% of the true between school variance in support for scientific enquiry was accounted for by the ESCSMEAN.

4.1.2.7 The Findings from Means-As-Outcome Models

1. The combined science score and the science competencies scores of Turkish students were predicted by the proportion of girls at school **(PCGIRL)**, school size **(SCHSIZE)**, school academic selectivity recoded **(SELECT)**, teacher shortage (negative scale) **(TCSHORT)**, means of students' index of economic, social and cultural status **(ESCSMEAN)** and vocational high school - high school **(VOCATION)** in the means-as-outcome models. The science attitudes skills of Turkish students were only predicted by the means of students' index of economic, social and cultural status **(ESCSMEAN)**.

2. The mean of index of economic, social and cultural status; **(ESCSMEAN)**, were related to *high school* students' combined science, science competencies and science attitude scores. The relations were positively for mean achievement of combined science and science competencies. Nonetheless, even after ESCSMEAN were hold constant, schools varied significantly in their average achievement levels.

3. The proportions of variances explained by means-as-outcome models of combined science and science competencies change between 60% and 69%. The proportions of variances explained by means-as-outcome models of interest in learning science and support for scientific enquiry are 23% and 32% respectively.

4.1.3 Random Coefficient Model

Specifically, at student level the combined science, competencies of science and attitudes towards science for student i in school j (Y_{ij}) was regressed on the analysis of the independent variables; *Student information on science-related careers;* **CARINFO,** *School preparation for science-related careers*; **CARPREP,** *Cultural possessions at home;* **CULTPOSS,** *Awareness of environmental issues*; **ENVAWARE,** *Environmental optimism*; **ENVOPT,** *Perception of environmental issues*; **ENVPERC**, *Index of economic, social and cultural status*; **ESCS**, *General value of science*; **GENSCIE,** *Home educational resources;* **HEDRES,** *Index of home possessions*; **HOMEPOSS,** *Instrumental motivation in science;* **INSTSCIE,** *General interest in learning science*; **INTSCIE,** *Enjoyment of science*; **JOYSCIE,** *Personal value of science*; **PERSCIE,** *Responsibility for sustainable development;* **RESPDEV,** *Science Teaching -Focus on applications or models;* **SCAPPLY,** *Science Teaching - Hands-on activities;* **SCHANDS,** *Science activities;* **SCIEACT,** *Science self-efficacy;* **SCIEEFF,** *Future-oriented science motivation;* **SCIEFUT,** *Science Teaching – Interaction;* **SCINTACT,** *Science Teaching - Student investigations*; **SCINVEST,** *Science self-concept;* **SCSCIE,** *Family wealth;-* **WEALTH,** *Language at home;* **DIL,** *Vocational school;* **VOCATION** and *Gender;* **GENDER**.

The student-level model

$$
\begin{aligned}
(Y_{ij}) = {} & \beta_{0j} + \beta_{1j}^{*}(\text{CARINFO})_{ij} + \beta_{2j}^{*}(\text{CARPREP})_{ij} + \beta_{3j}^{*}(\text{CULTPOSS})_{ij} \\
& + \beta_{4j}^{*}(\text{ENVAWARE})_{ij} + \beta_{5j}^{*}(\text{ENVOPT})_{ij} + \beta_{6j}^{*}(\text{ENVPERC})_{ij} + \\
& \beta_{7j}^{*}(\text{ESCS})_{ij} + \beta_{8j}^{*}(\text{GENSCIE})_{ij} + \beta_{9j}^{*}(\text{HEDRES})_{ij} + \\
& \beta_{10j}^{*}(\text{HOMEPOSS})_{ij} + \beta_{11j}^{*}(\text{INSTSCIE})_{ij} + \beta_{12j}^{*}(\text{INTSCIE})_{ij} + \\
& \beta_{13j}^{*}(\text{JOYSCIE})_{ij} + \beta_{14j}^{*}(\text{PERSCIE})_{ij} + \beta_{15j}^{*}(\text{RESPDEV})_{ij} + \\
& \beta_{16j}^{*}(\text{SCAPPLY})_{ij} + \beta_{17j}^{*}(\text{SCHANDS})_{ij} + \beta_{18j}^{*}(\text{SCIEACT})_{ij} \\
& + \beta_{19j}^{*}(\text{SCIEEFF})_{ij} + \beta_{20j}^{*}(\text{SCIEFUT})_{ij} + \beta_{21j}^{*}(\text{SCINTACT})_{ij} + \\
& \beta_{22j}^{*}(\text{SCINVEST})_{ij} + \beta_{23j}^{*}(\text{SCSCIE})_{ij} + \beta_{24j}^{*}(\text{WEALTH})_{ij} + \\
& \beta_{25j}^{*}(\text{DIL})_{ij} + \beta_{26j}^{*}(\text{VOCATION})_{ij} + \beta_{27j}^{*}(\text{GENDER})_{ij} + r_{ij} \qquad (4.10)
\end{aligned}
$$

The variance of r_{ij}, σ^2, represents the residual variance at level-1 that remains unexplained after taking into account students' level predictors in equation 4.10.

The school level model is:

$$\beta_0 = \gamma_{00} + \upsilon_0$$
$$\beta_1 = \gamma_{10} + \upsilon_1$$
$$\vdots$$
$$\beta_{27} = \gamma_{270} + \upsilon_{27}$$

Where:

γ_{00} is the average of the school mean on scientific literacy across the population of schools;

γ_{10} - γ_{270} are the average predictors- scientific literacy regression slope across these schools;

υ_0 is the unique increment to the intercept associated with school j; and

υ_1- υ_{27} are the unique increment to the slope associated with school j;

The scientific literacy skills: the combined science, the identifying scientific issue, the explaining phenomena scientifically, the using scientific evidence, the interest in learning science and the supporting scientific enquiry were firstly regressed on the student-level predictors that were all group-mean centered. Then, the random coefficient models with the significant student-level variables were restructured for each scientific literacy scores.

The random coefficient regression models were reconstructed for all Turkish PISA 2006 sample. However, because of the school level variable of VOCATION, primary school data were not included in the model.

The research questions for the random coefficient regression model were;

i) What are the averages of the 149 regression equations of students' scientific literacy scores?

ii) How much do the regression equations (intercept and slopes) vary from school to school?

iii) What is the correlation between the intercept and slopes?

4.1.3.1 Combined Science

Two random coefficient models were restructured for the combined science score. The student-level variables that were all grand-mean centered were added in the first model explained in the section 4.1.3.1.1. The second model explained in the section 4.1.3.1.2, student-level variables were added group-mean centered. The purpose of the reconstructing two different combined science models are to show the differences between the grand-mean centered and group-mean centered.

4.1.3.1.1 Grand-Mean-Centered Combined Science Regression Model

At student-level model, combined science score was regressed on CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, HEDRES, INSTSCIE, SCIEEFF, SCINVEST and VOCATION. The following model is the significant application of equation 4.10.

$$\begin{aligned}\text{Combined Science (Y)} = {} & \beta_0 + \beta_1*(\text{CARPREP}) + \beta_2*(\text{ENVAWARE}) + \beta_3*(\text{ENVOPT}) \\ & + \beta_4*(\text{ENVPERC}) + \beta_5*(\text{ESCS}) + \beta_6*(\text{GENSCIE}) + \\ & \beta_7*(\text{HEDRES}) + \beta_8*(\text{INSTSCIE}) + \beta_9*(\text{SCIEEFF}) + \\ & \beta_{10}*(\text{SCINVEST}) + \beta_{11}*(\text{VOCATION}) + r\end{aligned}$$

The eight of the eleven coefficients in the student level model were specified as random in the level-2 model. Specifically;

$$\begin{aligned}\beta_0 &= \gamma_{00} + \upsilon_0 \\ \beta_1 &= \gamma_{10} + \upsilon_1 \\ \beta_2 &= \gamma_{20} + \upsilon_2 \\ \beta_3 &= \gamma_{30} + \upsilon_3 \\ \beta_4 &= \gamma_{40} + \upsilon_4\end{aligned}$$

$\beta_5 = \gamma_{50} + \upsilon_5$
$\beta_6 = \gamma_{50} + \upsilon_6$
$\beta_7 = \gamma_{60} + \upsilon_7$
$\beta_8 = \gamma_{80}$
$\beta_9 = \gamma_{90} + \upsilon_9$
$\beta_{10} = \gamma_{100}$
$\beta_{11} = \gamma_{110}$

The variance and covariance components of the model are displayed in Table 4.13. The estimated variance among the means is $\hat{T}_{00}$=1530.92. The estimated variance of level-1 predictor's slopes are; CARPREP slopes (τ_{11}) = 13.64, ENVAWARE slopes (τ_{22}) = 21.76, ENVOPT slopes (τ_{33}) = 8.22, ENVPERC slopes (τ_{44}) = 41.44, ESCS slopes (τ_{55}) = 31.36, GENSCIE slopes (τ_{66}) = 24.34, HEDRES slopes (τ_{77}) = 8.28 and SCIEEFF slopes (τ_{99}) = 30.41.

Table 4.13.
Variance-Covariance Components Matrix of the Model-Combined Science (Grand-Mean-Centered).

τ_{00}		β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_9
INTRCPT1,	β_0	1530.92								
CARPREP,	β_1	**19.07**	13.64							
		(0.13)								
ENVAWARE,	β_2	**57.67**	**-2.29**	21.76						
		(0.32)	(0.13)				Symmetric			
ENVOPT,	β_3	**44.76**	**-3.03**	**3.00**	8.22					
		(0.40)	(-0.29)	(0.22)						
ENVPERC,	β_4	**-111.32**	**-8.73**	**13.17**	**0.57**	41.44				
		(-0.44)	(-0.37)	(0.44)	(0.03)					
ESCS,	β_5	**25.99**	**-6.51**	**-0.29**	**1.26**	**1.25**	31.36			
		(0.12)	(-0.32)	(-0.01)	(0.08)	(0.04)				
GENSCIE,	β_6	**-57.64**	**-0.91**	**-7.13**	**1.19**	**-8.29**	**-9.36**	24.34		
		(-0.30)	(-0.05)	(-0.31)	(0.08)	(-0.26)	(-0.34)			
HEDRES,	β_7	**-3.22**	**-0.49**	**2.93**	**-0.29**	**6.40**	**-6.35**	**-4.24**	8.28	
		(0.03)	(-0.05)	(0.22)	(-0.04)	(0.35)	(-0.39)	(-0.30)		
SCIEEFF,	β_9	**28.29**	**0.62**	**-4.82**	**-4.12**	**-12.56**	**11.50**	**0.44**	**-6.49**	30.41
		(0.13)	(0.03)	(-0.19)	(-0.26)	(-0.35)	(0.37)	(0.02)	(-0.41)	

The bold numbers in Table 4.13 are the covariance between level-1 intercepts and slopes. The covariance value indicates how much intercepts and slopes covary. The correlation between the intercept and the slopes are displayed in the parentheses. Some of the correlations between intercept and slopes of the level-1 predictors are negative. A negative correlation can be described as one variable's values tend to increase; the other variable's values tend to decrease, that is, the higher the intercept, the smaller the slope. The correlations of ENVPERC and GENSCIE are negative. This indicates that as the school combined science score is high; the effects of ENVPERC and GENSCIE in those schools are smaller.

Table 4.14.

Results from the Random-Coefficient Model-Combined Science

(Grand-Mean-Centered).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1,						
INTRCPT2, β_0	γ_{00}	445.39	5.19	85.81	149	0.000
CARPREP, β_1	γ_{10}	-6.16	1.00	-6.17	95	0.000
ENVAWARE, β_2	γ_{20}	9.93	1.17	8.50	46	0.000
ENVOPT, β_3	γ_{30}	-7.28	0.89	-8.19	24	0.000
ENVPERC, β_4	γ_{40}	4.73	1.41	3.36	44	0.002
ESCS, β_5	γ_{50}	4.08	1.30	3.13	57	0.003
GENSCIE, β_6	γ_{60}	8.77	0.94	9.34	149	0.000
HEDRES, β_7	γ_{70}	3.49	0.87	4.02	98	0.000
INSTSCIE, β_8	γ_{80}	5.91	1.37	4.32	38	0.000
SCIEEFF, β_9	γ_{90}	8.51	1.22	7.00	56	0.000
SCINVEST, β_{10}	γ_{100}	-8.66	1.24	-6.98	31	0.000
VOCATION, B_{11}	γ_{110}	-38.81	7.09	-5.47	61	0.000

Table 4.14 provides the estimates for the average regression equation within school. The average schools' combined science was estimated as 445.39, that is, combined science score for someone with average CARPREP- School preparation for science-related careers (*M*=-0.15, *SD*=1.15), average ENVAWARE- Awareness of

environmental issues (*M*=0.11, *SD*=1.00), average ENVOPT- Environmental optimism (*M* =-0.10, *SD* =1.26), average ENVPERC- Perception of environmental issues (*M* = 0.93, *SD* = 0.81), average ESCS- Index of economic, social and cultural status (*M* =-1.22, *SD* = 1.08), average GENSCIE - General value of science (*M* = 0.50, *SD* = 1.08), average HEDRES - Home educational resources (*M* = -0.62, *SD* = 1.30), average INSTSCIE- Instrumental motivation in science (*M* = 0.33, *SD* = 0.98), average SCIEEFF - Science self-efficacy (*M* = 0.04, *SD* = 0.99) and average SCINVEST- Science Teaching - Student investigations (*M* = 0.79, *SD* = 1.01) was estimated as 445.39.

The fixed effects of the student level predictors can be also attained from the model, that is, each unit increase in a student-level predictor is associated with changes in combined science score. In terms of this model, a unit increase in ENVAWARE was associated with 9.93 unit increase in combined science score; a unit increase in SCINVEST was associated with 8.66 unit decrease in combined science score.

The student level variance has been reduced from σ^2= 3125.20 estimated in the random ANOVA model to σ^2= 2228.68, after taking into account students' outcome variables. To compare the σ^2 estimates across the two models, proportion reduction in variance or variance explained at student level can be calculated.

$$\text{Proportion of variance explained at Level -1} = [\sigma^2_{(ANOVA)} - \sigma^2_{(RAN.\ COE)}]/\sigma^2_{(ANOVA)} \quad (4.11)$$

$$= (3125.20 - 2228.68) / 3125.20$$

$$= 0.29$$

It can be seen that adding CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, HEDRES, INSTSCIE, SCIEEFF, SCINVEST and VOCATION as the predictors of combined science score reduced the within-school performance by 29%. That is, CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, HEDRES, INSTSCIE, SCIEEFF, SCINVEST and VOCATION account for about 29% of the student-level variance in the outcome.

The environmental optimism (ENVOPT) is significant only for 24 of 150 schools. The remaining 126 schools did not have within school variance on ENVOPT, which is why *df* is 24 in the Table 4.14.

4.1.3.1.2 Group-Mean-Centered Combined Science Regression Model

The combined science score was regressed on CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, HEDRES, INSTSCIE, SCHANDS, SCIEEFF and VOCATION at student model. The following model is the significant application of equation 4.13 for group-mean-centered combined science score.

$$\text{Combined Science (Y)} = \beta_0 + \beta_1\text{*(CARPREP)} + \beta_2\text{*(ENVAWARE)} + \beta_3\text{*(ENVOPT)} + \beta_4\text{*(ENVPERC)} + \beta_5\text{*(ESCS)} + \beta_6\text{*(GENSCIE)} + \beta_7\text{*(HEDRES)} + \beta_8\text{*(INSTSCIE)} + \beta_9\text{*(SCHANDS)} + \beta_{10}\text{*(SCIEEFF)} + \beta_{11}\text{*(VOCATION)} + r$$

The nine of the eleven coefficients in the student level model were specified as random in the level-2 model. Specifically;

$$\beta_0 = \gamma_{00} + \upsilon_0$$
$$\beta_1 = \gamma_{10} + \upsilon_1$$
$$\beta_2 = \gamma_{20} + \upsilon_2$$
$$\beta_3 = \gamma_{30} + \upsilon_3$$
$$\beta_4 = \gamma_{40} + \upsilon_4$$
$$\beta_5 = \gamma_{50} + \upsilon_5$$
$$\beta_6 = \gamma_{60} + \upsilon_6$$
$$\beta_7 = \gamma_{70} + \upsilon_7$$
$$\beta_8 = \gamma_{80}$$
$$\beta_9 = \gamma_{90} + \upsilon_9$$
$$\beta_{10} = \gamma_{100} + \upsilon_{10}$$
$$\beta_{11} = \gamma_{110}$$

The variance and covariance components were displayed in the Table 4.15.

Table 4.15.

Variance-Covariance Components Matrix of the Model-Combined Science (Group-Mean-Centered).

		β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_9	β_{10}
INTRCPT1,	β_0	<u>2503.52</u>									
CARPREP,	β_1	**7.17**	<u>10.64</u>								
		(0.04)									
ENVAWARE,	β_2	**63.48**	**-1.16**	<u>20.80</u>							
		(0.28)	(-0.08)								
ENVOPT,	β_3	**71.16**	**-1.55**	**2.50**	<u>11.61</u>						
		(0.42)	(-0.14)	(0.16)				**Symmetric**			
ENVPERC,	β_4	**-153.64**	**-6.61**	**11.25**	**-2.95**	<u>40.48</u>					
		(-0.48)	(-0.32)	(0.39)	(-0.14)						
ESCS,	β_5	**-33.80**	**-6.23**	**0.37**	**-0.71**	**3.62**	<u>32.36</u>				
		(-0.12)	(-0.34)	(0.01)	(-0.04)	(0.10)					
GENSCIE,	β_6	**-58.78**	**2.11**	**-4.41**	**4.05**	**-8.96**	**-6.84**	<u>26.62</u>			
		(-0.23)	(0.13)	(-0.19)	(0.23)	(-0.27)	(-0.23)				
HEDRES,	β_7	**-16.19**	**-1.83**	**1.85**	**-1.66**	**7.74**	**-3.35**	**-6.18**	<u>8.92</u>		
		(-0.11)	(-0.19)	(0.14)	(-0.16)	(0.41)	(-0.20)	(-0.40)			
SCHANDS,	β_9	**-24.38**	**-1.71**	**-2.16**	**-7.67**	**9.22**	**-5.57**	**-14.04**	**5.05**	<u>29.39</u>	
		(-0.09)	(-0.10)	(-0.09)	(-0.42)	(0.27)	(-0.18)	(-0.50)	(0.31)		
SCIEEFF,	β_{10}	**8.89**	**-1.45**	**-3.07**	**-4.82**	**-11.14**	**15.33**	**3.58**	**-5.85**	**-9.98**	<u>35.72</u>
		(0.03)	(-0.08)	(-0.11)	(-0.24)	(-0.29)	(0.45)	(0.12)	(-0.33)	(-0.31)	

The estimated variance among the means is $\hat{T}_{00}$=2503.52. The estimated variance of level-1 predictor's slopes are; CARPREP slopes (τ_{11}) = 10.64, ENVAWARE slopes (τ_{22}) = 20.80, ENVOPT slopes (τ_{33}) = 11.61, ENVPERC slopes (τ_{44})= 40.48, ESCS slopes (τ_{55}) = 32.36, GENSCIE slopes (τ_{66}) = 26.62, HEDRES slopes (τ_{77}) = 8.92, SCHANDS slopes (τ_{99}) = 29.39 and SCIEEFF slopes (τ_{1010}) = 35.72.

The bold numbers in Table 4.15 were displayed the covariance between level-1 intercepts and slopes. Tau as correlation was displayed in the parenthesis. The negative correlations between some intercept and slopes of the level-1 predictors indicated that if the school combined science score is high; the effects of ENVPERC, ESCS, GENSCIE, HEDRES and SCHANDS in those schools are smaller.

Table 4.16 provides the estimates for the average regression equation within school. The average school combined science score was estimated as 452.61. In other words, the combined science score for someone with average CARPREP- School preparation for science-related careers (*M*= -0.15, *SD* = 1.15), average ENVAWARE- Awareness of environmental issues (*M* = 0.11, *SD* = 1.00), average ENVOPT- Environmental optimism (*M* = -0.10, *SD* = 1.26), average ENVPERC- Perception of environmental issues (*M* = 0.93, *SD* = 0.81), average ESCS- Index of economic, social and cultural status (*M* = -1.22, *SD* = 1.08), average GENSCIE - General value of science (*M* = 0.50, *SD* = 1.08), average HEDRES - Home educational resources (*M* = -0.62, *SD* = 1.30), average INSTSCIE- Instrumental motivation in science (*M* = 0.33, *SD* = 0.98), average SCHANDS- Science Teaching – Hands-on activities (*M* = 0.03, *SD* = 1.12) and average SCIEEFF - Science self-efficacy (*M* = 0.04, *SD* = 0.99) was estimated as **452.61**.

The fixed effects of the student level predictors can also be attained from the model, that is, each unit increase in a student-level predictor is associated with changes in combined science score. In terms of this model, a unit increase in ENVAWARE is associated with 9.50 unit increase in combined science score; a unit increase in SCHANDS is associated with 7.62 unit decrease in combined science score.

Table 4.16.

Results from the Random-Coefficient Model -Combined Science (Group-Mean-Centered).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1,						
INTRCPT2, β_0	γ_{00}	452.61	6.49	69.75	149	0.000
CARPREP, β_1	γ_{10}	-6.43	0.92	-6.99	88	0.000
ENVAWARE, β_2	γ_{20}	9.50	1.17	8.11	41	0.000
ENVOPT, β_3	γ_{30}	-7.04	0.89	-7.92	27	0.000
ENVPERC, β_4	γ_{40}	4.41	1.40	3.15	42	0.003
ESCS, β_5	γ_{50}	3.50	1.34	2.62	41	0.013
GENSCIE, β_6	γ_{60}	8.70	0.95	9.17	149	0.000
HEDRES, β_7	γ_{70}	3.22	0.87	3.69	102	0.001
INSTSCIE, β_8	γ_{80}	5.60	1.30	4.29	44	0.000
SCHANDS, β_9	γ_{90}	-7.62	1.09	-6.98	149	0.000
SCIEEFF, β_{10}	γ_{100}	8.26	1.22	6.78	63	0.000
VOCATION, B_{11}	γ_{110}	-59.40	8.69	-6.83	69	0.000

The student level variance, σ^2= 2188.50, is substantially smaller than the original, σ^2= 3125.20 estimated in the random ANOVA model. To compare the σ^2 estimates across the two models, proportion reduction in variance or variance explained at student level can be calculated.

Proportion of variance explained at Level -1 $= [\sigma^2_{(ANOVA)} - \sigma^2_{(RAN. COE)}]/\sigma^2_{(ANOVA)}$ (4.11)

$= (3125.20-2188.50) / 3125.20$

$= 0.30$

Adding CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, HEDRES, INSTSCIE, SCHANDS, SCIEEFF and VOCATION as the predictors of combined science reduced the within-school performance by 30%.

4.1.3.2 Identifying Scientific Issues

In this model, CARPREP, ENVAWARE, ENVOPT, ESCS, GENSCIE, HEDRES, JOYSCIE, PERSCIE, SCIEEFF, SCINTACT, WEALTH, VOCATION and GENDER are significantly related ($p<0.05$) to identifying scientific issues within schools. The following model is the significant application of equation 4.10 for group-mean-centered identifying scientific issues score.

$$\text{Identifying Scientific Issues (Y)} = \beta_0 + \beta_1{*}(\text{CARPREP}) + \beta_2{*}(\text{ENVAWARE}) + \beta_3{*}(\text{ENVOPT}) + \beta_4{*}(\text{ESCS}) + \beta_5{*}(\text{GENSCIE}) + \beta_6{*}(\text{HEDRES}) + \beta_7{*}(\text{JOYSCIE}) + \beta_8{*}(\text{PERSCIE}) + \beta_9{*}(\text{SCIEEFF}) + \beta_{10}{*}(\text{SCINTACT}) + \beta_{11}{*}(\text{WEALTH}) + \beta_{12}{*}(\text{VOCATION}) + \beta_{13}{*}(\text{GENDER}) + r$$

The eleven of the thirteen coefficients in the student level model were specified as random in the level-2 model. Specifically;

$$\beta_0 = \gamma_{00} + \upsilon_0$$
$$\beta_1 = \gamma_{10} + \upsilon_1$$
$$\beta_2 = \gamma_{20} + \upsilon_2$$
$$\beta_3 = \gamma_{30} + \upsilon_3$$
$$\beta_4 = \gamma_{40} + \upsilon_4$$
$$\beta_5 = \gamma_{50} + \upsilon_5$$
$$\beta_6 = \gamma_{60} + \upsilon_6$$
$$\beta_7 = \gamma_{70}$$
$$\beta_8 = \gamma_{80} + \upsilon_8$$
$$\beta_9 = \gamma_{90} + \upsilon_9$$
$$\beta_{10} = \gamma_{100} + \upsilon_{10}$$
$$\beta_{11} = \gamma_{110} + \upsilon_{11}$$
$$\beta_{12} = \gamma_{120}$$
$$\beta_{13} = \gamma_{130}$$

The variance and covariance components are displayed in Table 4.17. The estimated variance among the means is $\hat{T}_{00} = 2121.84$. The estimated variance of level-1 predictor's slopes are; CARPREP slopes (τ_{11}) = 24.89, ENVAWARE slopes (τ_{22}) = 22.66, ENVOPT slopes (τ_{33}) = 8.88, ESCS slopes (τ_{44}) = 31.26, GENSCIE slopes

(τ_{55}) = 27.16, HEDRES slopes (τ_{66}) = 17.11, PERSCIE slopes (τ_{88}) = 50.60, SCIEEFF slopes (τ_{99}) = 21.91, SCINTACT slopes (τ_{1010}) = 44.97 and. WEALTH slopes (τ_{1111}) =30.26

The bold numbers in Table 4.17 are displayed the covariance between level-1 intercepts and slopes. Tau as correlation is displayed in the parenthesis. The negative correlations between some intercept and slopes of the level-1 predictors indicate that if the school identifying scientific issues is high, the effects of CARPREP, ESCS, GENSCIE, SCIEEFF, SCINTACT and WEALTH in those schools are smaller.

Table 4.17.

Variance-Covariance Components Matrix of the Model-Identifying Scientific Issues (Group-Mean-Centered).

	β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_8	β_9	β_{10}	β_{11}
INTRCPT1, β_0	**2121.84**										
CARPREP, β_1	**-1.44** (-0.01)	**24.89**									
ENVAWARE, β_2	**82.20** (0.38)	**-6.30** (-0.26)	**22.66**								
ENVOPT, β_3	39.22 (0.29)	**-1.11** (-0.07)	**3.09** (0.21)	**8.88**							
ESCS, β_4	**-17.53** (-0.07)	**-2.26** (-0.08)	**6.53** (0.25)	**-0.96** (-0.06)	**31.26**			**Symmetric**			
GENSCIE, β_5	**-36.98** (-0.15)	**-3.43** (-0.13)	**-7.79** (-0.31)	**5.50** (0.35)	**-5.66** (-0.19)	**27.16**					
HEDRES, β_6	**8.47** (0.04)	**-6.63** (-0.32)	**3.03** (0.15)	**-1.44** (-0.12)	**-2.68** (-0.12)	**-1.45** (-0.07)	**17.11**				
PERSCIE, β_8	**57.84** (0.18)	**-0.39** (-0.01)	**15.23** (0.45)	**-0.75** (-0.04)	**6.94** (0.17)	**-24.33** (-0.66)	**-3.74** (-0.13)	**50.60**			
SCIEEFF, β_9	**-3.6 1** (-0.02)	**6.75** (0.29)	**-5.10** (-0.23)	**0.44** (0.03)	**3.73** (0.14)	**-2.33** (-0.10)	**-5.60** (-0.29)	**5.06** (0.15)	**21.91**		
SCINTACT, β_{10}	**-17.59** (-0.06)	**-13.27** (-0.42)	**-2.33** (-0.08)	**-4.44** (-0.24)	**-11.29** (-0.32)	**-2.09** (-0.06)	**13.98** (0.54)	**-12.36** (-0.28)	**-13.72** (-0.47)	**39.76**	
WEALTH, β_{11}	**-35.58** (-0.14)	**-0.14** (-0.01)	**-1.50** (-0.06)	**4.10** (0.25)	**-4.08** (-0.13)	**4.96** (0.17)	**-13.92** (-0.61)	**5.90** (0.15)	**10.28** (0.40)	**-15.82** (-0.46)	**30.26**

Table 4.18 provides the estimates for the average regression equation within school. The average schools mean was estimated as 443.42. In other words, the identifying scientific issues for male student in vocational high school with average CARPREP- *School preparation for science-related careers* (*M*= -0.15, *SD*= 1.15), average ENVAWARE- *Awareness of environmental issues* (*M* = 0.11, *SD* = 1.00), average ENVOPT- *Environmental optimism* (*M* = -0.10, *SD* = 1.26), average ESCS- *Index of economic, social and cultural status* (*M* = -1.22, *SD* = 1.08), average GENSCIE - *General value of science* (*M* = 0.50, *SD* = 1.08), average HEDRES - *Home educational resources* (*M* = -0.62, *SD* = 1.30), average JOYSCIE- (*M* = 0.42, *SD* = 0.97), average PERSCIE- (*M* = 0.32, *SD* = 1.03), average SCIEEFF - *Science self-efficacy* (*M* = 0.04, *SD* = 0.99), average SCINTACT- *Science Teaching – Interaction,* (*M* = 0.45, *SD* = 0.92) and average WEALTH- *Family wealth,* (*M* = -1.47, *SD* = 1.01) was **443.42.**

Table 4.18.

Results from the Random-Coefficient Model -Identifying Scientific Issues.

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1,						
INTRCPT2, β_0	γ_{00}	443.42	6.25	71.00	149	0.000
CARPREP, β_1	γ_{10}	-6.33	1.17	-5.40	24	0.000
ENVAWARE, β_2	γ_{20}	7.37	1.26	5.86	32	0.000
ENVOPT, β_3	γ_{30}	-6.85	0.81	-8.44	46	0.000
ESCS, β_4	γ_{40}	3.37	1.39	2.42	149	0.017
GENSCIE, β_5	γ_{50}	3.80	1.14	3.34	149	0.001
HEDRES, β_6	γ_{60}	6.50	1.01	6.44	149	0.000
JOYSCIE, β_7	γ_{70}	5.38	1.52	3.55	33	0.001
PERSCIE, β_8	γ_{80}	-4.48	1.89	-2.37	36	0.023
SCIEEFF, β_9	γ_{90}	6.48	1.05	6.14	149	0.000
SCINTACT, β_{10}	γ_{100}	3.56	1.37	2.60	28	0.015
WEALTH, B_{11}	γ_{110}	-4.51	1.38	-3.27	149	0.002
VOCATION, β_{12}	γ_{120}	-50.59	9.39	-5.39	55	0.000
GENDER, B_{13}	γ_{130}	17.79	1.95	9.13	702	0.000

The fixed effects of the student level predictors can be also attained from the model, that is, each unit increase in a student-level predictor is associated with changes in combined science score. In terms of this model, a unit increase in ENVAWARE is associated with 7.37 unit increase in identifying scientific issues; a unit increase in WEALTH is associated with 4.51 unit decrease in identifying scientific issues.

The student level variance, σ^2= 2338.75, is substantially smaller than the original, σ^2= 2878.33 estimated in the random ANOVA model. To compare the σ^2 estimates across the two models, proportion reduction in variance or variance explained at student level can be calculated.

Proportion of variance explained at Level -1 $= [\sigma^2_{(ANOVA)} - \sigma^2_{(RAN.\ COE)}] / \sigma^2_{(ANOVA)}$ (4.11)

$= (3116.72-2338.75) / 3116.72$

$= 0.25$

It can be seen that adding CARPREP, ENVAWARE, ENVOPT, ESCS, GENSCIE, HEDRES, JOYSCIE, PERSCIE, SCIEEFF, SCINTACT, WEALTH VOCATION and GENDER as the predictors of identifying scientific issues reduced the within-school performance by 25%.

4.1.3.3 Explaining Phenomena Scientifically

In this model, CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, SCHANDS, SCIEEFF, SCINVEST, SCSCIE, VOCATION and GENDER are significantly related ($p<0.05$) to explaining phenomena scientifically within schools.. The following model is the significant application of equation 4.13 for the competency of explaining phenomena scientifically.

Explaining Phenomena Scientifically (Y_{ij}) = β_0 + β_1*(CARPREP) + β_2*(ENVAWARE) + β_3*(ENVOPT) + β_4*(ENVPERC) + β_5*(ESCS) + β_6*(GENSCIE) + β_7* (SCHANDS) + β_8*(SCIEEFF) + β_9*(SCINVEST) + β_{10}* (SCSCIE) + β_{11}*(VOCATION) + β_{12}* (GENDER) + r_{ij}

The eleven of the thirteen coefficients in the student level model were specified as random in the level-2 model. Specifically;

$$\beta_0 = \gamma_{00} + \upsilon_0$$
$$\beta_1 = \gamma_{10} + \upsilon_1$$
$$\beta_2 = \gamma_{20} + \upsilon_2$$
$$\beta_3 = \gamma_{30} + \upsilon_3$$
$$\beta_4 = \gamma_{40} + \upsilon_4$$
$$\beta_5 = \gamma_{50} + \upsilon_5$$
$$\beta_6 = \gamma_{60} + \upsilon_6$$
$$\beta_7 = \gamma_{70} + \upsilon_7$$
$$\beta_8 = \gamma_{80} + \upsilon_8$$
$$\beta_9 = \gamma_{90} + \upsilon_9$$
$$\beta_{10} = \gamma_{100} + \upsilon_{10}$$
$$\beta_{11} = \gamma_{110}$$
$$\beta_{12} = \gamma_{120}$$

The variance and covariance components were displayed in Table 4.19. The estimated variance among the means is $\hat{T}_{00}$ =2680.41. The estimated variance of level-1 predictor's slopes are; CARPREP slopes (τ_{11}) = 19.88, ENVAWARE slopes (τ_{22}) = 23.34, ENVOPT slopes (τ_{33}) = 17.64, ENVPERC slopes (τ_{44}) = 31.65, ESCS slopes (τ_{55}) = 26.72, GENSCIE slopes (τ_{66}) = 27.38, SCHANDS slopes (τ_{77}) = 37.81, SCIEEFF slopes (τ_{88}) = 27.96, SCINVEST slopes (τ_{99}) = 42.08 and SCSCIE slopes (τ_{1010}) = 22.48.

The bold numbers in Table 4.19 are displayed the covariance between level-1 intercepts and slopes. Tau as correlation was displayed in the parenthesis. The negative correlations between some intercept and slopes of the level-1 predictors indicated that if the school explaining phenomena scientifically is high, the effects of ENVPERC, ESCS, GENSCIE, SCHANDS, SCIEEFF and SCINVEST in those schools are smaller.

Table 4.19.

Variance-Covariance Components Matrix of the Model-Explaining Phenomena Scientifically (Group-Mean-Centered)

		β_0	β_1	β_2	β_3	β_4	β_5	β_6	B_7	β_8	B_9	B_{10}
INTRCPT1,	β_0	**2680.41**										
CARPREP,	β_1	3.39	**19.88**					Symmetric				
		(0.02)										
ENVAWARE,	β_2	78.03	-3.61	**23.34**								
		(0.31)	(-0.17)									
ENVOPT,	β_3	82.85	-3.05	5.47	**17.64**							
		(0.38)	(-0.16)	(0.27)								
ENVPERC,	β_4	-117.27	-9.84	5.41	2.08	**31.65**						
		(-0.40)	(-0.39)	(0.19)	(0.09)							
ESCS,	β_5	-58.07	-10.07	5.63	-5.11	4.10	**26.72**					
		(-0.22)	(-0.44)	(0.23)	(-0.24)	(0.14)						
GENSCIE,	β_6	-49.85	5.88	-3.97	6.10	-7.97	-8.65	**27.38**				
		(-0.18)	(0.25)	(-0.16)	(0.28)	(-0.27)	(-0.32)					
SCHANDS,	β_7	-3.27	4.26	-6.41	-0.93	-1.33	-3.96	-7.30	**37.81**			
		(-0.01)	(0.16)	(-0.22)	(-0.04)	(-0.04)	(-0.13)	(-0.23)				
SCIEEFF,	β_8	-20.24	0.67	3.05	-3.96	-8.07	10.12	-1.66	4.25	**27.96**		
		(-0.07)	(0.03)	(0.12)	(-0.18)	(-0.27)	(0.37)	(-0.06)	(0.13)			
SCINVEST,	β_9	-59.03	-12.66	-3.17	-2.81	14.60	2.37	-6.50	-22.19 (-	-16.98	**42.08**	
		(-0.18)	(-0.44)	(-0.10)	(-0.10)	(0.40)	(0.07)	(-0.19)	0.56)	(-0.50)		
SCSCIE,	β_{10}	57.29	-1.68	1.14	-6.58	-4.31	4.33	-9.64	6.94	10.21	-9.49	**22.48**
		(0.23)	(-0.08)	(0.05)	(-0.33)	(-0.16)	(0.18)	(-0.39)	(0.24)	(0.41)	(-0.31)	

Table 4.20 provides the estimates for the average regression equation within school. The average schools mean was estimated as 458.70.

Table 4.20.

Results from the Random-Coefficient Model-Explaining Phenomena Scientifically.

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1,						
INTRCPT2, β_0	γ_{00}	458.70	6.69	68.60	149	0.000
CARPREP, β_1	γ_{10}	-4.71	1.13	-4.17	24	0.000
ENVAWARE, β_2	γ_{20}	11.03	1.38	8.01	20	0.000
ENVOPT, β_3	γ_{30}	-7.68	0.91	-8.47	49	0.000
ENVPERC, β_4	γ_{40}	4.26	1.21	3.51	149	0.001
ESCS, β_5	γ_{50}	5.54	1.13	4.90	46	0.000
GENSCIE, β_7	γ_{60}	9.62	1.03	9.36	128	0.000
SCHANDS, β_7	γ_{70}	-5.96	1.36	-4.37	149	0.000
SCIEEFF, β_8	γ_{80}	8.53	1.07	7.96	149	0.000
SCINVEST, β_9	γ_{90}	-5.56	1.37	-4.05	149	0.000
SCSCIE, B_{10}	γ_{100}	5.84	1.32	4.41	18	0.000
VOCATION, β_{11}	γ_{110}	-59.65	9.14	-6.53	66	0.000
GENDER, B_{12}	γ_{120}	-15.78	2.07	-7.64	4478	0.000

In this model, explaining phenomena scientifically for male student in vocational high school with average CARPREP- *School preparation for science-related careers* (M= -0.15, SD = 1.15), average CULTPOSS- *Cultural possessions at home* (M = 0.00, SD = 0.94), average ENVAWARE- *Awareness of environmental issues* (M = 0.11, SD = 1.00), average ENVOPT- *Environmental optimism* (M = -0.10, SD = 1.26), average ENVPERC- *Perception of environmental issues* (M = 0.93, SD = 0.81), average ESCS- *Index of economic, social and cultural status* (M = -1.22, SD = 1.08), average GENSCIE - *General value of science* (M = 0.50, SD = 1.08), average SCHANDS- *Science Teaching - Hands-on activities* (M = 0.03, SD = 1.12), average SCIEEFF - *Science self-efficacy* (M = 0.04, SD = 0.99), average SCINVEST- *Science*

Teaching - Student investigations (M = 0.79, SD = 1.01), average SCSCIE- *Science self-concept* (M = 0.15, SD = 1.00) was **458.70**.

The fixed effects of the student level predictors can be also attained from the model, that is, each unit increase in a student-level predictor is associated with changes in explaining phenomena scientifically score. In terms of this model, a unit increase in ENVAWARE is associated with 11.03 unit increase in explaining phenomena scientifically; a unit increase in CARPREP is associated with 4.71 unit decrease in explaining phenomena scientifically.

The student level variance, σ^2= 2375.86, is substantially smaller than the original, σ^2= 3510.08 estimated in the random ANOVA model. To compare the σ^2 estimates across the two models, proportion reduction in variance or variance explained at student level can be calculated.

$$\text{Proportion of variance explained at Level -1} = [\sigma^2_{(ANOVA)} - \sigma^2_{(RAN.\ COE)}]/\sigma^2_{(ANOVA)} \quad (4.11)$$

$$= (3510.08\text{-}2375.86) / 3510.08$$

$$= 0.32$$

It can be seen that adding CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, SCHANDS, SCIEEFF, SCINVEST, SCSCIE, VOCATION and GENDER as the predictors of explaining phenomena scientifically reduced the within-school performance by 32%.

4.1.3.4. Using Scientific Evidence

In this model, CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, HEDRES, JOYSCIE, RESPDEV, SCHANDS, SCIEEFF and VOCATION are significantly related ($p<0.05$) to using scientific evidence within schools. Therefore, the using scientific evidence was regressed on CARPREP, ENVAWARE, ENVOPT,

ENVPERC, ESCS, GENSCIE, HEDRES, JOYSCIE, RESPDEV, SCHANDS, SCIEEFF and VOCATION. The following model is the significant application of equation 4.13 for the group-mean-centered using scientific evidence score.

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Using Scientific Evidence (Y_{ij}) = β_0 + β_1*(CARPREP) + β_2* (ENVAWARE) + β_3*(ENVOPT) + β_4*(ENVPERC) + β_5*(ESCS) + β_6*(GENSCIE) + β_7*(HEDRES) + β_8* (JOYSCIE) + β_9*(RESPDEV) + β_{10}*(SCHANDS) + β_{11}* (SCIEEFF) + β_{12}*(VOCATION) + r_{ij}

The eleven of the thirteen coefficients in the student level model were specified as random in the level-2 model. Specifically;

$$\beta_0 = \gamma_{00} + \upsilon_0$$
$$\beta_1 = \gamma_{10} + \upsilon_1$$
$$\beta_2 = \gamma_{20} + \upsilon_2$$
$$\beta_3 = \gamma_{30} + \upsilon_3$$
$$\beta_4 = \gamma_{40} + \upsilon_4$$
$$\beta_5 = \gamma_{50} + \upsilon_5$$
$$\beta_6 = \gamma_{60} + \upsilon_6$$
$$\beta_7 = \gamma_{70} + \upsilon_7$$
$$\beta_8 = \gamma_{80}$$
$$\beta_9 = \gamma_{90} + \upsilon_9$$
$$\beta_{10} = \gamma_{100} + \upsilon_{10}$$
$$\beta_{11} = \gamma_{110} + \upsilon_{11}$$
$$\beta_{12} = \gamma_{120}$$

The variance and covariance components were displayed in Table 4.21. The estimated variance among the means is $\hat{T}_{00}$ =3150.54. The estimated variance of level-1 predictor's slopes are; CARPREP slopes (τ_{11}) = 21.82, ENVAWARE slopes (τ_{22}) = 17.04, ENVOPT slopes (τ_{33}) = 13.41, ENVPERC slopes (τ_{44}) = 39.38, ESCS slopes (τ_{55}) = 46.82, GENSCIE slopes (τ_{66}) = 33.77, HEDRES slopes (τ_{88}) = 10.91, RESPDEV slopes (τ_{99}) = 31.28, SCHANDS slopes (τ_{1010}) = 20.64 and SCIEEFF slopes (τ_{1111}) = 40.62.

Table 4.21.

Variance-Covariance Components Matrix of the Model-Using Scientific Evidence (Group-Mean-Centered).

		β_0	β_1	β_2	β_3	β_4	β_5	β_6	B_7	β_9	β_{10}	β_{11}
INTRCPT1,	β_0	3150.54										
CARPREP,	β_1	41.96	21.82									
		(0.16)										
ENVAWARE,	β_2	22.55	0.49	17.04								
		(0.10)	(0.03)									
ENVOPT,	β_3	68.80	-4.95	2.03	13.41							
		(0.34)	(-0.29)	(0.14)					Symmetric			
ENVPERC,	β_4	-176.86	-9.17	6.78	3.71	39.38						
		(-0.50)	(-0.31)	(0.26)	(0.16)							
ESCS,	β_5	18.66	-3.17	5.81	-2.88	-3.26	46.82					
		(0.05)	(-0.10)	(0.21)	(-0.12)	(-0.08)						
GENSCIE,	β_6	18.52	3.80	0.35	6.10	-9.72	-11.70	33.77				
		(0.06)	(0.14)	(0.02)	(0.29)	(-0.27)	(-0.29)					
HEDRES,	β_8	-36.98	-2.29	-4.20	-2.83	2.54	-3.30	-7.25	10.91			
		(-0.20)	(-0.15)	(-0.31)	(-0.23)	(0.12)	(-0.15)	(-0.38)				
RESPDEV,	β_9	-124.61	-13.46	-2.61	1.03	11.21	13.08	-13.84	5.55	31.28		
		(-0.40)	(-0.52)	(-0.11)	(0.05)	(0.32)	(0.34)	(-0.43)	(0.30)			
SCHANDS,	β_{10}	12.81	-6.60	-1.66	-1.69	2.72	-3.23	-7.22	2.25	-3.50	20.64	
		(0.05)	(-0.31)	(-0.09)	(-0.10)	(0.10)	(-0.11)	(-0.27)	(0.15)	(-0.14)		
SCIEEFF,	β_{11}	45.02	1.85	1.92	-8.68	-15.69	9.75	0.25	-2.04	-10.14	2.61	40.62
		(0.13)	(0.06)	(0.07)	(-0.37)	(-0.39)	(0.34)	(0.01)	(-0.10)	(-0.28)	(0.09)	

The bold numbers in Table 4.21 are displayed the covariance between level-1 intercepts and slopes. Tau as correlation was displayed in the parenthesis. The negative correlations between some intercept and slopes of the level-1 predictors indicated that if the school using scientific evidence score is high, the effects of ENVPERC, HEDRES and RESPDEV in those schools are smaller.

Table 4.22 provides the estimates for the average regression equation within school. The average schools mean was estimated as 451.35. In this random coefficient model, using scientific evidence for students in vocational high school with average CARPREP- *School preparation for science-related careers* (*M*= -0.15, *SD*= 1.15), average ENVAWARE- *Awareness of environmental issues* (*M* = 0.11, *SD* = 1.00), average ENVOPT- *Environmental optimism* (*M* = -0.10, *SD* = 1.26), average ENVPERC- *Perception of environmental issues* (*M* = 0.93, *SD* = 0.81)average, ESCS- *Index of economic, social and cultural status* (*M* = -1. 22, *SD* = 1.08), average GENSCIE - *General value of science* (*M* = 0.50, *SD* = 1.08), average HEDRES- *Home educational resources* (*M* = - 0.62, *SD* = 1.30), average RESPDEV- *Responsibility for sustainable development* (*M* = 0.79, *SD* = 1.07), average SCHANDS- *Science Teaching - Hands-on activities* (*M* = 0.03, *SD* = 1.12), average SCIEEFF - *Science self-efficacy* (*M* = 0.04, *SD* = 0.99) was **451.35**.

The fixed effects of the student level predictors can be also attained from the model, that is, each unit increase in a student-level predictor is associated with changes in using scientific evidence score. In terms of this model, a unit increase in SCIEEFF is associated with 7.27-unit increase in using scientific evidence; a unit increase in ENVOPT is associated with 7.29 unit decrease in using scientific evidence.

Table 4.22.

Results from the Random-Coefficient Model (Using Scientific Evidence).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1,						
INTRCPT2, β_0	γ_{00}	451.35	7.11	63.51	149	0.000
CARPREP, β_1	γ_{10}	-7.54	1.07	-7.04	78	0.000
ENVAWARE, β_2	γ_{20}	10.40	1.33	7.80	25	0.000
ENVOPT, β_3	γ_{30}	-7.29	0.94	-7.73	37	0.000
ENVPERC, β_4	γ_{40}	5.28	1.36	3.90	149	0.000
ESCS, β_5	γ_{50}	3.54	1.40	2.54	109	0.013
GENSCIE, β_6	γ_{60}	9.93	1.20	8.29	110	0.000
HEDRES, β_7	γ_{70}	3.94	0.97	4.05	149	0.000
JOYSCIE, β_8	γ_{80}	6.53	1.38	4.73	40	0.000
RESPDEV, β_9	γ_{90}	5.36	1.16	4.63	109	0.000
SCHANDS, β_{10}	γ_{100}	-8.05	1.00	-8.06	149	0.000
SCIEEFF, B_{11}	γ_{110}	7.27	1.24	5.85	149	0.000
VOCATION, β_{12}	γ_{120}	-67. 70	9.90	-6.84	59	0.000

The student level variance, σ^2= 2821.53, is substantially smaller than the original, σ^2= 4107.90 estimated in the random ANOVA model. To compare the σ^2 estimates across the two models, proportion reduction in variance or variance explained at student level can be calculated.

Proportion of variance
explained at Level -1 $= [\sigma^2_{(ANOVA)} - \sigma^2_{(RAN.\ COE)}] / \sigma^2_{(ANOVA)}$ (4.11)

$= (4107.90\text{-}2821.53) / 4107.90$

$= 0.31$

It can be seen that adding CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, HEDRES, JOYSCIE, RESPDEV, SCHANDS, SCIEEFF and VOCATION as the predictors of using scientific evidence reduced the within-school performance by 31%.

4.1.3.5 Interest in Learning Science

In this model, CARPREP, ESCS, GENSCIE, INTSCIE, JOYSCIE, RESPDEV, SCIEACT, SCIEEFF, SCINVEST, SCSCIE and GENDER are significantly related ($p<0.05$) to interest in learning science within schools. Therefore, the interest in learning science was regressed on CARPREP, ESCS, GENSCIE, INTSCIE, JOYSCIE, RESPDEV, SCIEACT, SCIEEFF, SCINVEST, SCSCIE and GENDER. The following model is the significant application of equation 4.10 for the group-mean-centered interest in learning science score.

$$\text{Interest in Learning Science (Y)} = \beta_0 + \beta_1*(\text{CARPREP}) + \beta_2*(\text{ESCS}) + \beta_3*(\text{GENSCIE}) + \beta_4*(\text{INTSCIE}) + \beta_5*(\text{JOYSCIE}) + \beta_6*(\text{RESPDEV}) + \beta_7*(\text{SCIEACT}) + \beta_8*(\text{SCIEEFF}) + \beta_9*(\text{SCINVEST}) + \beta_{10}*(\text{SCSCIE}) + \beta_{11}*(\text{GENDER}) + r$$

The ten of the twelve coefficients in the student level model were specified as random in the level-2 model. Specifically;

$$\beta_0 = \gamma_{00} + \upsilon_0$$
$$\beta_1 = \gamma_{10} + \upsilon_1$$
$$\beta_2 = \gamma_{20} + \upsilon_2$$
$$\beta_3 = \gamma_{30} + \upsilon_3$$
$$\beta_4 = \gamma_{40} + \upsilon_4$$
$$\beta_5 = \gamma_{50} + \upsilon_5$$
$$\beta_6 = \gamma_{60} + \upsilon_6$$
$$\beta_7 = \gamma_{70} + \upsilon_7$$
$$\beta_8 = \gamma_{80} + \upsilon_8$$
$$\beta_9 = \gamma_{90} + \upsilon_9$$
$$\beta_{10} = \gamma_{100}$$
$$\beta_{11} = \gamma_{110}$$

The variance and covariance components were displayed in Table 4.23. The estimated variance among the means is $\hat{T}_{00} = 746.62$. The estimated variance of level-1 predictor's slopes are; CARPREP slopes (τ_{11}) = 30.59, ESCS slopes (τ_{22}) = 42.62, GENSCIE slopes (τ_{33}) = 80.23, INTSCIE slopes (τ_{44}) = 92.76, JOYSCIE slopes (τ_{55}) = 90.44, RESPDEV slopes (τ_{66}) = 14.94, SCIEACT slopes (τ_{77}) = 92.40, SCIEEFF slopes (τ_{88}) = 73.85 and SCINVEST slopes (τ_{99}) = 28.31.

The bold numbers in Table 4.23 are displayed the covariance between level-1 intercepts and slopes. Tau as correlation was displayed in the parenthesis. The negative correlations between some intercept and slopes of the level-1 predictors indicated that if the school interest in learning science score is high, the effects of CARPREP, ESCS, SCIEACT and SCINVEST in those schools are smaller.

Table 4.23.

Variance-Covariance Components Matrix of the Model - Interest in Learning Science (Group-Mean -Centered).

		β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9
INTRCPT1,	β_0	746.62									
CARPREP,	β_1	**16.82** (0.11)	30.59								
ESCS,	β_2	**-28.25** (-0.16)	**9.68** (0.27)	42.62							
GENSCIE,	β_3	**50.28** (0.21)	**-17.36** (-0.35)	7.32 (0.13)	80.23			**Symmetric**			
INTSCIE,	β_4	35.77 (0.14)	8.67 (0.16)	**24.87** (0.40)	32.94 (0.38)	92.76					
JOYSCIE,	β_5	**-8.92** (-0.03)	-7.72 (-0.15)	**0.12** (0.00)	**3.00** (0.04)	**-43.72** (-0.48)	90.44				
RESPDEV,	β_6	**35.60** (0.34)	-2.75 (-0.13)	**-11.31** (-0.45)	-2.40 (-0.07)	-5.76 (-0.16)	**-3.55** (-0.10)	14.94			
SCIEACT,	β_7	**-23.61** (-0.09)	**1.04** (0.02)	**-35.83** (-0.57)	**-36.14** (-0.42)	**-56.57** (-0.61)	**-1.70** (-0.02)	**11.66** (0.31)	92.40		
SCIEEFF,	β_8	**1.57** (0.01)	**6.91** (0.15)	**32.05** (0:57)	**15.31** (0.20)	**43.17** (0.52)	**-35.45** (-0.43)	**-6.06** (-0.18)	**-38.51** (-0.47)	73.85	
SCINVEST,	β_9	**-30.83** (-0.21)	**4.42** (0.15)	**11.03** (0.31)	**-20.26** (-0.43)	**-11.69** (-0.23)	**4.58** (0.10)	**-3.72** (-0.18)	**-3.80** (-0.01)	**16.10** (0.01)	28.31

Table 4.24 provides the estimates for the average regression equation within school. The average schools mean was estimated as 544.96.

Table 4.24.

Results from the Random-Coefficient Model (Interest in Learning Science).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1,						
INTRCPT2, β_0	γ_{00}	544.96	3.08	176.76	149	0.000
CARPREP, β_1	γ_{10}	6.43	1.37	4.69	139	0.000
ESCS, β_2	γ_{20}	-8.11	1.40	-5.79	149	0.000
GENSCIE, β_3	γ_{30}	5.56	1.71	3.25	104	0.002
INTSCIE, β_4	γ_{40}	28.56	2.36	12.08	80	0.000
JOYSCIE, β_5	γ_{50}	19.68	2.33	8.44	149	0.000
RESPDEV, β_6	γ_{60}	14.50	1.35	10.78	81	0.000
SCIEACT, β_7	γ_{70}	9.04	2.25	4.01	149	0.000
SCIEEFF, β_8	γ_{80}	14.79	1.74	8.52	149	0.000
SCINVEST, β_9	γ_{90}	8.75	1.44	6.07	149	0.000
SCSCIE, β_{10}	γ_{100}	-5.63	2.06	-2.73	112	0.008
GENDER, B_{11}	γ_{110}	-12.23	3.01	-4.06	3182	0.000

In this model, interest in learning science for a male student with average; CARPREP- *School preparation for science-related careers* (*M*= -0.15, *SD* = 1.15), ESCS- *Index of economic, social and cultural status* (*M* = -1.22, *SD* = 1.08), average GENSCIE - *General value of science* (*M* = 0.50, *SD* = 1.08), average INTSCIE- *Instrumental motivation in science* (*M* = 0.24, *SD* = 0.95), average JOYSCIE- *Enjoyment of science* (*M* = 042., *SD* = 0.97), average RESPDEV- *Responsibility for sustainable development* (*M* = 0.79, *SD* = 1.07), average SCIEACT- *Science activities* (*M* = 0.57, *SD* = 0.96), average SCIEEFF - *Science self-efficacy* (*M* = 0.04, *SD* = 0.99), average SCINVEST- *Science Teaching - Student investigations* (*M* = 0.79, *SD* = 1.01) and average SCSCIE- *Science self-concept* (*M* = 0.15, *SD* = 1.00) was **544.96**.

The fixed effects of the student level predictors can be also attained from the model, that is, each unit increase in a student-level predictor is associated with changes in interest in learning science. In terms of this model, a unit increase in INTSCIE is associated with 28.56-unit increase in interest in learning science; a unit increase in ESCS is associated with 8.11-unit decrease in interest in learning science.

The student level variance, $\sigma^2 = 5398.16$, is substantially smaller than the original, $\sigma^2 = 9933.71$estimated in the random ANOVA model. To compare the σ^2 estimates across the two models, proportion reduction in variance or variance explained at student level can be calculated.

Proportion of variance explained at Level -1 $= [\sigma^2_{\text{(ANOVA)}} - \sigma^2_{\text{(RAN. COE)}}] / \sigma^2_{\text{(ANOVA)}}$ (4.11)

$= (9933.71 - 5398.16) / 9933.71$

$= 0.46$

It can be seen that adding CARPREP, ESCS, GENSCIE, INTSCIE, JOYSCIE, RESPDEV, SCIEACT, SCIEEFF, SCINVEST, SCSCIE and GENDER as the predictors of interest in learning science reduced the within-school performance by 46%.

4.1.3.6. Support for Scientific Enquiry

In this model, ENVAWARE, GENSCIE, INTSCIE, JOYSCIE, PERSCIE, RESPDEV, SCIEEFF, VOCATION and GENDER are significantly related ($p<0.05$) to support for scientific enquiry within schools. Therefore, the support for scientific enquiry was regressed on ENVAWARE, GENSCIE, INTSCIE, JOYSCIE, PERSCIE, RESPDEV, SCIEEFF, VOCATION and GENDER. The following model is the significant application of equation 4.13 for the group-mean-centered support for scientific enquiry score.

Support for Scientific Enquiry (Y) = β_0 + β_1*(ENVAWARE) + β_2 *(GENSCIE) + β_3* (INTSCIE) + β_4*(JOYSCIE) + β_5*(PERSCIE) + β_6* (RESPDEV) + β_7* (SCIEEFF) + β_8*(VOCATION) + β_9* (GENDER) + r

The eight of the ten coefficients in the student level model were specified as random in the level-2 model. Specifically;

$$\beta_0 = \gamma_{00} + \upsilon_0$$
$$\beta_1 = \gamma_{10} + \upsilon_1$$
$$\beta_2 = \gamma_{20} + \upsilon_2$$
$$\beta_3 = \gamma_{30} + \upsilon_3$$
$$\beta_4 = \gamma_{40} + \upsilon_4$$
$$\beta_5 = \gamma_{50} + \upsilon_5$$
$$\beta_6 = \gamma_{60} + \upsilon_6$$
$$\beta_7 = \gamma_{70} + \upsilon_7$$
$$\beta_8 = \gamma_{80}$$
$$\beta_9 = \gamma_{90}$$

The variance and covariance components are displayed in Table 4.25. The estimated variance among the means is $\hat{T}_{00}$ =1223.09. The estimated variance of level-1 predictor's slopes are; ENVAWARE slopes (τ_{11}) = 80.12, GENSCIE slopes (τ_{22}) = 111.73, INTSCIE slopes (τ_{33}) = 45.75, JOYSCIE slopes (τ_{44}) = 93.68, PERSCIE slopes (τ_{55}) = 80.47, RESPDEV slopes (τ_{66}) = 84.10 and SCIEEFF slopes (τ_{77}) = 100.86.

Table 4.25.

Variance-Covariance Components Matrix of the Model -Support for Scientific Enquiry (Group-Mean-Centered).

		β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7
INTERCPT1,	β_0	1223.09							
ENVAWARE,	β_1	**-6.52**	80.12						
		(-0.02)							
GENSCIE,	β_2	**69.15**	**11.60**	111.73					
		(0.19)	(0.12)						
INTSCIE,	β_3	**21.14**	**5.57**	**6.94**	45.75			**Symmetric**	
		(0.09)	(0.09)	(0.10)					
JOYSCIE,	β_4	**-65.32**	**3.55**	**-20.72**	**-28.62**	93.68			
		(-0.19)	(0.04)	(-0.20)	(-0.44)				
PERSCIE,	β_5	**54.07**	**-33.66**	**-24.49**	**6.63**	**-32.49**	80.47		
		(0.17)	(-0.42)	(-0.26)	(0.11)	(-0.37)			
RESPDEV,	β_6	**91.36**	**2.88**	**-6.39**	**-17.67**	**-11.33**	**-15.75**	84.10	
		(0.29)	(0.04)	(-0.07)	(-0.29)	(-0.13)	(-0.19)		
SCIEEFF,	β_7	**24.04**	**-44.80**	**-17.65**	**-10.21**	**8.64**	**3.15**	**1.45**	100.86
		(0.07)	(-0.50)	(-0.17)	(-0.15)	(0.09)	(0.04)	(0.02)	

The bold numbers in Table 4.25 were displayed the covariance between level-1 intercepts and slopes. Tau as correlation was displayed in the parenthesis. The negative correlations between some intercept and slopes of the level-1 predictors indicated that if the school support for scientific enquiry score is high, the effects of JOYSCIE in those schools are smaller.

Table 4.26 provides the estimates for the average regression equation within school. The average schools mean was estimated as 576.58.

Table 4.26.

Results from the Random-Coefficient Model-Support for Scientific Enquiry.

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1,						
INTRCPT2, β_0	γ_{00}	576.58.	5.00	115.28	149	0.000
ENVAWARE, β_1	γ_{10}	5.02	1.90	2.64	149	0.010
GENSCIE, β_2	γ_{20}	39.12	2.25	17.39	135	0.000
INTSCIE, β_3	γ_{30}	10.18	2.95	3.45	14	0.004
JOYSCIE, β_4	γ_{40}	10.76	2.91	3.70	67	0.001
PERSCIE, β_5	γ_{50}	7.38	2.54	2.90	59	0.006
RESPDEV, β_6	γ_{60}	27.74	1.98	14.00	39	0.000
SCIEEFF, β_7	γ_{70}	10.16	2.24	4.53	116	0.000
VOCATION, β_8	γ_{80}	-34.91	6.37	-5.48	4481	0.000
GENDER, β_9	γ_{90}	15.24	3.23	4.72	115	0.000

In this model, support for scientific enquiry for someone with average ENVAWARE- *Awareness of environmental issues* (*M* = 0.11, *SD*= 1.00),average GENSCIE - *General value of science* (*M* = 0.50, *SD* = 1.08), average INTSCIE- *General interest in learning science* (*M* = 0.24, *SD* = 0.95), average JOYSCIE- *Enjoyment of science* (*M* = 0.42, *SD* = 0.97), average PERSCIE- *Personal value of science* (*M* = 0.32, *SD* = 1.03), average RESPDEV- *Responsibility for sustainable development* (*M* = 0.79, *SD* = 1.07) and average SCIEEFF - *Science self-efficacy* (*M* = 0.04, *SD* = 0.99) was **576.58.**

The fixed effects of the student level predictors can be also attained from the model, that is, each unit increase in a student-level predictor is associated with changes in support for scientific enquiry score. In terms of this model, a unit increase in RESPDEV is associated with 27.74 unit increase in support for scientific enquiry; a unit increase in JOYSCIE is associated with 10.76 unit increase in support for scientific enquiry.

The student level variance, σ^2= 7057.10, is substantially smaller than the original, σ^2= 13691.92 estimated in the random ANOVA model. To compare the σ^2 estimates across the two models, proportion reduction in variance or variance explained at student level can be calculated.

$$\text{Proportion of variance explained at Level -1} = [\sigma^2_{(ANOVA)} - \sigma^2_{(RAN.\ COE)}] / \sigma^2_{(ANOVA)} \tag{4.11}$$

$$= (13691.92 - 7057.10) / 13691.92$$

$$= 0.48$$

It can be seen that adding ENVAWARE, GENSCIE, INTSCIE, JOYSCIE, PERSCIE, RESPDEV and SCIEEFF, as the predictors of support for scientific enquiry reduced the within-school performance by 48%.

4.1.3.7 The Findings from the Random Coefficient Models

1. The general value of science **(GENSCIE)** and science self-efficacy **(SCIEEFF)** have significant effect on all scientific literacy skills of Turkish students. In spite of the cultural possession at home **(CULTPOSS),** and the index of home possessions **(HOMEPOSS)** have not significant effect on any scientific literacy skills, index of economic, social, and cultural status has significant effect on combined science, science competencies. Moreover, the student information on science-related careers **(CARINFO),** the applications or models in science teaching **(SCAPPLY),** the future-oriented science motivation **(SCIEFUT)** and language at home **(DIL)** have not significant effect on scientific literacy skills of Turkish students.

2. There is significant difference between general high schools and vocational high schools, even after the student-level predictors were hold constant these schools varied significantly in their average combined science and science competencies.

3. The proportions of variances explained by random coefficient models of combined science and science competencies change between 25% and 32%.The proportions of variances explained by random coefficient models of interest in learning science and support for scientific enquiry are 46% and 48% respectively.

4. Some of the student-level predictors affected the students' outcomes negatively:
   - the school perception for science careers **(CARPREP)** and optimism regarding environmental issues **(ENVOPT)** in combined science and all science competencies;
   - personal value of science **(PERSCIE)** and family wealth **(WEALTH)** in identifying scientific issues;
   - hands-on activities in science teaching **(SCHANDS)** in combined science, explain phenomena scientifically and using scientific evidence;
   - science teaching - student investigations **(SCINVEST)** in combined science and explain phenomena scientifically;
   - index of economic, social and cultural status **(ESCS)** and Science self-concept **(SCSCIE)**

Considering these predictors, unit increase in, for example, SCHAND, decreases 7.62 points of students combined science score.

5. The general interest in learning science **(INTSCIE)** and science activities **(SCIEACT)** have only effect on science attitude scores.

6. The effects of some variables become fewer when the mean scientific literacy scores are higher, for example, general value of science (GENSCIE) in combined science and science competencies models.

4.1.4 An Intercepts - And Slopes - As - Outcomes Model: The Effects of School and Students

A-intercepts-and slopes-as-outcomes model combines the two previous models so that both mean differences in scientific literacy and the differences in slope can be evaluated across the school-level predictors. This type of model allows us to explain the variation in both intercepts and slopes. It is called cross-level interactions model because we make the effect of student level variables dependent upon the value of school level variables.

This model is an explanatory model to illuminate how differences among schools characteristics might influence the students' outcome distribution of scientific literacy skills of Turkish students within schools.

4.1.4.1 Combined Science

The dependent variable for this model is combined science score, the independent variables in the student level model are CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, HEDRES, INSTSCIE, SCIEEFF and SCINVEST All level-1 independent variables are firstly centered on a grand mean (grand-mean centered) then centered around group mean. The models were sought to find the answers of "Why some schools have higher means than other schools" and "why in some schools the relationship between student's *PISA outcome variables* and combined science score is stronger than the other schools.

The following regression equation was used to answer the research questions;

i) Do *school academic selectivity recoded* ***(SELECT),*** teacher shortage (negative scale) ***(TCSHORT)*** and mean of index of economic, social and cultural status ***(ESCSMEAN)*** significantly predict the intercept?
ii) Do *school academic selectivity recoded* ***(SELECT),*** teacher shortage (negative scale) ***(TCSHORT)*** and mean of index of economic, social and cultural status ***(ESCSMEAN)*** significantly predict the within school slopes?

iii) How much variation in the intercepts and the slopes is explained by using *school academic selectivity recoded **(SELECT)**,* teacher shortage (negative scale) ***(TCSHORT)*** and mean of index of economic, social and cultural status ***(ESCSMEAN)*** as predictors?

4.1.4.1.1 Grand-Mean-Centered

The student level model and the school level model can be written as:

Level-1 Model

$$\text{Combined Science (Y)} = \beta_0 + \beta_1*(\text{CARPREP}) + \beta_2*(\text{ENVAWARE}) + \beta_3*(\text{ENVOPT}) + \beta_4*(\text{ENVPERC}) + \beta_5*(\text{ESCS}) + \beta_6*(\text{GENSCIE}) + \beta_7*(\text{HEDRES}) + \beta_8*(\text{INSTSCIE}) + \beta_9*(\text{SCIEEFF}) + \beta_{10}*(\text{SCINVEST}) + r$$

Level-2 Model

$$\beta_0 = \gamma_{00} + \gamma_{01}*(\text{SELECT}) + \gamma_{02}*(\text{TCSHORT}) + \gamma_{03}*(\text{ESCSMEAN}) + \gamma_{04}*(\text{VOCATION}) + \upsilon_0$$
$$\beta_1 = \gamma_{10} + \gamma_{11}*(\text{VOCATION}) + \upsilon_1$$
$$\beta_2 = \gamma_{20} + \upsilon_2$$
$$\beta_3 = \gamma_{30} + \upsilon_3$$
$$\beta_4 = \gamma_{40} + \upsilon_4$$
$$\beta_5 = \gamma_{50} + \upsilon_5$$
$$\beta_6 = \gamma_{50} + \upsilon_6$$
$$\beta_7 = \gamma_{60} + \upsilon_7$$
$$\beta_8 = \gamma_{80}$$
$$\beta_9 = \gamma_{90} + \upsilon_9$$
$$\beta_{10} = \gamma_{100}$$

Table 4.27 displays the results. As seen in the table SELECT ($\gamma_{01} = 11.10$, t=4.11), TCSHORT ($\gamma_{02} = 3.92$, t=2.21) and ESCSMEAN ($\gamma_{03} = 39.75$, t=7.35) were significantly predict the intercept and positively related to school mean of the combined science score The general high schools had also significantly higher mean combined science score than vocational high schools.

As regard to the slops, VOCATION significantly predict within schools, the school perception for science-related careers, CARPREP, slopes. These slopes were shown in the Figure 4.1. The red slopes are displayed the vocational high schools and blue slopes are general high schools.

Table 4.27.
Results from the Intercepts- and Slopes-as- Outcome Model / Combined Science (Grand- Mean-Centered).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1, β_0						
INTRCPT2,	γ_{00}	429.95	2.48	172.99	141	0.000
SELECT,	γ_{01}	11.10	2.70	4.11	96	0.000
TCSHORT,	γ_{02}	3.92	1.78	2.21	141	0.029
ESCSMEAN,	γ_{03}	39.75	5.41	7.35	141	0.000
VOCATION,	γ_{04}	-17.69	5.69	-3.11	141	0.003
CARPREP, β_1						
INTRCPT2,	γ_{10}	-5.61	0.95	-5.93	143	0.000
VOCATION,	γ_{11}	-5.56	1.60	-3.48	60	0.001
ENVAWARE, β_2	γ_{20}	10.20	1.13	9.06	65	0.000
ENVOPT, β_3	γ_{30}	-7.28	0.88	-8.24	22	0.000
ENVPERC, β_4	γ_{40}	4.30	1.37	3.15	48	0.003
ESCS, β_5	γ_{50}	3.26	1.22	2.67	139	0.009
GENSCIE, β_6	γ_{60}	8.37	0.95	8.84	145	0.000
HEDRES, β_7	γ_{70}	3.33	0.80	4.14	145	0.000
INSTSCIE, β_8	γ_{80}	6.10	1.39	4.39	38	0.000
SCIEEFF, β_9	γ_{90}	8.66	1.24	7.00	57	0.000
SCINVEST, β_{10}	γ_{100}	-9.41	1.20	-7.88	27	0.000

The graph indicates that the schools of high mean combined science score were substantially less negatively steep than the schools of low mean combined science.

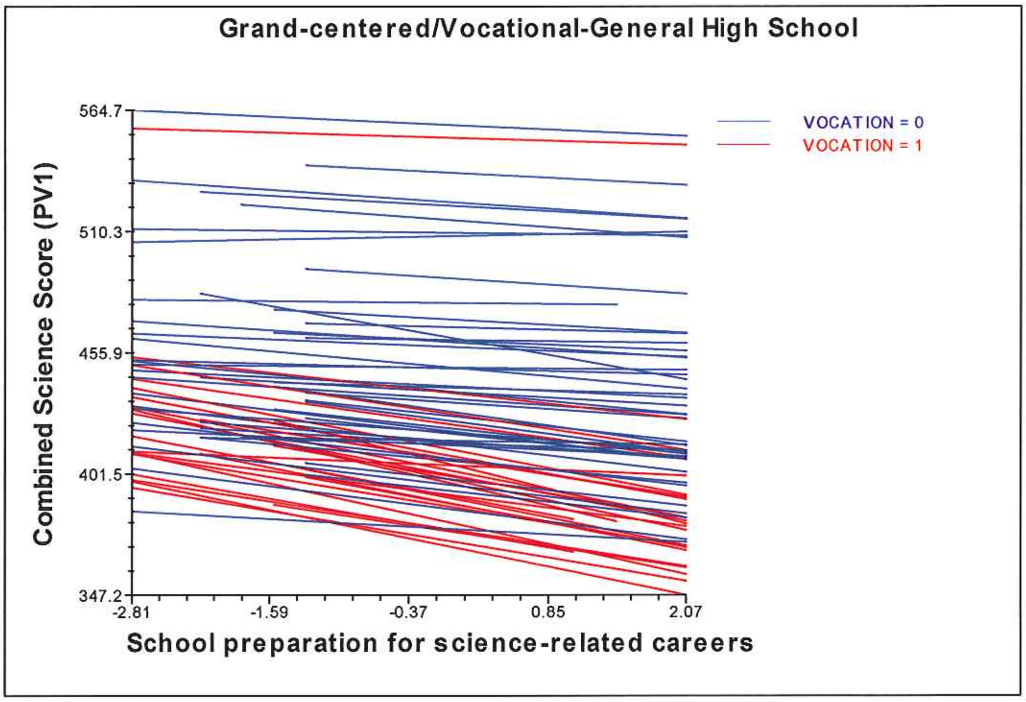

Figure 4.1. The Regressions of Combined Science as a Function of School Perception for Science-related Careers and High School Types (Grand- Mean-Centered).

There is a tendency for schools, which have low combined science, to have steeper slopes than schools, which have high combined science. In other words, a student, who has high CARPREP score from a vocational school, has low combined science.

School academic selectivity recoded ***(SELECT),*** teacher shortage (negative scale) ***(TCSHORT)*** and mean of index of economic, social and cultural status ***(ESCSMEAN)*** did not significantly predict the within school slopes.

Table 4.28 was displayed the estimated variances of this model. Bold numbers in the table cells were estimated variances of an intercepts-and slopes-as-outcomes model of the combined science. The numbers above the bold ones were random coefficient model (the first model of the preceding regression equations) of the combined science.

Table 4.28.

Variance-Covariance Components Matrix of the Model - Combined Science (Grand- Mean-Centered).

τ_{00}		β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_9
INTRCPT1,	β_0	1530.92								
		764.98								
CARPREP,	β_1	19.07	13.64							
		7.45	**10.18**							
ENVAWARE,	β_2	57.67	-2.29	21.76						
		12.56	**-3.31**	**19.47**						
ENVOPT,	β_3	44.76	-3.03	3.00	8.22					
		42.26	**-0.89**	**2.00**	**7.58**			**Symmetric**		
ENVPERC,	β_4	-111.32	-8.73	13.17	0.57	41.44				
		-52.08	**-4.35**	**16.62**	**-0.42**	**37.87**				
ESCS,	β_5	25.99	-6.51	-0.29	1.26	1.25	31.36			
		32.43	**-7.89**	**-0.10**	**1.32**	**0.65**	**24.69**			
GENSCIE,	β_6	-57.64	-0.91	-7.13	1.19	-8.29	-9.36	24.34		
		-20.28	**-1.34**	**-7.52**	**0.51**	**-13.20**	**-7.38**	**22.92**		
HEDRES,	β_7	-3.22	-0.49	2.93	-0.29	6.40	-6.35	-4.24	8.28	
		7.68	**2.35**	**3.04**	**0.03**	**5.37**	**-5.10**	**-4.67**	**6.91**	
SCIEEFF,	β_9	28.29	0.62	-4.82	-4.12	-12.56	11.50	0.44	-6.49	30.41
		11.25	**-5.09**	**-5.00**	**-4.32**	**-10.59**	**8.76**	**2.77**	**-5.73**	**32.07**

*Bold numbers in the cells were estimated variances of an intercepts-and slopes-as-outcomes model of the combined science. The numbers above the bold ones were random coefficient model of the combined science.

The estimated variance of the intercepts and slopes as outcomes model were considerably smaller than they had been without control for *school academic selectivity recoded* ***(SELECT),*** teacher shortage (negative scale) ***(TCSHORT)*** and mean of index of economic, social and cultural status ***(ESCSMEAN).***

4.1.4.1.2 Group-Mean-Centered

The student level model and the school level model can be written as:

Level-1 Model

$$\text{Combined Science (Y)} = \beta_0 + \beta_1*(\text{CARPREP}) + \beta_2*(\text{ENVAWARE}) + \beta_3*(\text{ENVOPT}) + \beta_4*(\text{ENVPERC}) + \beta_5*(\text{ESCS}) + \beta_6*(\text{GENSCIE}) + \beta_7*(\text{HEDRES}) + \beta_8*(\text{INSTSCIE}) + \beta_9*(\text{SCHANDS}) + \beta_{10}*(\text{SCIEEFF}) + r$$

Level-2 Mode
l

$$\beta_0 = \gamma_{00} + \gamma_{01}*(\text{SELECT}) + \gamma_{02}*(\text{TCSHORT}) + \gamma_{03}*(\text{ESCSMEAN}) + \gamma_{04}*(\text{VOCATION}) + \upsilon_0$$
$$\beta_1 = \gamma_{10} + \gamma_{11}*(\text{VOCATION}) + \upsilon_1$$
$$\beta_2 = \gamma_{20} + \upsilon_2$$
$$\beta_3 = \gamma_{30} + \upsilon_3$$
$$\beta_4 = \gamma_{40} + \upsilon_4$$
$$\beta_5 = \gamma_{50} + \upsilon_5$$
$$\beta_6 = \gamma_{50} + \upsilon_6$$
$$\beta_7 = \gamma_{60} + \upsilon_7$$
$$\beta_8 = \gamma_{80}$$
$$\beta_9 = \gamma_{90} + \upsilon_9$$
$$\beta_{10} = \gamma_{100} + \upsilon_{10}$$

Table 4.29 displays the results. As seen in the table SELECT (γ_{01} = 11.46, t=3.41), TCSHORT (γ_{02} = 4.25, t=2.02) and ESCSMEAN (γ_{03} = 57.40, t=9.02) were significantly predict the intercept and positively related to school mean of the combined science score The general high schools had also significantly higher mean combined science score than vocational high schools.

As regard to the slops, VOCATION significantly predict within schools CARPREP slopes. These slopes were shown in the Figure 4.2. The red slopes denote the vocational high schools and blue slopes are general high schools.

As denoted in the grand-centered combined science score model, the graph and the table indicate that the schools of high mean scores of "the school perception for science-related careers-CARPREP" have low combined science score than the schools of low mean scores of "the school perception for science-related careers-CARPREP".

Table 4.29.

Results from the Intercepts- and Slopes-as- Outcome Model / Combined Science (Group- Mean-Centered).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1, β_0						
INTRCPT2,	γ_{00}	439.37	3.98	110.47	141	0.000
SELECT	γ_{01}	11.46	3.36	3.41	141	0.001
TCSHORT	γ_{02}	4.25	2.10	2.02	141	0.045
ESCSMEAN	γ_{03}	57.40	6.36	9.02	141	0.000
VOCATION	γ_{04}	-25.10	6.79	-3.70	141	0.001
CARPREP, β_1						
INTRCPT2,	γ_{10}	-3.78	1.07	-3.52	67	0.001
VOCATION	γ_{11}	-5.50	1.55	-3.54	60	0.001
ENVAWARE, β_2	γ_{20}	9.74	1.12	8.66	54	0.000
ENVOPT, β_3	γ_{30}	-7.08	0.88	-8.07	26	0.000
ENVPERC, β_4	γ_{40}	4.02	1.34	3.00	43	0.005
ESCS, β_5	γ_{50}	3.22	1.25	2.58	90	0.012
GENSCIE, β_6	γ_{60}	8.46	0.96	8.80	145	0.000
HEDRES, β_7	γ_{70}	3.29	0.80	4.11	145	0.000
INSTSCIE, β_8	γ_{80}	5.54	1.31	4.24	47	0.000
SCHANDS, β_9	γ_{90}	-8.04	1.05	-7.66	145	0.000
SCIEEFF, β_{10}	γ_{100}	8.48	1.26	6.72	55	0.000

*School academic selectivity recoded **(SELECT)**,* teacher shortage (negative scale) ***(TCSHORT)*** and mean of index of economic, social and cultural status ***(ESCSMEAN)*** did not significantly predict the within school slopes.

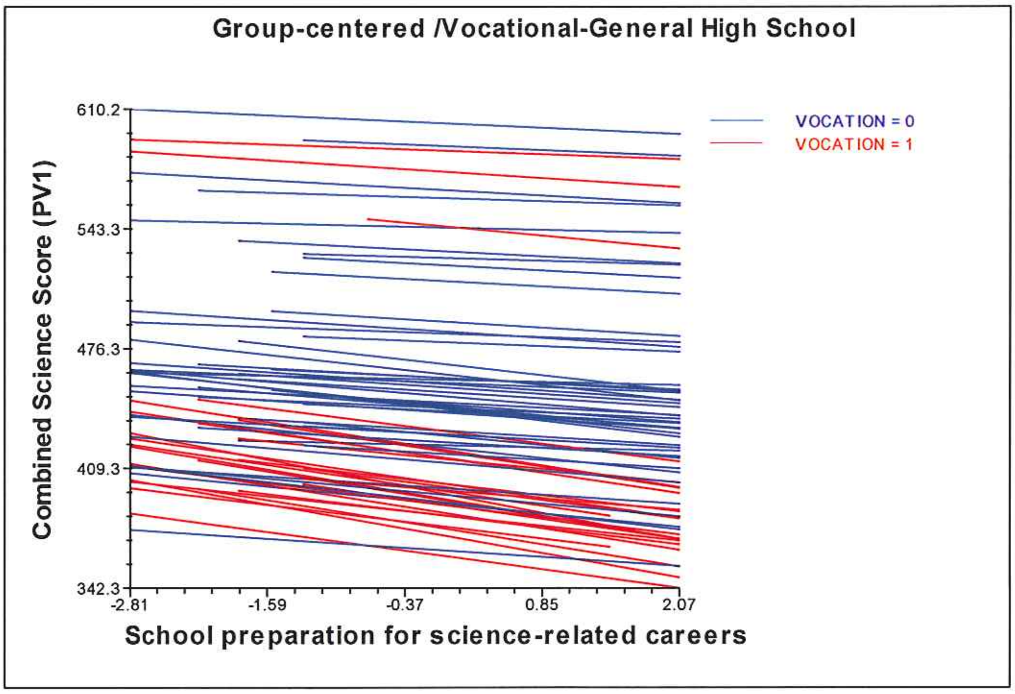

Figure 4.2. The Regressions of Combined Science as a Function of School Perception for Science-related Careers and High School Types (Group- Mean-Centered).

Table 4.30 was displayed the estimated variances of this model. The estimated variance of the intercepts and slopes as outcomes model were considerably smaller than they had been without control for *school academic selectivity recoded* ***(SELECT),*** teacher shortage (negative scale) ***(TCSHORT)*** and mean of index of economic, social and cultural status ***(ESCSMEAN)***.

Table 4. 30.

Variance-Covariance Components Matrix of the Model -Combined Science (Group- Mean-Centered).

		β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_9	β_{10}
INTRCPT1,	β_0	2503.52									
		1128.22									
CARPREP,	β_1	7.17	10.64								
		0.34	**7.74**								
ENVAWARE,	β_2	63.48	-1.16	20.80							
		9.51	**-2.48**	**18.20**							
ENVOPT,	β_3	71.16	-1.55	2.50	11.61						
		53.23	**-0.21**	**1.29**	**9.83**				**Symmetric**		
ENVPERC,	β_4	-153.64	-6.6 1	11.25	-2.95	40.48					
		-74.95	**-2.90**	**13.81**	**-3.11**	**34.16**					
ESCS,	β_5	-33.80	-6.23	0.37	-0.71	3.62	32.36				
		12.30	**-8.33**	**3.19**	**-1.35**	**1.79**	**30.48**				
GENSCIE,	β_6	-58.78	2.11	-4.41	4.05	-8.96	-6.84	26.62			
		1.33	**0.54**	**-4.90**	**2.96**	**-12.97**	**-8.21**	**23.02**			
HEDRES,	β_7	-16.19	-1.83	1.85	-1.66	7.74	-3.35	-6.18	8.92		
		3.65	**0.74**	**2.54**	**-0.90**	**6.07**	**-3.17**	**-5.74**	**6.99**		
SCHANDS,	β_9	-24.38	-1.71	-2.16	-7.67	9.22	-5.57	-14.04	5.05	29.39	
		-37.07	**0.16**	**-1.36**	**-6.13**	**10.12**	**-4.60**	**-11.24**	**4.53**	**27.86**	
SCIEEFF,	β_{10}	8.89	-1.45	-3.07	-4.82	-11.14	15.33	3.58	-5.85	-9.98	35.72
		1.06	**-6.20**	**-3.99**	**-5.18**	**-10.16**	**14.44**	**6.06**	**-5.81**	**-11.64**	**38.35**

*Bold numbers in the cells were estimated variances of an intercepts-and slopes-as-outcomes model of the combined science. The numbers above the bold ones were random coefficient model of the combined science.

4.1.4.2 Science Competencies

The explanatory models to account for variability across Turkish schools for the identifying scientific issues, the explaining phenomena scientifically and the using scientific evidences were built. Except GENDER, all other level-1 independent variables were centered on a group mean. The models were sought to find the answers of "Why some schools have higher means than other schools" and "why in some schools the relationship between student's *PISA outcome variables* and science competency scores are stronger than the other schools.

4.1.4.2.1 Identifying Scientific Issues

The following regression equation was used to answer the research questions;

i) Do *school academic selectivity recoded* ***(SELECT)*** and mean of index of economic, social and cultural status ***(ESCSMEAN)*** significantly predict the intercept?
ii) Do *school academic selectivity recoded* ***(SELECT)*** and mean of index of economic, social and cultural status ***(ESCSMEAN)*** significantly predict the within school slopes?

The student level model and the school level model can be written as:

Level-1 Model

Identifying Scientific Issues $(Y_{ij}) = \beta_0 + \beta_1$*(CARPREP) + β_2*(ENVAWARE) + β_3*(ENVOPT) + β_4*(ESCS) + β_5*(GENSCIE) + β_6*(HEDRES) + β_7*(JOYSCIE) + β_8*(PERSCIE) + β_9*(SCIEEFF) + β_{10}*(SCINTACT) + β_{11}* (WEALTH) + β_{12} * (GENDER) + r_{ij}

Level-2 Model

$$\beta_0 = \gamma_{00} + \gamma_{01}*(SELECT) + \gamma_{02}*(ESCSMEAN) + \gamma_{03}*(VOCATION) + \upsilon_0$$

$$\beta_1 = \gamma_{10} + \upsilon_1$$

$$\beta_2 = \gamma_{20} + \upsilon_2$$

$$\beta_3 = \gamma_{30} + \upsilon_3$$

$$\beta_4 = \gamma_{40} + \upsilon_4$$

$$\beta_5 = \gamma_{50} + \upsilon_5$$

$$\beta_6 = \gamma_{60} + \upsilon_6$$

$$\beta_7 = \gamma_{70}$$

$$\beta_8 = \gamma_{80} + \upsilon_8$$

$$\beta_9 = \gamma_{90} + \upsilon_9$$

$$\beta_{10} = \gamma_{100} + \upsilon_{10}$$

$$\beta_{11} = \gamma_{110} + \upsilon_{11}$$

$$\beta_{12} = \gamma_{120}$$

Table 4.31 displays the results. As seen in the table SELECT ($\gamma_{01} = 9.85$, t=3.01), and ESCSMEAN ($\gamma_{02} = 47.27$, t=7.15) were significantly predict the intercept and positively related to school mean of the identifying scientific issues score. The general high schools had also significantly higher mean identifying scientific issues score than vocational high schools.

Table 4.31.

Results from the Intercepts- and Slopes-as- Outcome Model / Identifying Scientific Issues (Group- Mean-Centered).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1, β_0						
INTRCPT2,	γ_{00}	432.82	4.54	95.36	142	0.000
SELECT,	γ_{01}	9.85	3.28	3.01	142	0.004
ESCSMEAN,	γ_{02}	47.27	6.62	7.15	142	0.000
VOCATION,	γ_{03}	-21.54	7.31	-2.95	142	0.004
CARPREP, β_1	γ_{11}	-6.24	1.13	-5.53	30	0.000
ENVAWARE, β_2	γ_{20}	7.76	1.24	6.25	26	0.000
ENVOPT, β_3	γ_{30}	-6.88	0.85	-8.07	32	0.000
ESCS, β_4	γ_{40}	2.94	1.39	2.11	145	0.036
GENSCIE, β_5	γ_{50}	3.54	1.13	3.15	145	0.002
HEDRES, β_6	γ_{60}	6.45	1.03	6.27	136	0.000
JOYSCIE, β_7	γ_{70}	5.71	1.57	3.64	28	0.001
PERSCIE, β_8	γ_{80}	-4.28	1.98	-2.16	27	0.039
SCIEEFF, β_9	γ_{90}	6.55	1.06	6.16	145	0.000
SCINTACT, β_{10}	γ_{100}	3.05	1.27	2.40	54	0.020
WEALTH, β_{11}	γ_{110}	-4.22	1.32	-3.19	145	0.002
GENDER, β_{12}	γ_{120}	17.73	1.97	8.99	1084	0.000

*School academic selectivity recoded **(SELECT)*** and mean of index of economic, social and cultural status ***(ESCSMEAN)*** did not significantly predict the within school slopes.

4.1.4.2.2 Explaining Phenomena Scientifically

The following regression equation was used to answer the research questions;

i) *Do school size **(SCHSIZE)**, school academic selectivity recoded **(SELECT)**,* teacher shortage (negative scale) ***(TCSHORT)*** and mean of index of economic, social and cultural status ***(ESCSMEAN)*** significantly predict the intercept?

ii) *Do school size **(SCHSIZE)**, school academic selectivity recoded **(SELECT),*** teacher shortage (negative scale) ***(TCSHORT)*** and mean of index of economic, social and cultural status ***(ESCSMEAN)*** significantly predict the within school slopes?

The student level model and the school level model can be written as:

Level-1 Model

Explaining Phenomena Scientifically (Y_{ij}) = β_0 + β_1*(CARPREP) + β_2*(ENVAWARE) + β_3*(ENVOPT) + β_4*(ENVPERC) + β_5*(ESCS) + β_6*(GENSCIE) + β_7* (SCHANDS) + β_8*(SCIEEFF) + β_9*(SCINVEST) + β_{10}* (SCSCIE) + β_{11}* (GENDER) + r_{ij}

Level-2 Model

β_0 = γ_{00} + γ_{01} *(SCHSIZE) + γ_{02} *(SELECT) + γ_{03} *(TCSHORT) + γ_{04} *(ESCSMEAN) + γ_{05} *(VOCATION) + υ_0

$\beta_1 = \gamma_{10} + \upsilon_1$

$\beta_2 = \gamma_{20} + \upsilon_2$

$\beta_3 = \gamma_{30} + \gamma_{31}$*(SELECT) + υ_3

$\beta_4 = \gamma_{40} + \upsilon_4$

$\beta_5 = \gamma_{50} + \upsilon_5$

$\beta_6 = \gamma_{60} + \upsilon_6$

$\beta_7 = \gamma_{70} + \upsilon_7$

$\beta_8 = \gamma_{80} + \upsilon_8$

$\beta_9 = \gamma_{90} + \upsilon_9$

$\beta_{10} = \gamma_{100} + \upsilon_{10}$

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

Table 4.32 displays the results. As seen in the table SCHSIZE (γ_{01} = -0.01, t=-3.29), SELECT (γ_{02} = 12.69, t=3.59), TCSHORT (γ_{03} = 4.61, t=2.10), and ESCSMEAN (γ_{04} = 58.58, t=8.36) were significantly predict the intercept. Except SCHSIZE, the predictors of SELECT, TCSHORT and ESCSMEAN were positively related to school mean of the explaining phenomena scientifically score. The general high schools had also significantly higher mean explaining phenomena scientifically score than vocational high schools.

As regard to the slops, SELECT significantly predicted within schools, environmental optimism, ENVOPT, slopes. These slopes were shown in the Figure 4.3. The green slopes denote upper-selected group, the red slopes denote medium-selected group and blue slopes denote low-selected group

Table 4.32.

Results from the Intercepts- and Slopes-as- Outcome Model / Explaining Phenomena Scientifically (Group- Mean-Centered).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1, β_0						
INTRCPT2,	γ_{00}	445.95	4.36	102.09	140	0.000
SCHSIZE,	γ_{01}	-0.01	0.00	-3.29	140	0.002
SELECT,	γ_{02}	12.69	3.53	3.59	140	0.001
TCSHORT,	γ_{03}	4.61	2.19	2.10	140	0.037
ESCSMEAN,	γ_{04}	58.58	7.00	8.36	140	0.000
VOCATION,	γ_{05}	-28.51	7.47	-3.82	140	0.000
CARPREP, β_1	γ_{10}	-4.39	1.08	-4.08	38	0.000
ENVAWARE, β_2	γ_{20}	11.37	1.39	8.19	16	0.000
ENVOPT, β_3						
INTRCPT2,	γ_{30}	-7.68	0.97	-7.93	25	0.000
SELECT,	γ_{31}	1.66	0.68	2.44	144	0.016
ENVPERC, β_4	γ_{40}	3.89	1.28	3.05	89	0.003
ESCS, β_5	γ_{50}	5.22	1.05	4.98	145	0.000
GENSCIE, β_6	γ_{60}	9.37	1.04	8.98	77	0.000
SCHANDS, β_7	γ_{70}	-5.86	1.34	-4.39	145	0.000
SCIEEFF, β_8	γ_{80}	8.60	1.11	7.74	145	0.000
SCINVEST, β_9	γ_{90}	-6.19	1.35	-4.57	145	0.000
SCSCIE, β_{10}	γ_{100}	6.29	1.18	5.35	36	0.000
GENDER, β_{11}	γ_{110}	-16.26	2.07	-7.87	4452	0.000

As denoted the graph and the table of the model, the relationship between ENVOPT and explaining phenomena scientifically score was displayed for upper-selected, medium- selected and low-selected schools. The within-school ENVOPT- explaining phenomena scientifically score slopes were less steep in upper-selected group. The upper-selected slopes appeared in the upper part of the graph.

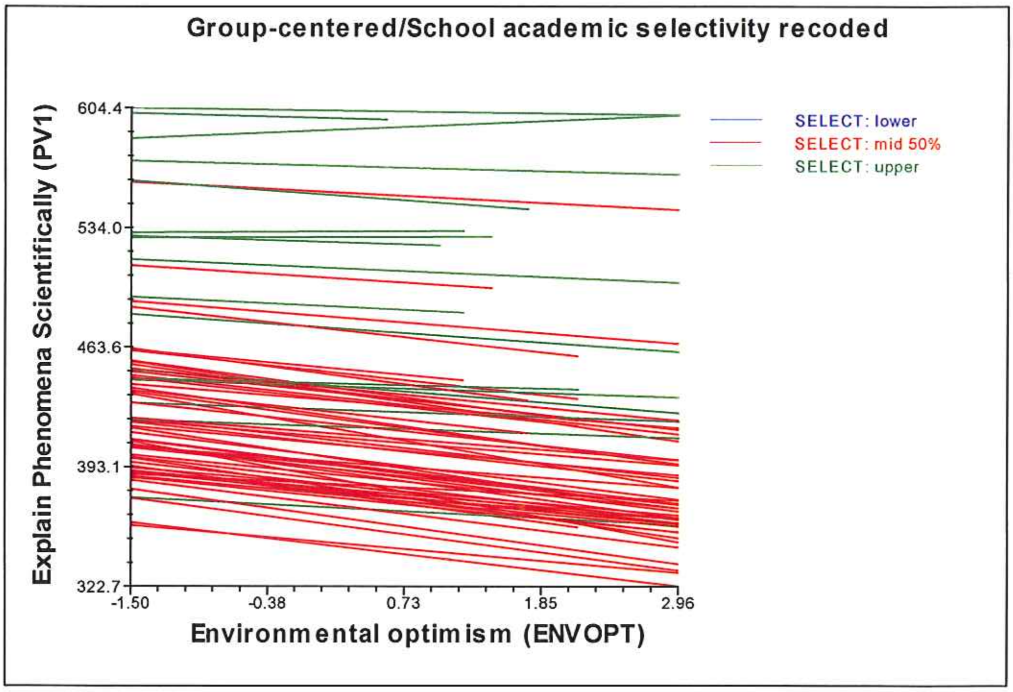

Figure 4.3. The Regressions of Explaining Phenomena Scientifically as a Function of Environmental Optimism and School Academic Selectivity (Group- Mean -Centered)

4.1.4.2.3 Using Scientific Evidence

The following regression equation was used to answer the research questions;

i) *Do school academic selectivity recoded* ***(SELECT),*** teacher shortage (negative scale) ***(TCSHORT)*** and mean of index of economic, social and cultural status ***(ESCSMEAN)*** significantly predict the intercept?

ii) *Do school academic selectivity recoded* ***(SELECT),*** teacher shortage (negative scale) ***(TCSHORT)*** and mean of index of economic, social and cultural status ***(ESCSMEAN)*** significantly predict the within school slopes?

The student level model and the school level model can be written as:

Level-1 Model

Using Scientific Evidence (Y_{ij}) = $\beta_0 + \beta_1$*(CARPREP) + β_2* (ENVAWARE) + β_3*(ENVOPT) + β_4*(ENVPERC) + β_5*(ESCS) + β_6*(GENSCIE) + β_7*(HEDRES) + β_8* (JOYSCIE) + β_9*(RESPDEV) + β_{10}*(SCHANDS) + β_{11}* (SCIEEFF) + r_{ij}

Level-2 Model

$\beta_0 = \gamma_{00} + \gamma_{01}$*(SELECT) + γ_{02}*(TCSHORT) + γ_{03}*(ESCSMEAN) + γ_{04}*(VOCATION) + υ_0

$\beta_1 = \gamma_{10} + \gamma_{11}$*(VOCATION) + υ_1

$\beta_2 = \gamma_{20} + \upsilon_2$

$\beta_3 = \gamma_{30} + \gamma_{31}$ *(SELECT) + υ_3

$\beta_4 = \gamma_{40} + \upsilon_4$

$\beta_5 = \gamma_{50} + \upsilon_5$

$\beta_6 = \gamma_{60} + \upsilon_6$

$\beta_7 = \gamma_{70} + \upsilon_7$

$\beta_8 = \gamma_{80}$

$\beta_9 = \gamma_{90} + \upsilon_9$

$\beta_{10} = \gamma_{100} + \upsilon_{10}$

$\beta_{11} = \gamma_{110} + \upsilon_{11}$

Table 4.33 displayed the results. As seen in the table SELECT (γ_{02} = 13.22, t=3.85), TCSHORT (γ_{03} = 5.15, t=2.13), and ESCSMEAN (γ_{04} = 63.87, t=9.00) were significantly predict the intercept. SELECT, TCSHORT and ESCSMEAN were positively related to school mean of the using scientific evidence score. The general high schools had also significantly higher mean using scientific evidence score than vocational high schools.

Table 4.33.

Results from the Intercepts- and Slopes-as- Outcome Model / Using Scientific Evidence (Group- Mean-Centered).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1, β_0						
INTRCPT2,	γ_{00}	437.99	4.14	105.22	141	0.000
SELECT,	γ_{01}	13.22	3.43	3.85	141	0.000
TCSHORT,	γ_{02}	5.15	2.42	2.13	141	0.035
ESCSMEAN,	γ_{03}	63.87	7.11	9.00	141	0.000
VOCATION,	γ_{04}	-32.33	7.49	-4.32	141	0.000
CARPREP, β_1						
INTRCPT2,	γ_{10}	-4.35	1.31	-3.32	27	0.003
VOCATION,	γ_{11}	-6.76	1.84	-3.66	62	0.001
ENVAWARE, β_2	γ_{20}	10.61	1.35	7.87	23	0.000
ENVOPT, β_3						
INTRCPT2,	γ_{30}	-7.21	0.93	-7.74	28	0.000
SELECT,	γ_{31}	1.81	0.70	2.60	144	0.011
ENVPERC, β_4	γ_{40}	4.97	1.32	3.78	112	0.000
ESCS, β_5	γ_{50}	3.45	1.31	2.64	145	0.010
GENSCIE, β_6	γ_{60}	9.78	1.21	8.09	66	0.000
HEDRES, β_7	γ_{70}	3.81	0.99	3.86	89	0.000
JOYSCIE, β_8	γ_{80}	6.58	1.39	4.75	41	0.000
RESPDEV, β_9	γ_{90}	5.53	1.19	4.66	98	0.000
SCHANDS, β_{10}	γ_{100}	-8.22	1.03	-7.96	145	0.000
SCIEEFF, B_{11}	γ_{110}	7.39	1.25	5.93	145	0.000

As regard to the slops, VOCATION significantly predict within schools CARPREP and SELECT significantly predict within schools ENVOPT slopes. These slopes were shown in the Figure 4.4 and Figure 4.4 respectively.

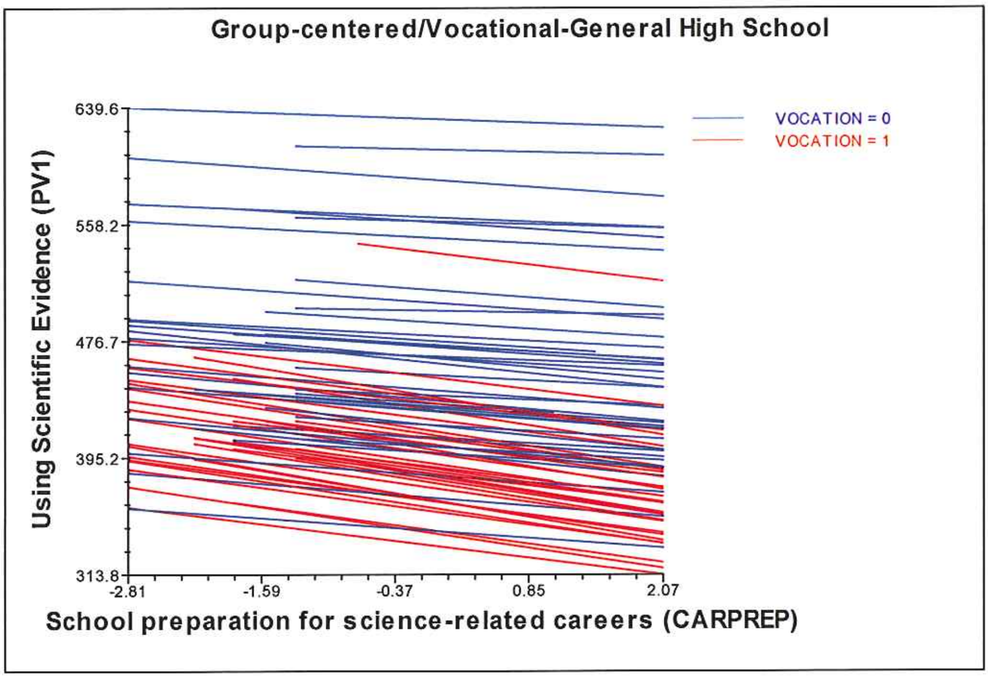

Figure 4.4. The Regressions of Using Scientific Evidence as a Function of Environmental Optimism and School Academic Selectivity (Group- Mean -Centered)

In Figure 4.4, the red slopes denote the vocational high schools and blue slopes are general high schools. The graph indicates that the schools of high mean using scientific evidence score have low CARPREP than the schools of low mean using scientific evidence score.

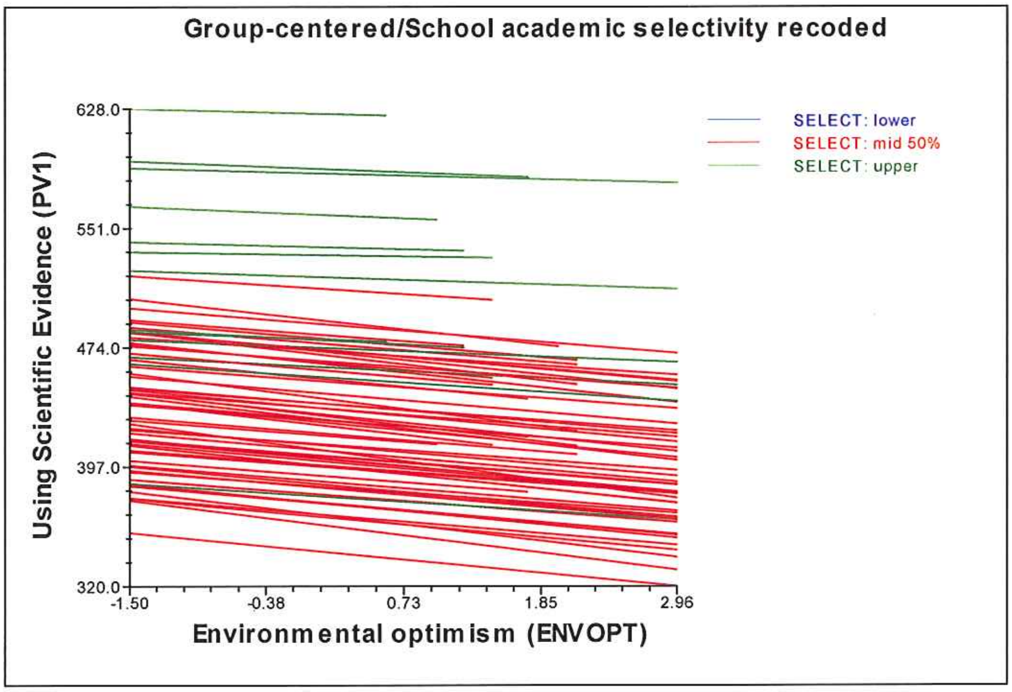

Figure 4.5. The Regressions of Using Scientific Evidence as a Function of Environmental Optimism and School Academic Selectivity (Group- Mean-Centered)

In Figure 4.5, the green slopes denote upper-selected group, the red slopes denote medium-selected group and blue slopes denote low-selected group

4.1.4.3 Science Attitudes

The explanatory models to account for variability across Turkish schools for the interest in learning science and support for scientific enquiry were built. Except GENDER, all other level-1 independent variables were centered on a group mean. The models were sought to find the answers of "Why some schools have higher means than other schools" and "why in some schools the relationship between student's *PISA outcome variables* and science attitudes score is stronger than the other schools.

The following regression equation was used to answer the research questions;

i) Does the mean of index of economic, social and cultural status ***(ESCSMEAN)*** significantly predict the intercept?

ii) Does the mean of index of economic, social and cultural status ***(ESCSMEAN)*** significantly predict the within school slopes?

4.1.4.3.1 Interest in Learning Science

The student level model and the school level model can be written as:

Level-1 Model

Interest in Learning Science (Y_{ij}) = β_0 + β_1*(CARPREP) + β_2 *(ESCS) + β_3*(GENSCIE) + β_4* (INTSCIE) + β_5*(JOYSCIE) + β_6* (RESPDEV) + β_7* (SCIEACT) + β_8*(SCIEEFF) + β_9* (SCINVEST) + β_{10}* (SCSCIE) + β_{11}* (GENDER) + r_{ij}

Level-2 Model

$\beta_0 = \gamma_{00} + \gamma_{01}$*(ESCSMEAN) + γ_{02}*(VOCATION) + υ_0
$\beta_1 = \gamma_{10} + \upsilon_1$
$\beta_2 = \gamma_{20} + \upsilon_2$
$\beta_3 = \gamma_{30} + \upsilon_3$
$\beta_4 = \gamma_{40} + \upsilon_4$
$\beta_5 = \gamma_{50} + \upsilon_5$
$\beta_6 = \gamma_{60} + \upsilon_6$
$\beta_7 = \gamma_{70}+ \upsilon_7$
$\beta_8 = \gamma_{80}+ \upsilon_8$
$\beta_9 = \gamma_{90} + \upsilon_9$
$\beta_{10}= \gamma_{100}$
$\beta_{10}= \gamma_{110}$

Table 4.34 displays the results. As seen in the table, the aggregated variable ESCSMEAN (γ_{04} = -23.36, t = -4.44) were significantly predict the intercept. The ESCSMEAN was negatively related to school mean of the interest in learning science score. The general high schools' the interest in learning science score had significantly higher mean than vocational high schools.

Table 4.34.

Results from the Intercepts- and Slopes-as- Outcome Model / Interest in Learning Science (Group- Mean-Centered).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1, β_0						
INTRCPT2,	γ_{00}	550.94	3.80	145.04	143	0.000
ESCSMEAN,	γ_{01}	-23.36	5.27	-4.44	143	0.000
VOCATION,	γ_{02}	-12.26	5.38	-2.28	143	0.024
CARPREP, β_1	γ_{10}	5.89	1.30	4.53	145	0.000
ESCS, β_2	γ_{20}	-8.54	1.40	-6.09	145	0.000
GENSCIE, β_3	γ_{30}	5.58	1.65	3.39	145	0.001
INTSCIE, β_4	γ_{40}	28.28	2.29	12.38	57	0.000
JOYSCIE, β_5	γ_{50}	19.57	2.31	8.47	145	0.000
RESPDEV, β_6	γ_{60}	14.83	1.28	11.55	104	0.000
SCIEACT, β_7	γ_{70}	9.70	2.16	4.48	145	0.000
SCIEEFF, β_8	γ_{80}	14.27	1.71	8.33	145	0.000
SCINVEST, β_9	γ_{90}	8.87	1.33	6.69	145	0.000
SCSCIE, β_{10}	γ_{100}	-5.44	2.09	-2.60	140	0.011
GENDER, β_{11}	γ_{110}	-10.48	2.93	-3.58	4456	0.001

4.1.4.3.2 Support for Scientific Enquiry

The student level model and the school level model can be written as:

Level-1 Model

Support for Scientific Enquiry (Y_{ij}) = $\beta_0 + \beta_1$*(ENVAWARE) + β_2 *(GENSCIE) + β_3* (INTSCIE) + β_4*(JOYSCIE) + β_5*(PERSCIE) + β_6* (RESPDEV) + β_7* (SCIEEFF) + β_8 (GENDER) + r_{ij}

Level-2 Model

$$\beta_0 = \gamma_{00} + \gamma_{01}*(\text{ESCSMEAN}) + \gamma_{02}*(\text{VOCATION}) + \upsilon_0$$
$$\beta_1 = \gamma_{10} + \gamma_{11}$$
$$\beta_2 = \gamma_{20} + \upsilon_2$$
$$\beta_3 = \gamma_{30} + \upsilon_3$$
$$\beta_4 = \gamma_{40} + \upsilon_4$$
$$\beta_5 = \gamma_{50} + \upsilon_5$$
$$\beta_6 = \gamma_{60} + \upsilon_6$$
$$\beta_7 = \gamma_{70} + \upsilon_7$$
$$\beta_8 = \gamma_{80}$$

Table 4.35 displays the results. As seen in the table ESCSMEAN (γ_{04} = 27.61, t = 3.58) were significantly predict the intercept. The ESCSMEAN was positively related to school mean of the support for scientific enquiry score. The general high schools' the support for scientific enquiry had significantly higher mean than vocational high schools.

Table 4.35.

Results from the Intercepts- and Slopes-as- Outcome Model / Support for Scientific Enquiry (Group- Mean-Centered).

Fixed Effect		*Coefficient*	*SE*	*T-ratio*	*df*	*P-value*
INTRCPT1, β_0						
INTRCPT2,	γ_{00}	571.49	4.08	140.13	143	0.000
ESCSMEAN,	γ_{01}	27.61	7.72	3.58	143	0.001
VOCATION,	γ_{02}	-19.38	6.19	-3.13	143	0.003
ENVAWARE, β_1	γ_{10}	4.95	1.95	2.54	145	0.012
GENSCIE, β_2	γ_{20}	39.78	2.20	18.09	122	0.000
INTSCIE, β_3	γ_{30}	9.97	2.97	3.35	12	0.006
JOYSCIE, β_4	γ_{40}	10.33	2.80	3.69	90	0.001
PERSCIE, β_5	γ_{50}	7.20	2.60	2.78	54	0.008
RESPDEV, β_6	γ_{60}	28.26	1.85	15.26	73	0.000
SCIEEFF, β_7	γ_{70}	10.11	2.27	4.45	95	0.000
GENDER, β_8	γ_{80}	14.88	3.17	4.70	137	0.000

4.1.4.4 Findings from An Intercepts - And Slopes - As - Outcomes Model

1. The school level variables of school academic selectivity recoded **(SELECT),** teacher shortage (negative scale) **(TCSHORT),** means of students' index of economic, social and cultural status **(ESCSMEAN)** and vocational high school - high school **(VOCATION)** effect the most of the means of schools' scientific literacy scores.

2. There are significant interaction between some school-level and student level interaction;
   - The school perception for science related careers **(CARPREP)** and vocational and general high school **(VOCATION)** in combined science,
   - School academic selectivity recoded, **(SELECT)** and environmental optimism **(ENVOPT)** in explain phenomena scientifically,
   - The school perception for science related careers **(CARPREP)** and vocational and general high school **(VOCATION)** and school academic selectivity recoded, **(SELECT)** and environmental optimism **(ENVOPT)** in using scientific evidence.

3. The estimated variance of the intercepts and slopes as outcomes model were considerably smaller than they had been without control for school-level variables.

CHAPTER 5

CONCLUSION AND IMPLICATON

The purpose of this study was to examine the impact of student and school level factors on 15-year-old students' science literacy skills and to compare vocational and general high schools in terms of student characteristics variables –scientific literacy scores relationship after significant school characteristics were controlled. Therefore, great deals of models were built in the previous chapter. In this chapter, the student and school level factors effecting science literacy skills of the students in Turkey are discussed. Afterwards, the consequences of the study were explained and interpreted. Finally, the implications of the study were clarified.

5.1 Conclusion

The present study investigated students and school level factors that effected students' science literacy skills in Turkey. Hierarchical Linear Models were used to analyze the Turkish PISA 2006 student and school data. To investigate the science literacy skills of Turkish students not only analyzes the combined science score but the science competencies and science attitudes scores also analyzed separately.

5.1.1 Findings from Student Level Characteristics and School Level Characteristics

The submodels of hierarchical linear modeling from the simplest to the more complex were run in the study. At the beginning of the analyzing of each data, the one-way ANOVA with random effects was used. Afterwards, a regression model with means-as-outcomes model, a random-coefficients regression model and a model with intercepts-and slopes – as - outcomes model were executed for combined science score, science competencies scores and science attitudes scores one by one.

The Null Model or the one-way ANOVA with random effects was used to partition the variances in the outcome variables into within - and - between - school components.

Because of the predictor of VOCATION, the Null Model was executed two times for all outcomes variables. All PISA 2006 Turkish samples, including the primary schools, the vocational high schools and the general high schools, were used at the first execution. In the second execution, the high schools included by the PISA 2006 Turkish sample were used.

The results of Null Models for all Turkish students and Null Models for except primary schools can be seen in Table 4.1 - Table 4.6. The fixed coefficients of the combined science, the science competencies and the science attitudes were significant in the tables. The significance of the coefficients interpreted as the average scores of the students at different schools were highly different from each other.

The range of average outcomes of the schools, student level variance, school level variance and intra-class correlation can also be seen in these tables. The intra-class correlation coefficients of combined science and the intra-class correlation coefficients of science competencies were higher than the intra-class correlation coefficients of attitudes. It can be summarized that the proportion of variances explained by the grouping structure in the combined science and the science competencies are higher than the proportion of variance explained by the grouping structure in the science attitudes. In other words, the impact of school characteristics on students' combined science score and science competencies scores is larger than the impact of school characteristics on students' science attitude scores.

i. School Characteristics

The means-as-outcomes model was executed to predict variation in the combined science, science competencies and science attitudes using school level predictors. The regression model with means-as-outcomes predicts variation in the scientific literacy skills of Turkish high schools' students using school level predictors.

Table 5.1, Table 5.2, and Table 5.3 display the school level variables of the means-as-outcomes model. The figures in the intercept column provide the mean of the outcome variable for someone with average predictors. The other figures in the tables provide fixed effects of the school level predictors. Table 5.3 is the continuation of the Table 5.1 and Table 5.2. Therefore, the intercepts columns in these tables are identical. The rows in the tables include the intercept and the fixed effects of the models. For example, the average combined science for someone who attends general high school **(VOCATION)** with average **SELECT,** average **TCSHORT** and average **ESCSMEAN** is 438.49.

The combined science score, the science competencies scores and the science attitudes scores of Turkish students were predicted by the proportion of girls at school **(PCGIRL),** school size **(SCHSIZE),** school academic selectivity recoded **(SELECT),** teacher shortage (negative scale) **(TCSHORT),** means of students' index of economic, social and cultural status **(ESCSMEAN)** and vocational high school - high school **(VOCATION)** .

The significant school predictors in the means-as-outcome models of combined science, identifying scientific issues, explaining phenomena scientifically, using scientific evidence, interest in learning science and support for scientific enquiry are clarified below.

Table 5.1.

Fixed Effects of Means-as –Outcome Model/ School Level Variables-I

		Intercept	Proportion of girls at school, **PCGIRL**	Ratio of computers to school size, **RATCOMP**	School size, **SCHSIZE**	School academic selectivity recoded, **SELECT**	Teacher-student ratio, **STRATIO**
	Science	438.49**	----	----	----	13.90**	----
Competencies	Identifying scientific issues	439.99**	42.38**	----	----	10.33**	----
Competencies	Explaining phenomena scientifically	437.80**	----	----	-0.01**	14.55**	----
Competencies	Using scientific evidence	437.04**	----	----	----	14.77**	----
Attitudes	Interest in learning science	539.91**	----	----	----	----	----
Attitudes	Support for scientific enquiry	568.22**	----	----	----	----	----

*p <.05, **p <.01.

1. The school level predictor of, the means of students' index of economic, social and cultural status-ESCSMEAN (*M*= -1.38, *SD*= 0.630), is an aggregated variable, which was created from variable of students' index of economic, social and cultural status. The PISA index of economic, social and cultural status was derived to grasp the student's family, home background and occupational status. The most of the means-as outcome models, the ESCSMEAN was the school level variable to predict the six outcome variables of the students' scientific literacy skills. This predictor is an identifier for Turkish students, because the unit increase in ESCSMEAN is associated with 59.65 points increase in combined science score, 46.87 points increase in identifying scientific issues, 59.73 points increase in explaining phenomena scientifically and 67.48 points increase in using scientific evidence.

   The models with "interest in learning science" and "support for scientific enquiry" were dissimilar to the combined science model and the science competencies models. Because the unit increase in ESCSMEAN is associated with 19.46 points decrease in the interest in learning science model, and 36.56 points increase in support for scientific enquiry model.

2. The school level predictor of **VOCATION** symbolized the vocational high schools (VOCATION=1) and general high school (VOCATION=0). This school level variable is significant in the model of combined science, the model of identifying scientific issues, the model of explaining phenomena scientifically and the model of using scientific evidence. Through the VOCATION column in Table 5.2 it can be seen that the performances of the general high school students are better than the performance of vocational high school students. For example, average performance of general high schools in the combined science is 25.38 points higher than vocational high schools.

   The predictor of VOCATION was not significant in model of interest in learning science and the model of support for scientific enquiry.

Table 5.2.

Fixed Effects of Means-as –Outcome Model/ School Level Variables-II

		Intercept	School activities for learning environmental topics, **ENVLEARN**	Responsibility for resource allocation - School: Central Authority, **RESPRES**	Responsibility for curriculum & assessment - School: Central Authority, **RESPCURR**	School activities to promote the learning of science, **SCIPROM**	Quality of educational resources, **SCMATEDU**
	Science	438.49**	----	----	----	----	----
Competencies	Identifying scientific issues	439.99**	----	----	----	----	----
	Explaining phenomena scientifically	437.80**	----	----	----	----	----
	Using scientific evidence	437.04**	----	----	----	----	----
Attitudes	Interest in learning science	539.91**	----	----	----	----	----
	Support for scientific enquiry	568.22**	----	----	----	----	----

*p <.05, **p <.01.

3. The school level predictor of the school academic selectivity recoded, **SELECT** (*M*= 2.16, *SD*= 1.115) was formed from the school principals' responses. This index was constructed from the items regarding high academic selectivity of school admittance. In four means-as outcome models, the SELECT was one of the school level variables to predict the outcome variables; combined science, identifying scientific issues, explaining phenomena scientifically, and using scientific evidence. The significance of this independent variable exhibit one of the issues of our education system. Because the student selection is used effectively at the end of eight grade level in Turkish education system. The unit increase in SELECT is associated with 13.90 points increase in combined science, 10.33 points increase in identifying scientific issues, 14.55 points increase in explaining phenomena scientifically, and 14.77 points increase in using scientific evidence.

   The predictor of SELECT was not significant in the model of interest in learning science, and the model of support for scientific enquiry. In other words, the school academic selectivity recoded does not affect student attitudes.

4. The school level predictor of teacher shortage (negative scale), **TCSHORT** (*M*= 1.28, *SD*= 1.077) was formed from the school principals' responses. School-level index of teacher shortage is the school principals' view on the extent to which instruction was hindered by a lack of qualified teachers in key subject areas. The school principals in Turkey considered that instruction was hindered by a lack of science teachers even in schools where there were no vacancies. Seven percent of school principals in Turkey reported that one or more vacant science teaching positions were not filled. (PISA 2006- Science Competencies for Tomorrow's World)

Table 5.3

Fixed Effects of Means-as –Outcome Model/ School Level Variables-III

		Intercept	Teacher shortage (negative scale) **TCSHORT**	Mean of index of economic, social and cultural status , **ESCSMEAN**	Vocational-general high school, **VOCATION**	Class size, **CLASIZ**	**KAYNAK**	Urban-rural high school, **URBAN**
	Science	438.49**	5.56**	59.65**	-25.38**	----	----	----
Competencies	Identifying scientific issues	439.99**	----	46.87**	-22.22**	----	----	----
	Explaining phenomena scientifically	437.80**	5.69**	59.73**	-28.12**	----	----	----
	Using scientific evidence	437.04**	6.71**	67.48**	-33.96**	----	----	----
Attitudes	Interest in learning science	539.91**	----	-19.46**	----	----	----	----
	Support for scientific enquiry	568.22**	----	36.56**	----	----	----	----

*p <.05, **p <.01.

Teacher shortage is positively related to science performance. In other words, the students in schools that reported a higher incidence of teacher shortage tended to perform better. This finding is important to understand if this school-level predictor is due to cultural translation misconception, or other predictors that might have affected students' learning in the absence of the science teacher. The predictor of TCSHORT was not significant in the model of interest in learning science and the model of support for scientific enquiry.

5. The proportion of girls at school, **PCGIRL** (*M*=0.43, *SD*= 0.223) was constructed from the school principals' responses. This predictor is significant only for the model of identifying scientific issues. The unit increase in PCGIRL is associated with 42.38 points increase in identifying scientific issues. On the other hand, the female students are more successful than the male students in the random coefficient model of identifying scientific issues and the random coefficient model of support for scientific enquiry.

6. The school level predictor of school size, **SCSIZE** (*M*= 512.19, *SD*= 500.740) comprises the total enrollment on school based enrollment data by school principal. The effect of this predictor is significant only for the model of explaining phenomena scientifically. The magnitude of fixed effect of school size is very low. The unit increases in SCSIZE is associated with 0.01 points decrease in explaining phenomena scientifically performance.

ii. Student Characteristics

The random-coefficients regression model was executed to answer the following questions:

i) What is the average intercept and slope of the 149 Turkish high schools regression equations?

ii) How much do the regression equations vary from school to school? Specifically, how much do the intercepts vary and how much do the slopes vary?

iii) What is the correlation between the intercepts and the slopes?

The tables between 5.4 and 5.11 display the student level variables of the random-coefficients regression models. Each intercept value provides the mean of the outcome variable for someone with average level-1 predictors. In other words, the mean of combined science score, the mean of identifying scientific issues score, the mean of explaining phenomena scientifically score, the mean of using scientific evidence score, the mean of interest in learning science score and the mean of support for scientific enquiry score for some students with average student predictors were displayed in the second column of these tables. These tables (from 5.4 to 5.11) are continuation of the previous one. Therefore, the second columns of these tables are identical. The rows in the tables include the intercept and the fixed effects of the models. To interpret the models clearly, all student level variables used in the models were categorized in eight groups;

i) Student background variables,
ii) Variables of socio-economic status,
iii) Variables of motivational factors,
iv) Variables of science self belief,
v) Variables of value beliefs regarding science,
vi) Variables of science-related careers,
vii) Variables of science teaching and learning
viii) Variables of scientific literacy and the environment

When student-level variables are adjusted the average combined science score for some general high schools' students is 452.61. In other words, the average combined science score for some general high schools' students with average CARPREP, average ENVAWARE, average ENVOPT, average ENVPERC, average ESCS, average GENSCIE, average HEDRES, average INSTSCIE, average SCIEEFF and average SCHANDS is 452.61.

Likewise, the average combined science score for some vocational high schools' students with average CARPREP, average ENVAWARE, average ENVOPT, average ENVPERC, average ESCS, average GENSCIE, average HEDRES, average INSTSCIE, average SCIEEFF and average SCHANDS is 393.21.

The attitude scores of some high schools' students with average student-level predictors were extremely high when considering the combined science score and science competencies' scores of the students.

The outcomes of science attitude were different from the outcome of combined science and the outcomes of science competencies. Students' support for scientific enquiry and students' interest in learning science topics were directly assessed in the PISA test using embedded questions. The students were able to report one of the following responses; "highly interest," "medium interest," low interest" or "no interest" for students' interest in learning science items. For attitudinal items measuring students' support for scientific enquiry, students were asked to explain their level of agreement using one of the following responses; "strongly agree," "agree," "disagree," "strongly disagree" (OECD, 2006).

The results from student-level variables being in the random-coefficients regression model of combined science, identifying scientific issues, explaining phenomena scientifically, using scientific evidence, interest in learning science and support for scientific enquiry are discussed below.

1. Table 5.4 displays the results of student background variables. Three dichotomous variables were included in this category; the language of the students at home, gender of the students and school type. Language at home, DIL, was not significant for Turkish students.

Table 5.4.

Student Background -Fixed Effects of Random Coefficient Model

		Mean of School' Means	Language at home, (Turkish=1, Other=0) DIL	Gender, (Male=0, Female=1) GENDER	Vocational school, (High School=0, Vocational School=1) VOCATION
	Science	452.61**	---	---	-59.40**
Competencies	Identifying scientific issues	443.42**	---	17.79**	-50.59**
	Explaining phenomena scientifically	458.70**	---	-15.78**	-59.65**
	Using scientific evidence	451.35**	---	---	-67.70**
Attitudes	Interest in learning science	544.96**	---	-12.23**	---
	Support for scientific enquiry	576.58**	---	15.24**	-34.91**

*p <.05, **p <.01.

The gender differences in combined science and using scientific evidence were not significant. The performances of female students in the identifying scientific issues were higher than males, while the performances of male students were higher in the explaining phenomena scientifically. Considering science attitude scores, the performance of female students were lower than the performance of male students in the interest in learning science while the performance of male students were lower in the support for scientific enquiry.

The science performances of students in the high schools were better than the vocational high schools. The performance differences between the high schools and vocational high schools increase while increasing the strength of the science competency.

2. Variation in the students' scientific literacy was examined in the students' socio economic status. Table 5.5 displays the results of students' socio economic status variables. In this category, the economic, social, and cultural status, ESCS(*M*=-1,22, SD= 1,082), the index of home possession, HOMEPOSS(*M* =-1,03, *SD*= 1,141), the home educational resources, HEDRES(*M*= -0,62, *SD* = 1,297), the cultural possessions at home, CULTPOSS(*M* =0,00, *SD* = ,939) and the index of family wealth, WEALTH(*M* =-1,47, *SD* = 1,006) were included.

   The index of home possession, HOMEPOSS and the cultural possessions at home, CULTPOSS were not significant for Turkish students. However, the economic, social, and cultural status including all the variables of HOMEPOSS, HEDRES, CULTPOSS and WEALTH was significant for combined science, identifying scientific issues, explaining phenomena scientifically, using scientific evidence, and interest in learning science. None of the variables of students' socio economic status was significant for the support for scientific enquiry. The combined science for some high schools' students with average CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, HEDRES, INSTSCIE, SCIEEFF and SCHANDS was 452.61; each unit increase in ESCS without any change in the other predictors of the model is associated with 3.50 points increase in combined science.

Table 5.5.

Socio-economic Status /Fixed Effects of Random Coefficient Model (Group-Mean-Centered)

		Mean of School Means	Economic, social, and cultural status, **ESCS**	Index of home possession, **HOMEPOSS**	Home educational resources, **HEDRES**	Cultural possessions at home, **CULTPOSS**	Index of family wealth, **WEALTH**
	Science	452.61**	3.50*	---	3.22**	---	---
Competencies	Identifying scientific issues	443.42**	3.37*	---	6.50**	---	- 4.51**
	Explaining phenomena scientifically	458.70**	5.54**	---	---	---	---
	Using scientific evidence	451.35**	3.54*	---	3.94**	---	---
Attitudes	Interest in learning science	544.96**	-8.11**	---	---	---	---
	Support for scientific enquiry	576.58**	---	---	---	---	---

ESCS: i) a desk to study, ii) a room of their own, iii)a quiet place to study, iv)a computer they con use for school, v)an educational software, vi)a link to the internet, vii) their own calculator, viii) classic literature, ix) books of poetry, x) works of art, xi) books to help with their school work, xii) a dictionary, xiii) a dishwasher, xiv) a DVD player or VCR, xv) the number of cellular phones, xvi)televisions, xvii) computers, xviii) cars, ixx)books at home and three other country specific items.

HOMEPOSS : i) whether students had a room of their own, a link to the internet, a dishwasher and a DVD or VCR player, ii) how many of the following items they had at their home: cellular phones, televisions, computers and cars, iii) three country specific items thought to indicate wealth defined by each country.

HEDRES : i) a desk to study, ii) a quiet place to study, iii) a computer they can use for school work, iv) an educational software, v) their own calculator, vi) books to help with their school work,

CULTPOSS : i) classic literature, ii)book of poetry, iii)works of art

WEALTH a. whether the students had : i) a room of their own, ii) a link to the internet, iii) a dishwasher, iv) a DVD player or VCR, **b.** how many of the following items they had at home: i) cellular phones, ii) televisions, iii) computers, iv)cars, **c.** whether the students had :v) three other country specific items

*$p < .05$, **$p < .01$.

The index of economic social cultural status encloses HOMEPOSS, HEDRES, CULTPOSS and WEALTH. In spite of the index of economic social cultural status have strongly affected the performance of science competencies, the index of home educational resources have affected the science performance.

The outcome variable of interest in learning science with average CARPREP, ESCS, GENSCIE, INTSSCIE, JOYSCI, RESPDEV, SCIEACT, SCIEEFF, SCINVEST, SCSCIE and VOCATION was 544.96; each unit increase in ESCS without any change in the indexes of the model is associated with 8.11 points decrease in interest in learning science score.

The student level variable of index of family wealth, (WEALTH) displays different result from the other socio economic status variables. The relationship between dependent variable of identifying scientific issues and WEALTH is negative. This result shows that the unit increase in WEALTH without any change in the other indexes of the random-coefficients regression model is associated with 4.51 points decrease in identifying scientific issue score of Turkish students.

3. The result of the category of motivational factors is summarized in Table 5.6. The general interest in learning science, INTSCIE (*M*=0.24. *SD*= 0.954), enjoyment of science, JOYSCIE (*M* =0.42, *SD* = 0.974), instrumental motivation to learn science, INSTSCIE (*M* =0.33, *SD* = 0.975) and future-oriented motivation to learn science and SCIEFUT (*M* =0.65, *SD* = 1.031) were included.

The instrumental motivation to learn science, INSTSCIE and future-oriented motivation to learn science, SCIEFUT were extrinsic motivation to learn science. The extrinsic motivation is define as; whether the students are motivated to learn because they perceive science to be useful to them for either their future studies or careers.

Table 5.6.

Motivational Factors-Fixed Effects of Random Coefficient Model

(Group-Mean-Centered)

		Mean of School Means	Motivational Factors			
			General Interest in learning science INTSCIE	Enjoyment of science JOYSCIE	Instrumental motivation to learn science INSTSCIE	Future-oriented motivation to learn science SCIEFUT
	Science	452.61**	---	---	5.60*	---
Competencies	Identifying scientific issues	443.42**	---	5.38**	---	---
Competencies	Explaining phenomena scientifically	458.70**	---	---	---	---
Competencies	Using scientific evidence	451.35**	---	6.53**	---	---
Attitudes	Interest in learning science	544.96**	28.56**	19.68**	---	---
Attitudes	Support for scientific enquiry	576.58**	10.18**	10.76**	---	---

*p <.05, **p <.01.

INTSCIE : i)topics in physics, ii) topics in chemistry, iii)the biology of plants, iv)human biology, v)topics in astronomy, vi)topics in geology, vii) way scientists design experiment, viii) what is required for scientific explanations
[categories **"high interest", "medium interest", "low interest" and "no interest"**]

JOYSCIE : i)I generally have fun when I am learning broad science topics, ii)I like reading about broad science, iii)I am happy doing broad science problems iv) I enjoy acquiring new knowledge in broad science, v) I am interested in learning about broad science
[categories **"strongly agree", "agree", "disagree" and "strongly disagree"**]

INSTSCIE : i)making an effort in my school science subject(s) is worth it because this will help me in the work I want to do later on, ii) what I learn in my school science
iii) subject(s) is important because I need this for what I work to study later on, iv) I study school science because I know it is useful for me, v) Study my school science subject(s) is worthwhile for me because what I learn will improve my career prospects, vi) I will learn many things in my school science subject(s) that will help me get a job.
[categories **"strongly agree", "agree", "disagree" and "strongly disagree"**]

SCIEFUT : i) I would like to work in a career involving broad science, ii) I would like to study broad science after secondary school, iii)I would like to spend my life doing advanced broad science, iv) I would like to work on broad science projects as an adult.
[categories **"strongly agree", "agree", "disagree" and "strongly disagree"**]

Considering the combined science and science competencies scores the index of future-oriented motivation to learn science, SCIEFUT and general interest in learning science; INTSCIE were not significant. The fixed effects of students' enjoyment of science, JOYSCIE were estimated for identifying scientific issue and using scientific evidence. The other fixed effect was estimated between instrumental motivation to learn science, INSTSCIE, and combined science However, the variation across schools the INTSCIE and the INSTSCIE were not significant. A large percentage of Turkish students tended to report more positive attitudes in these indexes across OECD countries. But the effects of the motivational factors on Turkish students' performance were not significant in the hierarchical linear modeling.

The combined science for some high schools' students with average CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, HEDRES, INSTSCIE, SCIEEFF and SCHANDS was 452.61. Considering the increase only in the INSTSCIE-predictor of the model, each unit increase in INSTSCIE without any change is associated with 5.60 points increase in combined science.

As regards to the attitudinal scores, the fixed effects of the general interest in learning science and the enjoyment of science were significantly estimated. The unit increase in general interest in learning science is associated with 28.56 and 10.18 points increase in interest in learning science scale and support for scientific enquiry scale respectively. The unit increase in enjoyment of science is associated with 19.68 and 10.76 points increase in interest in learning science scale and support for scientific enquiry scale respectively.

4. Bandura (1997) defined self-efficacy as "benefits in one's capabilities to organize and execute the courses of action required to produce given attainments (p. 27). The self-efficacy in science refer to the confidence a student has about his or her ability to succeed in the field of science (Mintzes et al., 2006)

The other important factor to student's success in science is self-concept. As Mintzes et al. (2006, p. 353) state, "if students have a realistic and positive attitude toward their ability to succeed in college, the changes of success increase. When students have doubts about their academic ability or when they have an unrealistic perception of academic ability their chances of success diminish."

The result of this category of science self-belief summarized in Table 5.7.The indexes of self-efficacy, SCIEFF (M=0.04, SD= 0.991), in science and self-concept in science, SCSCIE (M=0.15, SD = 1.004) were included.

The index of self-efficacy in science has a significant effect on Turkish students' science literacy skills. The fixed effects on combined science, science competencies and science attitudes changed between 6.48 and 14.79. The unit increase in self-efficacy is associated with 8.26 points increase in one's combined science, 6.48 points increase in one's identifying scientific issue score, 8.53 points increase in one's explaining phenomena scientifically score, 7.27 points increase in one's using scientific evidence score, 14.79 points increase in interest in learning science scale and 10.16 points increase in support for scientific enquiry.

Another predictor in this category affected students' scientific literacy skills is self-concept in science. Contrary to the predictor of self-efficacy, one science competency and one science attitude scale were significant. The significant fixed effects of self-concept in science were estimated for explaining phenomena scientifically and interest in learning science scales. However, the science self-concept of the students affected the interest in science negatively. In other words, the unit increase in self-concept in science is associated with 5.63 points decrease in one's interest in learning science scale, but the variation in the slope of self-concept in science, SCSCIE, was not significant.

Table 5.7.

Science Self- Belief-Fixed Effects of Random Coefficient Model (Group-Mean-Centered)

		Mean of School Means	Science Self- Belief	
			Self-efficacy in science **SCIEEFF**	Self-concept in science **SCSCIE**
	Science	452.61**	8.26**	---
Competencies	Identifying scientific issues	443.42**	6.48**	---
	Explaining phenomena scientifically	458.70**	8.53**	5.84**
	Using scientific evidence	451.35**	7.27**	---
Attitudes	Interest in learning science	544.96**	14.79**	-5.63**
	Support for scientific enquiry	576.58**	10.16**	---

*p <.05, **p <.01.

SCIEEFF : i)recognize the science question that underlines a newspaper report on a health issue, ii) explain why earthquakes occur more frequently in some areas than in others, iii)describe the role of antibiotics in the treatment of disease, iv) identified the science question associated with the disposal of garbage, v) predict how changes to an environment will affect the survival of certain species, vi) interpret the scientific information provided on the labeling of food items, vii) discuss how new evidence can lead you to change your understanding about the possibility of life on Mars, viii) identify the better of two explanations for the formation of acid rain. [categories "**I could do this easy, I could do this with a bit of effort, I would struggle to do this on my own** and **I couldn't do this**"]

SCSCIE: i) learning advanced school science topics would be easy for me, ii) I can usually give good answer to test questions on school science topics, iii) I learn school science topics quickly, iv) school science topics are easy for me, v) when I am being taught school science, I can understand the concepts very well, vi)I can easily understand new ideas in school science. [categories "**strongly agree, agree, disagree and strongly disagree**"]

5. The category of value beliefs regarding science includes three indexes; general value of science, personal value of science and science activities. In this

category, student's attitudes towards science concern were discussed. Students' attitude toward science concerns their general appreciation of science and scientific enquiry, and their perceptions of the personal and subjective importance of science (OECD, 2007).

A strong general value of science reflects to what extent students value the contribution of science and technology for understanding the natural and constructed world and for the improvement of natural, technological and social conditions of life (OECD, 2007).As displayed in Table 5.8, the index of general value of science (GENSCIE), has a significant effect on Turkish students' science literacy scores. The fixed effects on combined science, science competencies and science attitudes ranged between 3.80 and 39.12.

The unit increase in general value of science index is associated with 8.70 points increase in one's combined science, 3.80 points increase in one's identifying scientific issue score, 9.62 points increase in one's explaining phenomena scientifically score, 9.93 points increase in one's using scientific evidence score, 5.56 points increase in interest in learning science scale, and 39.12 points increase in support for scientific enquiry. The support for scientific enquiry scale has the highest fixed effects. Because general value of science index, GENSCIE, personal value of science, PERSCIE, and support for scientific enquiry scale are three measures of students' value of science.

The personal value of science (PERSCIE) is to what extent students translate the general values of science into science being of personal value. Contrary to the predictor of the general value of science, the personal value of science has not significant fixed effects on all the science literacy scores. This finding can be interpreted, as science is generally important, but students do not necessarily relate this to their own lives and behavior (OECD, 2007).

Table 5.8.

Value Beliefs Regarding Science-Fixed Effects of Random Coefficient Model (Group-Mean-Centered)

			Value beliefs regarding science		
		Mean of School Means	General value of science **GENSCIE**	Personal value of science **PERSCIE**	Science activities **SCIEACT**
	Science	452.61**	8.70**	---	---
Competencies	Identifying scientific issues	443.42**	3.80**	-4.48*	---
	Explaining phenomena scientifically	458.70**	9.62**	---	---
	Using scientific evidence	451.35**	9.93**	---	---
Attitudes	Interest in learning science	544.96**	5.56**	---	9.04**
	Support for scientific enquiry	576.58**	39.12**	7.38**	---

*p <.05, **p <.01.

GENSCIE : **i**) advances in broad science and technology usually improve people's living conditions, **ii)** broad science is important for helping us to understand the national world, **iii)** advances in broad science and technology usually help improve the economy, **iv)** broad science is valuable to society, v) advances in broad science and technology usually bring social benefits

[categories **"strongly agree, agree, disagree and strongly disagree"**]

PERSCIE : **i)** some concept in broad science help me see how I relate to other people, **ii)** I will use broad science in many ways when I am an adult, broad science is very relevant to me, **iii)** I find that broad science helps me to understand the things around me, **iv)** when I live school there will be many opportunities for me to use broad science,

[categories **"strongly agree, agree, disagree and strongly disagree"**]

SCIEACT : **i**) watch TV programmes about broad science, **ii)** borrow or buy books on broad science topic, **iii)** visit web sites about broad science topics, **iv)** listen to radio programmes about advances in broad science, **v)** read broad science magazines or science article in newspapers, **vi)** attend a science club

[categories "**very often, regularly, sometimes** and **never or hardly ever**"]

The significant fixed effects of the personal value of science, PERSCIE were estimated for identifying scientific issues, and support for scientific enquiry. However, the personal value of science affected the identifying scientific issues negatively. In other words, the unit increase in PERSCIE is associated with 4.48 points decrease in one's identifying scientific issues score.

Another predictor of this category is the science-related activities of the students in their free time. The significant fixed effect of the science-related activities, SCIEACT, was only for interest in learning science. The unit increase in (SCIEACT) is associated with 9.04 points increase in one's interest in learning science score.

6. As displayed in Table 5.9, the category of science-related careers includes two indexes; school preparation for science –related careers, (CARPREP) and student information on science-related careers (CARINFO). Contrary to the CARINFO, the effects of CARPREP on the combined science score, the science competencies scores, and one of the science attitude scores were significant. The most of the significant fixed effects of CARPREP are negatively related to the outcome variables. Except interest in learning science score, the combined science score, and science competencies scores were affected negatively by the index of CARPREP. The unit increase in school preparation for science –related careers is associated with 6.43 points decrease in one's combined science, 6.33 points decrease in one's identifying scientific issue score, 4.71 points decrease in one's explaining phenomena scientifically score, 7.54 points decrease in one's using scientific evidence score. In other words, the students who reported that they were not prepared to science related careers in school, performed better.

Table 5.9.

Science-Related Careers-Fixed Effects of Random Coefficient Model

(Group-Mean-Centered)

			Science-related careers	
		Mean of School Means	School Preparation for Science-Related Careers **CARPREP**	Student Information on Science-Related Careers **CARINFO**
	Science	452.61**	-6.43**	---
Competencies	Identifying scientific issues	443.42**	-6.33**	---
	Explaining phenomena scientifically	458.70**	-4.71**	---
	Using scientific evidence	451.35**	-7.54**	---
Attitudes	Interest in learning science	544.96**	6.43**	---
	Support for scientific enquiry	576.58**	---	---

*p <.05, **p <.01.

CARPREP : i)the subjects available at my school provide students with the basic skills and knowledge for a science related career, ii) the school science subjects at my school provide students with the basic skills and knowledge for many different career, iii) the subjects I study provide me with the basic skills and knowledge for a science related career, iv) my teacher equips me with the basic skills and knowledge I need for a science related career,
[categories "**strongly agree, agree, disagree** and **strongly disagree**"]

CARINFO : i) the science related careers that are available in the job market, ii) where to find information about science related careers, iii) the steps students need to take if they want a science related careers, iv)employers of companies that hire people to work in science related careers.
[categories "**very well informed, fairly informed, not well informed** and **not informed at all**"]

7. The seventh category included the predictors related to instructional methods. In this category, "how science is taught in Turkey? "was analyzed.

As displayed in Table 5.10, the interaction in science teaching and learning, hands-on activities in science teaching and learning, student investigation in science teaching and learning and focus on model or applications in science teaching and learning were included in the category of science teaching and learning.

The predictor of the interaction in science teaching and learning (SCINTACT) was related to one of the instructional method - discussion. The discussion method permits students to express their views and clarify their ideas. This is a good strategy for promoting student involvement in the classroom. However, in order for discussions to be productive and focused on the intended learning outcomes of the lesson, their purpose must be clear (Chiappetta et al, 2006). Nevertheless, the fixed effect of the interaction in science teaching and learning was only significant for identifying scientific issues score of Turkish students. Eventually, the unit increase in the interaction in science teaching and learning is associated with 3.56 points increase in one's identifying scientific issue score.

The importance of using more than one instructional strategy during a class period can not be argued. The experienced science teacher often uses several strategies to gain students' attention and to keep them involved in learning (Chiappetta et al, 2006, p. 34). However, the predictor of focus on model or applications in science teaching and learning (SCAPPLY) has not significant effects on the student scientific literacy skills.

A scientific model is a representation of phenomenon that we can not see or observe directly. These models become mental images or constructions that are used to explain abstract ideas. They include the most salient features of an idea or theory that the scientist is attempting to make considerable. While not a replica of the reality, a scientific model can be in the form of a concrete structure as well as in the form of a mathematical formula (Chiappetta et al., 2006). Turkish students reported that scientific model and applications were not used effectively in science lessons, for example, teachers do not explain how a school science idea can be applied to a number of different phenomena and the teacher do not use the examples of technological application to show how school science is relevant to society.

Chiappetta et al (2006) stated, laboratory exercise should be used frequently throughout a science course to promote science learning. Contrary to the described above, the predictor of the hands-on activities in science teaching and learning (SCHANDS), which was constructed to examine the students' laboratory work in science lessons, has significant negative effects on the combined science and science competencies. As a result, the unit increase in the hands-on activities in science teaching and learning is associated with 7.62 points decrease in one's combined science score, 5.96 points decrease in one's explaining phenomena scientifically score 8.05 points decrease in one's using scientific evidence score.

The other predictor in the science teaching and learning category is student investigation in science and learning. It is apparent that the predictor of student investigation in science and learning (SCINVEST) is related to the inquiry methods. Inquiry is the process by which scientists ask questions about the natural world and seek answers and deeper understanding, rather than knowing by authority or other processes (Trowbridge et al., 2004).

Table 5.10

Science Teaching and Learning-Fixed Effects of Random Coefficient Model (Group-Mean-Centered)

		Mean of School Means	Interaction in Science Teaching and Learning **SCINTACT**	Hands-On Activities in Science Teaching and Learning **SCHANDS**	Student Investigation in Science Teaching and Learning **SCINVEST**	Focus on Model or Applications in Science Teaching and Learning **SCAPPLY**
	Science	452.61**	---	-7.62**	---	---
Competencies	Identifying scientific issues	443.42**	3.56*	---	---	---
	Explaining phenomena scientifically	458.70**	---	-5.96**	-5.56**	---
	Using scientific evidence	451.35**	---	-8.05**	---	---
Attitudes	Interest in learning science	544.96**	---	---	8.75**	---
	Support for scientific enquiry	576.58**	---	---	---	---

SCINTACT: i)students are given opportunities to explain their ideas, ii) the lessons involve students' options about the topics, iii) there is a class debate and discussion iv) the students have discussions about the topics.

SCHANDS : i) students spends time in the laboratory doing practical experiments, ii) students are required to design how a school science question could be investigated in the laboratory, iii) students are asked to draw conclusion from an experiment they have conducted, iv) students do experiments by following the instruction of the teacher.

SCINVEST: i) students are allowed to design their own experiment, ii) students are given chance to choose their own investigation, iii) students are asked to do an investigation to test out their own ideas.

SCAPPLY: i)the teachers explains how a school science idea can be applied to a number of different phenomena (eg. The movement of the object, substance s with similar properties), ii) the teacher uses science to help students understand the world outside school, iii) the teacher clearly explains the relevance of broad science concepts to our lives, iv) the teacher uses the examples of technological application to show how school science is relevant to society.

[categories "**in all lessons, in most lessons, in some lessons** and **never or hardly ever**"]

When students study science using investigation and inquiry, they employ many different skills. Some of these skills are psychomotor skills that involve doing something physically. They also employ intellectual or academic skills such as analyzing data, making comparisons, evaluating results, preparing reports and communicating results to other students or teachers processes (Trowbridge et al. 2004).

Using investigation and inquiry in science was not significant for all science literacy scores. It was significant for explaining phenomena scientifically and interest in learning science. Same as the hands-on activities in science, the fixed effect of the student investigation in science and learning (SCINVEST) has significant negative effect on explaining phenomena scientifically score. In other word, the unit increase in the student investigation in science and learning is associated with 5.56 points decrease in one's explaining phenomena scientifically score. At the same time, SCINVEST has positive fixed effects on the interest in learning science. There was 8.75 points increase for every increase in the student investigation in science and learning.

This finding is consistent with the study of Kalender et al.'s (2008).They assessed the factors related to science achievement of Turkish students. In the study, a hypothesized model with latent variables such as socio-economic status, students' perception of success and interest in different subject matter areas, out-of-school activities, and classroom teaching learning activities in relation to science achievement of the students was tested via linear structural modeling. The data come from the Student Assessment Program-2002 conducted by the Ministry of National Education in Turkey. The results indicated that there were positive relationships between the socio-economic status of the students and teacher-centered activities in the classroom with science achievement. On the other hand, student-centered activities did not contribute to explain achievement measures positively.

Science teaching requires more than teaching skills and instructional strategies to facilitate content mastery of subject matter. Educational researchers have assisted the profession greatly by identifying many learning techniques that have shown increase in student achievement (Chiappetta et al, 2006). Therefore, the Board of Education and Discipline in Turkey had started to change the 6th, 7th and 8th grade level Science and Technology curriculum since 2004.

8. The last category displayed in Table 5.11 was related to environment and environmental issues. This category included the predictors of awareness of environmental issue, level of concern for environmental issue, optimism regarding environmental issue and responsibility for sustainable development.

   The awareness of environmental issue (ENVAWARE) was significant for all scientific literacy score except interest in learning science. The fixed effects of the scores were between 5.02 and 11.03. The highest change per unit of the index belonged to explaining phenomena scientifically. The explaining phenomena scientifically score was 11.03 points increase for every increase in the awareness of environmental issue.

   The level of concern for environmental issue (ENVPERC) was significant for combined science, explaining phenomena scientifically and using scientific evidence. The fixed effects of the outcome variables were smaller than the awareness of environmental issue. They were between 4.41 and 5.28.

   The optimism regarding environmental issue (ENVOPT) was significant for combined science and science competencies, but all fixed effects were negatively related to the outcome variables. In other words, the unit increase in ENVOPT was associated with 7.04 points decrease in one's combined science score, 6.85 points decrease in one's identifying scientific issue, 7.68 points decrease in one's explaining phenomena scientifically, 7.29 points decrease in one's using scientific evidence.

Table 5.11.
Scientific Literacy and the Environment-Fixed Effects of Random Coefficient Model (Group-Mean-Centered)

		Mean of School Means	Awareness of Environmental Issues **ENVAWARE**	Level of Concern for Environmental Issues **ENVPERC**	Optimism Regarding Environmental Issues **ENVOPT**	Responsibility for Sustainable Development **RESPDEV**
	Science	452.61**	9.50**	4.41**	-7.04**	---
Competencies	Identifying scientific issues	443.42**	7.37**	---	-6.85**	---
Competencies	Explaining phenomena scientifically	458.70**	11.03**	4.26**	-7.68**	---
Competencies	Using scientific evidence	451.35**	10.40**	5.28**	-7.29**	5.36**
Attitudes	Interest in learning science	544.96**	---	---	---	14.50**
Attitudes	Support for scientific enquiry	576.58**	5.02**	---	---	27.74**

ENVAWARE : i) the increase of greenhouse gases in the atmosphere, ii) the use of genetically modified organism (GMO), iii) acid rain, iv) nuclear waste, v) the consequences of clearing forests for other land use[categories "**I have never heard of this, I have heard of this but I would be able to explain what is really about, I know something about this and could explain the general issue** and **I am familiar with this and I would be able to explain this well** "]
ENVPERC : i)air pollution, ii) energy shortage, iii) extinction of plants and animals, iv) clearing of forests for other land use, v) water shortage, vi) nuclear waste[categories "**this is a serious concern for me personally as well as others, this is a serious concern for people in other countries , stay about the same** and **this is not a serious concern to anyone**"]
ENVOPT : i)air pollution, ii) energy shortage, iii) extinction of plants and animals, iv) clearing of forests for other land use, v) water shortage, vi) nuclear waste[categories "**improve, stay about the same** and **get worse** "]
RESPDEV : i)it is important to carry out regular check on the emissions from cars as a condition of their use, ii) it disturb me when energy is wasted through the unnecessary use of electrical appliances, iii) I am in favour of having laws that regulate factory emission even if this would increase the price of product, iv) to reduce waste the use of plastic packaging should be kept to a minimum, v) industries should be required to prove that they safely dispose of dangerous waste materials, vi) I am in favour of having laws that protect the habitats of endangered species, vii) electricity should be produced from renewable sources as much as possible, even if this increases the cost [categories "**strongly agree**", "**agree**", "**disagree**" and "**strongly disagree**"]

The last predictor was responsibility for sustainable development (RESPDEV). The average of interest in learning science and average of support for scientific enquiry were affected by the responsibility for sustainable development score.

5.1.2 Findings Related to Vocational High Schools and General High Schools

The science performances of vocational high schools and general high schools are significantly different from each other. The science performance differences between these schools were displayed from Table 5.11 to Table 5.16. When interpreting the results from these analyses, it should be born in mind that the category of vocational schools included Vocational Schools, Anatolian Vocational Schools, Technical High School and Multi Programmed High schools. In other words, they constitute a heterogeneous category and may differ from one another as much as differ from general high schools.

The comparison of the average combined science scores between the vocational high schools and general high schools were displayed in Table 5.12.

Table 5.12.

Average of Schools' Combined Science Mean

	Average of the schools' mean	Difference between vocational high school and general high school
None	424.95(5.34)**	---
Adjusted for selected student characteristics	452.61(6.49)**	-59.40(8.69)**
Adjusted for selected school characteristics	438.49(4.02)**	-25.38(7.21)**
Adjusted for selected student and school characteristics	439.37(3.98)**	-25.10(6.79)**

*p <.05, **p <.01.

The average high school's combined science score mean was 424.95. After adjusting for student characteristics (CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, HEDRES, INSTSCIE, SCIEEFF and SCINVEST) the difference in means was 59.40. Including school characteristics in the model (SELECT, TCSHORT and ESCSMEAN) resulted in reductions in the difference. The reduction in the difference is 34.3 points.

Table 5.13.

Average of Schools' Identifying Scientific Issue Mean

	Average of the schools' mean	Difference between vocational high school and general high school
None	427.64(5.09)**	---
Adjusted for selected student characteristics	443.42(6.25)**	-50.59(9.39)**
Adjusted for selected school characteristics	439.99(4.07)**	-22.38(7.22)**
Adjusted for selected student and school characteristics	432.82(4.54)**	-21.54(7.31)**

*p <.05, **p <.01.

The comparison of the average high schools' identifying scientific issue mean between the vocational high schools and general high schools were displayed in Table 5.13. The average high school's identifying scientific issue mean was 427.64. After adjusting for student characteristics (CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, HEDRES, JOYSCIE, PERSCIE, SCIEEFF SCINTACT and WELTH) the difference in means was 50.59. Including school characteristics in the model (PCGIRLS, SELECT and ESCSMEAN) resulted in reductions in the difference. The reduction in the difference is 29.05 points.

The comparisons of the average high schools' explaining phenomena scientifically mean between the vocational high schools and general high schools were displayed in Table 5.14.

Table 5.14.

Average of Schools' Explaining Phenomena Scientifically Mean

	Average of the schools' mean	Difference between vocational high school and general high school
None	423.71(5.41)**	---
Adjusted for selected student characteristics	458.61(6.69)**	-59.65(9.14)**
Adjusted for selected school characteristics	437.80(4.45)**	-28.12(7.64)**
Adjusted for selected student and school characteristics	445.95(4.36)**	-28.51(7.47)**

*p <.05, **p <.01.

The average high school's explaining phenomena scientifically mean was 423.71. After adjusting for student characteristics (CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, SCHANDS, SCIEEFF, SCINVEST and SCSCIE) the difference in means was 59.65. Including school characteristics in the model (SCSIZE, SELECT, TCSHORT and ESCSMEAN) resulted in reductions in the difference. The reduction in the difference is 31.14 points.

The comparison of the average high schools' using scientific evidence mean between the vocational high schools and general high schools were displayed in Table 5.15.

Table 5.15.

Average of High Schools' Using Scientific Evidence Mean

	Average of the schools' mean	Difference between vocational high school and general high school
None	420.05(6.03)**	---
Adjusted for selected student characteristics	451.35(7.11)**	-67.70(9.90)**
Adjusted for selected school characteristics	437.04(4.28)**	-33.96(7.88)**
Adjusted for selected student and school characteristics	437.99(4.14)**	-32.33(7.49)**

*p <.05, **p <.01.

The average high school's using scientific evidence mean was 420.05. After adjusting for student characteristics (CARPREP, ENVAWARE, ENVOPT, ENVPERC, ESCS, GENSCIE, HEDRES, JOYSCIE, RESPDEV, SCHANDS and SCIEEFF) the difference in means was 67.70. Including school characteristics in the model (SELECT, TCSHORT and ESCSMEAN) resulted in reductions in the difference. The reduction in the difference is 35.37points.

The comparison of the average high schools' interest in learning science mean between the vocational high schools and general high schools were displayed in Table 5.16.

Table 5.16

Average of Schools' Interest in Learning Science Mean

	Average of the schools' mean	Difference between vocational high school and general high school
None	538.99 (2.69)**	---
Adjusted for selected student characteristics	544.96(3.08)**	---
Adjusted for selected school characteristics	539.91(2.53)**	---
Adjusted for selected student and school characteristics	550.94(3.80)**	-12.26(5.38)**

*p <.05, **p <.01.

The average high school's interest in learning science score was 538.99. After adjusting for student characteristics (CARPREP, ESCS, GENSCIE, INTSCIE, JOYSCIE, RESPDEV, SCIEACT, SCIEEFF SCINVEST, and SCSCIE) the difference in means was zero. Including school characteristics in the model (ESCSMEAN) resulted in increases in the difference. The difference is 33.74 points.

The comparison of the average high schools' support for scientific enquiry mean between the vocational high schools and general high schools were displayed in Table 5.17.

Table 5.17.

Average of Schools' Support for Scientific Enquiry Mean

	Average of the schools' mean	Difference between vocational high school and general high school
None	567.62(3.63)**	---
Adjusted for selected student characteristics	576.58(5.00)**	-34.91(6.37)**
Adjusted for selected school characteristics	568.22(3.28)**	---
Adjusted for selected student and school characteristics	571.49(4.08)**	-19.38(6.19)**

*p <.05. **p <.01

The average high school's support for scientific enquiry score was 567.62. After adjusting for student characteristics (ENVAWARE, GENSCIE, INTSCIE, JOYSCIE, PERSCIE, RESPDEV, and SCIEEFF) the difference in means was zero. Including school characteristics in the model (ESCSMEAN) resulted in increases in the difference. The difference was 15.53 points.

5.2 Implications for Policy

The PISA regularly and directly compare the quality of education outcomes across the countries, as for the present study, "how much do the student characteristics and school characteristic effect on education outcomes of Turkish high school students" and "what were the strengths and weakness of Turkish high school students' scientific literacy skills" were analyzed. The findings of the study summarized above suggest that:

1. Students' socio-economic background plays an important role in the scientific literacy skills in Turkey. The results show that the impacts of the socio-economic background on students' scientific literacy, and schools' average scientific literacy were strong.

   This index was a composite measure derived from the student's family and home background variables in addition to occupational status of his/her family. In other words, the index was the composite of the student' parent income, parent's level of education and their occupations, number of books at home and more. Students whose parents have low incomes, low – prestige occupations, or are unemployed, are more likely to perform lower than students whose parents have high incomes, high – prestige occupations.

   The system needs to ensure that every student, rather than just some students has access to excellent instruction. Ensuring that every student benefits from high-quality instruction is not an important end in itself, the evidence from international assessments suggest that strong performance for the system as a whole is depend on this being the case. The PISA scores of the top performing systems show a low correlation between student outcomes and the socio-economic background of the students (McKinsey & Company, 2007).

   Turkish education system should be produced approaches to ensure that the school can compensate for the disadvantage resulting from the student's socio-economic background. In line with this purpose, the cumulative expenditure on educational institutions per students must be increased to deliver consistently high quality instruction.

2. The differences between combined science score and science competencies score of Turkish high school students are small. Turkish students show stronger skills in identifying scientific issue than the other science competencies and combined science score. The scientific literacy skills of Turkish students reduce

while increasing the strength of the science competencies. The general performance of the students on the science competencies were explained in the PISA 2006 Science Competencies for Tomorrow's World as;

> A simplified way of looking at these relative strengths is in terms of a sequence in dealing with science problems: first identifying the problem, then applying knowledge of scientific phenomena and finally interpreting and using the result. Traditional science teaching may often concentrate on the middle process, explaining phenomena scientifically, which requires familiarity with key science knowledge and theories. Yet without being able first to recognize a science problem and than to interpret findings in ways relevant to the real world, students are not fully scientifically literate. A student who has mastered a scientific theory but who is unable to weigh up evidence, for example, will make limited use of science in adult life (OECD, 2007, P. 62).

Turkish high school students generally have inadequacies in their scientific literacy skills. Beside the new science curriculum, which was developed by the Board of Education and Discipline in 2004, the expert teachers and instructional leaders should be developed to improve the teaching skills of the teachers. Expert teachers are sent into the classroom to observe and provide coaching in terms of feedback, modeling better instruction and in helping teachers to reflect upon their own practice.

The quality of the students' outcomes for any school systems is essentially the sum of the quality of the instruction that their teacher deliver. Delivering excellent instruction requires teachers to develop the high sophisticated set of skills. Teachers need to be able to assess precisely the strengths and weaknesses of each student, select the appropriate instructional methods to help them to learn, and deliver instruction in an effective and efficient manner (McKinsey & Company, 2007).

3. There is no significant difference in the average combined science score for males and females in the high schools of Turkey. Considering entire Turkish sample, there is 12 points difference in the average combined science score in

favor of female students. The gender difference is also significant in science competencies; females are stronger in identifying scientific issue, while males are stronger at explaining phenomena scientifically. The gender differences can not be attributed to features of the education system, however, some arrangements should be done to facilitate the science learning.

4. There are considerable differences in the extent to which science competencies of 15-year-old students vary between schools. The scientific literacy skills of vocational high school students were lower than general high school students. In other words, there are high differences between vocational high school and general high school, even after selected school characteristics were adjusted. The Board of Education and Discipline have started to restructure the high school's curricula for all subject matters since 2004, considering new approaches. The vision of these curricula is based on the principle that every child can learn. In line with this principle, the level of the scientific literacy performance of vocational high school students should be risen.

5. The motivation and engagement are regarded as catalyzing the learning. A greater percentage of Turkish students tended to report more positive attitudes in the indexes related to motivation across OECD countries. However, the motivational factors do not affect the change in Turkish students' scientific literacy skills as much as it is expected. The positive motivation of Turkish students should be used as an accelerator to teach science. The high motivational factors of Turkish students are not directed properly in the learning process. In fact, students' motivation affects the use of learning strategy. The effect of student motivation was explained in the PISA 2003 International Report as

   > Students' motivation, their positive-self related beliefs as well as their emotions also affect their use of learning strategies. There are good grounds for this: high quality learning time and effort-intensive. It involves control of learning process as well as the explicit checking of relations between previously acquired knowledge and new information, the formulation of hypothesis about possible connections and the testing of these hypotheses against the background of the new material. Learners are only willing to

> invest such effort if they have a strong interest in a subject or if there is a considerable benefit, in terms of high performance, with learners motivated by the external reward of performing well. Thus, students need to be willing to learn how to learn. From the perspective of teaching this implies that effective ways of learning – including goal setting, strategy selection and the control and evaluation of the learning process- can and should be fostered by the educational setting and by teachers(OECD, 2004, p.156).

As indicated above in the citation, student motivations are supported by the students' use of learning strategies. The effective learning should be advocated by the effective teachers. The effective teachers possess high overall level of literacy and numeracy, strong interpersonal and communication skills, a willingness to learn and motivation to teach (McKinsey & Company, 2007).

6. The findings related to teaching and learning activities were considerably dramatic and complicated for Turkey. The teaching science by using hands-on activities seems negatively related to science performance of the students. In other words, the students who report that they frequently used practical experiment, investigated in the laboratory and draw conclusion from an experiment perform low in combined science in PISA2006. In fact, science teaching was explained as;

> Science teaching should facilitate students learning about science and technology as they need to understand and use them in their personnel lives and as future citizens. Science teaching should sustain students' natural curiosity: develop their skills in inquiry and design; improve their scientific explanations; help them develop an understanding and use of technology: contribute to their understanding of the role, limits and possibilities of science and technology in society; and inform the choices they must make in their personal and social lives (Trowbridge, 2004, p. 4).

The effective teachers should be selected and developed to improve the scientific literacy skills of Turkish students. A bad selection decision can result in up to 30 years of poor teaching. To improve the teacher quality in Turkey, selection of students for teacher education departments and teacher education curriculum must be carefully planned. The academic achievement of the candidates, their communication skills and their motivation for teaching should be indispensible to select for the teacher training programs. Science teachers should know the different instruction methods and use the methods effectively to gain the scientific literacy skills to their students, for example, students are given opportunity to express their ideas, the lessons involve students' options about the topics, class debate and discussion are employed to use, students are given chance to discuss about the topics, to choose their own investigation and to design their own experiment, hands-on activities are used effectively, and science are used to help students understand the world outside school.

7. The students who had higher level of the awareness of environmental issues performed better in science than the students reporting least awareness of environmental issues. On the other hand, the high performing students were pessimistic to environmental issues.

> The data also suggest that levels of awareness of environmental issues are implicitly linked with students' scientific knowledge. There is a strong association between students' levels of awareness of environmental issues and science performance in all participating countries (OECD, 2007, p. 157).

One of the goals of the new science curriculum is to understand the mutual interactions among science, technology, society and the environment. In this approach environment is a part of the nature of science. This approach should increase the students' awareness of environmental issues such as air pollution; energy shortage; extinction of plants and animals; nuclear waste; and climate change.

8. The performance of students who had lower levels of information about science – related careers were lower. This finding suggests that schools need to promote effectively scientific careers and create pathways that encourage the students to continue studying the science. As a matter of fact, the long-standing goals of science education are scientific knowledge, scientific methods, societal issues,

personal needs and career awareness. Therefore, in the process of developing new science curriculum, this factor should be taken into account. The new curriculum should be provided to include information about science – related careers.

9. The findings related to students' science self beliefs are striking. The students who had higher level of self – efficacy beliefs performed better in combined science and science competencies than the students who had lower level of the self –efficacy. On the other hand, students' self concept in science seems not to associate with the science performance of Turkish students. The self –efficacy in tackling science problems was strongly associated with science attitudes of Turkish students. As explained in the PISA 2006 Science Competencies for Tomorrow's World, the important part of improving science performance is the building students' confidence in their skills. Schools should strive to build students' confidence in their skills through providing the teaching with essential skills.

10. Most of the Turkish students in PISA 2006 reported that they valued science. The scientific literacy skills of the students who valued science were also higher. While most of the Turkish students valued science in general, then, to what extent does general value translate into science being of personal value? The answer of this question in the model is complex, since persona value of science is not associated with students' combined science performance, and science competencies except for competency of identifying scientific issue. This result was explained in the PISA 2006 Science Competencies for Tomorrow's World as "students may be convinced that science is generally important, but do not necessarily relate this to their own lives and behaviors". To set the relation between students' lives and science, science teaching methods should be reconstructed to provide the connection to students' daily life.

11. School admittance policy is the basis of selection of the students for academic programs and for streaming students according to their future career. Our high schools have large performance differences arise from the student selection. The average combined science and science competencies performances of high schools which admit the selected students were considerably higher. This issue is discussed in the PISA 2006 Science Competencies for Tomorrow's World as;

> Differences in patterns of results according to how students are admitted to schools, grouped across schools and group within schools. Most importantly, in school systems where students are divided into different school groups at relatively early ages, the socio-economic differences in results by age 15 are relatively large through school compositional effects, while the average level of performance is not higher compared to comprehension education system. This suggest that countries practicing early tracking need to pay particular attention to the students grouped into schools with a disadvantaged socio economic background and the extent to which this may increase differences in performance. A smaller effect is the slightly lower overall performance of schools that group students by ability for all subjects internally, suggesting that such a policy might potentially hinder learning of certain students more than it enhances learning of others (OECD, 2007, p.276).

Herein, policy makers approach to the school admittance policy as multidimensional.

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APPENDIX A

STUDENT LEVEL VARIABLES

*1. STUDENT INFORMATION ON SCIENCE-RELATED CAREERS,**CARINFO***

This index, being one of the science-related careers variables, was derived from students' beliefs about their level of information about the following topics

a) the science related careers that are available in the job market,
b) where to find information about science related careers
c) the steps students need to take if they want a science related careers,
d) employers of companies that hire people to work in science related careers.

the four-point scale with the response categories "**very well informed**", "**fairly informed**", "**not well informed**" and "**not informed at all**" was used.

(OECD Science Competencies for Tomorrow's World,2007)

*2. SCHOOL PREPARATION FOR SCIENCE-RELATED CAREERS, **CARPREP***

This index ,being one of the science-related careers variables, was derived from students' level of agreement with the following statements:

a) the subjects available at my school provide students with the basic skills and knowledge for a science related career,
b) the school science subjects at my school provide students with the basic skills and knowledge for many different career,
c) the subjects I study provide me with the basic skills and knowledge for a science related career,
d) my teacher equip me with the basic skills and knowledge I need for a science related career,

the four-point scale with the response categories "**strongly agree**", "**agree**", "**disagree**" and "**strongly disagree**" was used.

(OECD Science Competencies for Tomorrow's World,2007)

3. CULTURAL POSSESSIONS AT HOME , ***CULTPOSS***

This index was derived from students' reports on the available of the following items in their home:

a) classic literature,
b) book of poetry,
c) works of art

(OECD Science Competencies for Tomorrow's World,2007)

4. AWARENESS OF ENVIRONMENTAL ISSUES , ***ENVAWARE***

This index was derived from students' beliefs regarding their own level of information on the following environmental issues:

a) the increase of greenhouse gases in the atmosphere,
b) the use of genetically modified organism (GMO),
c) acid rain,
d) nuclear waste,
e) the consequences of clearing forests for other land use

the four-point scale with the response categories "**I have never heard of this**", "**I have heard of this but I would be able to explain what is really about**", "**I know something about this and could explain the general issue**" and "**I am familiar with this and I would be able to explain this well** " was used.

(OECD Science Competencies for Tomorrow's World,2007)

5. ENVIRONMENTAL OPTIMISM, ***ENVOPT***

This index was derived from students' optimism concerning the development over the next over the 20 years of the problems associated with the following environmental issues:

a) air pollution,
b) energy shortage,
c) extinction of plants and animals,
d) clearing of forests for other land use,
e) water shortage,
f) nuclear waste

the three-point scale with the response categories "**improve**", "**stay about the same**" and "**get worse** " was used.

(OECD Science Competencies for Tomorrow's World,2007)

6. PERCEPTION OF ENVIRONMENTAL ISSUES, ***ENVPERC***

This index was derived from students' level of concern about the following environmental issues:

a) air pollution,
b) energy shortage,
c) extinction of plants and animals,
d) clearing of forests for other land use,
e) water shortage,
f) nuclear waste

the four-point scale with the response categories "**this is a serious concern for me personally as well as others**", "**this is a serious concern for people in other countries**" , "**stay about the same**" and "**this is not a serious concern to anyone**" was used.

(OECD Science Competencies for Tomorrow's World,2007)

*7. INDEX OF ECONOMIC, SOCIAL AND CULTURAL STATUS ,****ESCS***

This index was created to earn wider aspect aspects of student's family and home background in addition to occupational status. It is derived from the variables of highest international socio-economic index of occupational status ***(HISCEI)*** of the father or mother, the index of highest educational level of parents ***(HISCED)*** converted into years of schooling and index of home possession obtained by asking students whether they had at their home;

a) a desk to study,
b) a room of their own,
c) a quiet place to study,
d) a computer they con use for school,
e) an educational software,
f) a link to the internet,
g) their own calculator,
h) classic literature,
i) books of poetry,
j) works of art,
k) books to help with their school work,
l) a dictionary,
m) a dishwasher,
n) a DVD player or VCR,
o) the number of cellular phones,
p) televisions,
q) computers,
r) cars,
s) books at home

and three other country specific items.

(OECD Science Competencies for Tomorrow's World,2007)

8. GENERAL VALUE OF SCIENCE, ***GENSCIE***

This index ,being one of the value beliefs regarding science variables, was derived from students' level of agreement with the following statements:

a) advances in broad science and technology usually improve people's living conditions,
b) broad science is important for helping us to understand the national world,
c) advances in broad science and technology usually help improve the economy,
d) broad science is valuable to society,
e) advances in broad science and technology usually bring social benefits

the four-point scale with the response categories "**strongly agree**", "**agree**", "**disagree**" and "**strongly disagree**" was used.

(OECD Science Competencies for Tomorrow's World,2007)

9. HOME EDUCATIONAL RESOURCES, ***HEDRES***

This index was derived from students reports on the availability of the following items in their home:

a) a desk to study,
b) a quiet place to study,
c) a computer they can use for school work,
d) an educational software,
e) their own calculator,
f) books to help with their school work,

(OECD Science Competencies for Tomorrow's World,2007)

10. INDEX OF HOME POSSESSIONS, ***HOMEPOSS***

This index was derived from three sets of items:

a) whether students had a room of their own, a link to the internet, a dishwasher and a DVD or VCR player,
b) how many of the following items they had at their home: cellular phones, televisions, computers and cars,
c) three country specific items thought to indicate wealth defined by each country.

(OECD Science Competencies for Tomorrow's World,2007)

11. INSTRUMENTAL MOTIVATION IN SCIENCE, ***INSTSCIE***

This index ,being one of the motivational variables, was derived from students' level of agreement with the following statements:

a) making an effort in my school science subject(s) is worth it because this will help me in the work I want to do later on,
b) what I learn in my school science subject(s) is important because I need this for what I work to study later on,
c) I study school science because I know it is useful for me,
d) Study my school science subject(s) is worthwhile for me because what I learn will improve my career prospects,
e) I will learn many things in my school science subject(s) that will help me get a job.

the four-point scale with the response categories "**strongly agree**", "**agree**", "**disagree**" and "**strongly disagree**" was used.

(OECD Science Competencies for Tomorrow's World,2007)

12. GENERAL INTEREST IN LEARNING SCIENCE, ***INTSCIE***

This index ,being one of the motivational variables, was derived from students' level of interest in learning the following topics:

a) topics in physics,
b) topics in chemistry,
c) the biology of plants
d) human biology,
e) topics in astronomy,
f) topics in geology,
g) way scientists design **experiment**,
h) what is required for scientific explanations

the four-point scale with the response categories **"high interest", "medium interest", "low interest" and "no interest"** was used

(OECD Science Competencies for Tomorrow's World,2007)

13. ENJOYMENT OF SCIENCE, ***JOYSCIE***

This index ,being one of the motivational variables, was derived from students' level of agreement with the following statements:

a) I generally have fun when I am learning broad science topics,
b) I like reading about broad science,
c) I am happy doing broad science problems
d) I enjoy acquiring new knowledge in broad science
e) I am interested in learning about broad science

the four-point scale with the response categories **"strongly agree", "agree", "disagree" and "strongly disagree"** was used

(OECD Science Competencies for Tomorrow's World,2007)

14. PERSONAL VALUE OF SCIENCE, ***PERSCIE***

This index ,being one of the value beliefs regarding science variables, was derived from students' level of agreement with the following statements:

a) some concept in broad science help me see how I relate to other people,
b) I will use broad science in many ways when I am an adult,
c) broad science is very relevant to me,
d) I find that broad science helps me to understand the things around me
e) when I live school there will be many opportunities for me to use broad science,

the four-point scale with the response categories "**strongly agree**", "**agree**", "**disagree**" and "**strongly disagree**" was used.

(OECD Science Competencies for Tomorrow's World,2007)

*15. RESPONSIBILITY FOR SUSTAINABLE DEVELOPMENT, **RESPDEV***

This index ,being one of scientific literacy and the environment variables, was derived from students' level of agreement with the following statements:

a) it is important to carry out regular check on the emissions from cars as a condition of their use,
b) it disturb me when energy is wasted through the unnecessary use of electrical appliances,
c) I am in favour of having laws that regulate factory emission even if this would increase the price of product,
d) to reduce waste the use of plastic packaging should be kept to a minimum,
e) industries should be required to prove that they safely dispose of dangerous waste materials,
f) I am in favour of having laws that protect the habitats of endangered species,
g) electricity should be produced from renewable sources as much as possible, even if this increases the cost

the four-point scale with the response categories "**strongly agree**", "**agree**", "**disagree**" and "**strongly disagree**" was used.

(OECD Science Competencies for Tomorrow's World,2007)

*16. SCIENCE TEACHING -FOCUS ON APPLICATIONS OR MODELS IN SCIENCE, **SCAPPLY***

This index ,being one of the **science teaching and learning** variables, was derived from students' responses about the frequency with which the activities occur when learning school science topics at school:

a) the teachers explains how a school science idea can be applied to a number of different phenomena (eg. The movement of the object, substance s with similar properties),
b) the teacher uses science to help students understand the world outside school,
c) the teacher clearly explains the relevance of broad science concepts to our lives,
d) the teacher uses the examples of technological application to show how school science is relevant to society.

the four-point scale with the response categories "**in all lessons**", "**in most lessons**", "**in some lessons**" and "**never or hardly ever**" was used

(OECD Science Competencies for Tomorrow's World,2007)

17. SCIENCE TEACHING - HANDS-ON ACTIVITIES IN SCIENCE, ***SCHANDS***

This index ,being one of the **science teaching and learning** variables, was derived from students' responses about the frequency with which the activities occur when learning school science topics at school:

a) students spends time in the laboratory doing practical experiments,
b) students are required to design how a school science question could be investigated in the laboratory,
c) students are asked to draw conclusion from an experiment they have conducted,
d) students do experiments by following the instruction of the teacher.

the four-point scale with the response categories "**in all lessons**", "**in most lessons**", "**in some lessons**" and "**never or hardly ever**" was used

(OECD Science Competencies for Tomorrow's World,2007)

18. SCIENCE ACTIVITIES, ***SCIEACT***

This index ,being one of the value beliefs regarding science variables, was derived from students' level of agreement with the following statements:

a) watch TV programmes about broad science
b) borrow or buy books on broad science topic
c) visit web sites about broad science topics
d) listen to radio programmes about advances in broad science
e) read broad science magazines or science article in newspapers
f) attend a science club

the four-point scale with the response categories "**very often**", "**regularly**", "**sometimes**" and "**never or hardly ever**" was used

(OECD Science Competencies for Tomorrow's World,2007)

19. SCIENCE SELF-EFFICACY, ***SCIEEFF***

This index ,being one of the science **self-belief** variables, was derived from students' beliefs in their ability to perform the following tasks on their own:

a) recognize the science question that underlines a newspaper report on a health issue,
b) explain why earthquakes occur more frequently in some areas than in others,
c) describe the role of antibiotics in the treatment of disease,
d) identified the science question associated with the disposal of garbage,
e) predict how changes to an environment will affect the survival of certain species,
f) interpret the scientific information provided on the labeling of food items,
g) discuss how new evidence can lead you to change your understanding about the possibility of life on Mars,
h) identify the better of two explanations for the formation of acid rain.

the four-point scale with the response categories "**I could do this easy**", "**I could do this with a bit of effort**", "**I would struggle to do this on my own**" and "**I couldn't do this**" was used.

(OECD Science Competencies for Tomorrow's World,2007)

20. FUTURE-ORIENTED SCIENCE MOTIVATION, ***SCIEFUT***

This index ,being one of the **motivational** variables, was derived from students' level of agreement with the following statements:

a) I would like to work in a career involving broad science
b) I would like to study broad science after secondary school
c) I would like to spend my life doing advanced broad science
d) I would like to work on broad science projects as an adult.

the four-point scale with the response categories "**strongly agree**", "**agree**", "**disagree**" and "**strongly disagree**" was used

(OECD Science Competencies for Tomorrow's World,2007)

21. SCIENCE TEACHING – INTERACTION IN SCIENCE, ***SCINTACT***

This index ,being one of the **science teaching and learning** variables, was derived from students' responses about the frequency with which the activities occur when learning school science topics at school:

a) students are given opportunities to explain their ideas,
b) the lessons involve students' options about the topics,
c) there is a class debate and discussion,
d) the students have discussions about the topics

the four-point scale with the response categories "**in all lessons**", "**in most lessons**", "**in some lessons**" and "**never or hardly ever**" was used

(OECD Science Competencies for Tomorrow's World,2007)

22. SCIENCE TEACHING - STUDENT INVESTIGATIONS IN SCIENCE, ***SCINVEST***

This index ,being one of the **science teaching and learning** variables, was derived from students' responses about the frequency with which the activities occur when learning school science topics at school:

a) students are allowed to design their own experiment,
b) students are given chance to choose their own investigation,
c) students are asked to do an investigation to test out their own ideas.

the four-point scale with the response categories "**in all lessons**", "**in most lessons**", "**in some lessons**" and "**never or hardly ever**" was used

(OECD Science Competencies for Tomorrow's World,2007)

23. SCIENCE SELF-CONCEPT, ***SCSCIE***

This index ,being one of the science **self-belief** variables, was derived from students' students' level of agreement with the following statements:

a) learning advanced school science topics would be easy for me,
b) I can usually give good answer to test questions on school science topics,
c) I learn school science topics quickly,
d) school science topics are easy for me,
e) when I am being taught school science, I can understand the concepts very well,
f) I can easily understand new ideas in school science.

the four-point scale with the response categories "**strongly agree**", "**agree**", "**disagree**" and "**strongly disagree**" was used

(OECD Science Competencies for Tomorrow's World,2007)

24. FAMILY WEALTH, ***WEALTH***

This items derived from the sets of items;

a. whether the students had
   i) a room of their own,
   ii) a link to the internet,
   iii) a dishwasher,
   iv) a DVD player or VCR,

b. how many of the following items they had at home
   i) cellular phones,
   ii) televisions,
   iii) computers,
   iv) cars,

c. whether the students had
   i) three other country specific items

(OECD Science Competencies for Tomorrow's World,2007)

25. LANGUAGE AT HOME, ***DIL***

This index distinguishes between students who
   a) use the Turkish most of the time at home
   b) use the another language most of the time at home

25. VOCATIONAL SCHOOL, ***VOCATION***

27. GENDER, ***GENDER***

APPENDIX B

SCHOOL LEVEL VARIABLES

1. PROPORTION OF GIRLS AT SCHOOL, ***PCGIRL***

This index provides the proportion of female students at school. It is provided by the school principal based on enrolment data.

(OECD Science Competencies for Tomorrow's World,2007)

2. RATIO OF COMPUTERS TO SCHOOL SIZE, ***RATCOMP***

This index provides the proportion of computers at the school. It is provided by the school principal.

(OECD Science Competencies for Tomorrow's World,2007)

3. *SCHOOL SIZE,* ***SCHSIZE***

This index provides the total enrolment at school.
It is provided by the school principal based on the enrolment data.

(OECD Science Competencies for Tomorrow's World,2007)

4. SCHOOL ACADEMIC SELECTIVITY RECODED, ***SELECT***

This index was constructed from school principals' responses to how much consideration was given to the following factors when students were admitted to the school:

a) residence in a particular area,
b) students' academic record (including placement tests),
c) recommendation of feeder schools,
d) parents' endorsement of the instructional or religious philosophy of the school
e) student need or desire for a special programme
f) attendance of other family members at the school

the four-point scale with the response categories "**not considered**", "**considered**", "**high priority**" and "**pre-requisite**" was used

(OECD Science Competencies for Tomorrow's World,2007)

5. TEACHER-STUDENT RATIO, ***STRATIO***

This index provides the ratio of teachers to students at school. It is provided by the school principal.

(OECD Science Competencies for Tomorrow's World,2007)

6. SCHOOL ACTIVITIES FOR LEARNING ENVIRONMENTAL TOPICS, ***ENVLEARN***

This index was derived from school principals' responses indicating whether their school organizes any of the following activities:

a) outdoor education,
b) trips to museums,
c) trips to science and/or technology centers,
d) extracurricular environmental projects (including research),
e) lectures and/or seminars(e.g. guest speakers)

(OECD Science Competencies for Tomorrow's World,2007)

7. RESPONSIBILITY FOR RESOURCE ALLOCATION – SCHOOL: CENTRAL AUTHORITY, ***RESPRES,***
8. RESPONSIBILITY FOR CURRICULUM & ASSESSMENT – SCHOOL: CENTRAL AUTHORITY, ***RESPCURR***

This index was derived from school principals' responses about the responsibility for resource allocation and curriculum & assessment:

a) selecting teachers to hire,
b) dismissing teachers,
c) establishing teachers' starting salaries
d) determining teachers' salary increases,
e) formulating the school budged,
f) deciding on budget allocations within the school,
g) establishing student disciplinary policies,
h) establishing student assessment policies,
i) approving students for admission to the school,
j) choosing which textbooks are used,
k) determining course content,
l) deciding which courses are offered

the four-point scale with the response categories "**Müdür ya da Öğretmenler**", "**Okul yönetim kurulu**", "**İl İlçe Milli Eğitim Müdürlüğü**" and "**Milli Eğitim Bakanlığı**" was used

(OECD Science Competencies for Tomorrow's World,2007)

9. SCHOOL ACTIVITIES TO PROMOTE THE LEARNING OF SCIENCE, ***SCIPROM***

This index was derived from school principals' responses indicating whether their school is involved in any of the following activities:

a) excursions and field trips,
b) science competitions,
c) extracurricular science projects,
d) science fairs,
e) science clubs

(OECD Science Competencies for Tomorrow's World,2007)

10. QUALITY OF EDUCATIONAL RESOURCES, **SCMATEDU**

a) shortage or inadequacy of audio-visual resources,
b) shortage or inadequacy of library materials,
c) shortage or inadequacy of computer software for instruction,
d) lack or inadequacy of internet connectivity,
e) shortage or inadequacy of computer for instruction,
f) shortage or inadequacy of instructional materials (e.g. textbooks),
g) shortage or inadequacy of science laboratory equipment,

(OECD Science Competencies for Tomorrow's World,2007)

11. TEACHER SHORTAGE (NEGATIVE SCALE) ***TCSHORT***

This index was derived from items measuring the school principals' perceptions of potential factors hindering instruction at school:

a) a lack of qualified science teacher,
b) a lack of qualified mathematics teacher,
c) a lack of qualified Turkish teacher,
d) a lack of qualified teachers of other subjects,

the four-point scale with the response categories "**not at all**", "**very little**", "**to some extent**" and "**a lot**" was used

(OECD Science Competencies for Tomorrow's World,2007)

12. MEAN OF INDEX OF ECONOMIC, SOCIAL AND CULTURAL STATUS , ***ESCSMEAN***

This school level index was aggregated from student level data. It is the average index of economic, social and cultural status of the students.

13. VOCATIONAL-GENERAL HIGH SCHOOL, ***VOCATION***

It is dichotomous variable.
Vocational High School=1 (frequency=62) and
General High School=0 (frequency=88)

14. CLASS SIZE, ***CLASIZ***

It is dichotomous variable. including the number of students in a class fewer than 35 or equal to 35=1 (frequency=91) and the number of students in a class more than 35 =0 (frequency=57)

15. ***KAYNAK***

It is dichotomous variable. includes 61% and higher funding of the school by government=0 (frequency= 87) and up to 60% funding of the school by government =1 (frequency=63)

16. URBAN-RURAL HIGH SCHOOL, ***URBAN***

Variable. includes large city(population more than 100 000)=1 (frequency=81) and small town=0 (frequency=69)

APPENDIX C

EMBEDDED ATTITUDINAL ITEMS

C.1.a. Students Support for Scientific Enquiry / Sample Item

THE GRAND CANYON

How much do you agree with the following statements?

Tick only one box in each row.

		Strongly Agree	*Agree*	*Disagree*	*Strongly Disagree*
a)	The systematic study of fossils is important.	□$_1$	□$_2$	□$_3$	□$_4$
b)	Action to protect National Parks from damage should be based on scientific evidence.	□$_1$	□$_2$	□$_3$	□$_4$
c)	Scientific investigation of geological layers is important.	□$_1$	□$_2$	□$_3$	□$_4$

(OECD Science Competencies for Tomorrow's World, 2007, p: 93)

C.1.b. Students Support for Scientific Enquiry/ Sample Item

MARY MONTAGU

How much do you agree with the following statements?

Tick only one box in each row.

		Strongly Agree	*Agree*	*Disagree*	*Strongly Disagree*
a)	I am in favour of research to develop vaccines for new strains of influenza.	□1	□2	□3	□4
b)	The cause of a disease can only be identified by scientific research.	□1	□2	□3	□4
c)	The effectiveness of unconventional treatments for diseases should be subject to scientific investigation.	□1	□2	□3	□4

(OECD Science Competencies for Tomorrow's World, 2007, p: 96)

C.1.c. Students Support for Scientific Enquiry / Sample Item

ACID RAIN

How much do you agree with the following statements?

Tick only one box in each row.

		Strongly Agree	*Agree*	*Disagree*	*Strongly Disagree*
a)	Preservation of ancient ruins should be based on scientific evidence concerning the causes of damage.	□1	□2	□3	□4
b)	Statements about the causes of acid rain should be based on scientific research.	□1	□2	□3	□4

(OECD Science Competencies for Tomorrow's World, 2007, p: 107)

C.2.a. Students' Interest in Learning Science / Sample Item.

ACID RAIN

How much interest do you have in the following information?

Tick only one box in each row.

	High Interest	*Medium Interest*	*Low Interest*	*No Interest*
a) Knowing which human activities contribute most to acid rain	□1	□2	□3	□4
b) Learning about technologies that minimise the emission of gases that cause acid rain	□1	□2	□3	□4
c) Understanding the methods used to repair buildings damaged by acid rain	□1	□2	□3	□4

(OECD Science Competencies for Tomorrow's World, 2007, p: 107)

C.2.b. Students' Interest in Learning Science / Sample Item.

GENETICALLY MODIFIED CROPS

How much interest do you have in the following information?

Tick only one box in each row.

	High Interest	*Medium Interest*	*Low Interest*	*No Interest*
d) Learning about the process by which plants are genetically modified	□1	□2	□3	□4
e) Learning why some plants are not affected by herbicides	□1	□2	□3	□4
f) Understanding better the difference between cross-breeding and genetic modification of plants	□1	□2	□3	□4

(OECD Science Competencies for Tomorrow's World, 2007, p: 81)

APPENDIX D

EMBEDDED ATTITUDINAL ITEMS (TURKISH VERSION)

D.I.a Students Support for Scientific Enquiry/Sample Item

GRAND KANYON (BÜYÜK KANYON)

Aşağıdaki ifadelere ne derecede katılıyorsunuz?

Her sırada sadece bir kutuyu işaretleyiniz.

	Tümüyle Katılıyorum	*Katılı-yorum*	*Katılmı-yorum*	*Hiç Katıl-mıyorum*
Fosiller üzerinde düzenli çalışmalar yapılması önemlidir.	□1	□2	□3	□4
Millî parkları zarara uğramaktan korumak için alınacak önlemler bilimsel kanıtlara dayanmalıdır.	□1	□2	□3	□4
Yer kabuğundaki jeolojik katmanlar üzerinde bilimsel araştırmalar yapılması önemlidir.	□1	□2	□3	□4

(MEB, PISA 2006 Ulusal Ön Rapor, p: 98)

D.I.b Students Support for Scientific Enquiry/Sample Item

MARY MONTAGU

Aşağıdaki ifadelere ne ölçüde katılıyorsunuz?

Her sırada sadece bir kutuyu işaretleyiniz.

	Tümüyle Katılıyorum	*Katılı-yorum*	*Katılmı-yorum*	*Hiç Katıl-mıyorum*
a) Yeni grip çeşitlerine karşı aşı geliştirmek için araştırma yapılmasından yanayım.	□$_1$	□$_2$	□$_3$	□$_4$
b) Bir hastalığın nedeni sadece bilimsel araştırmalarla belirlenebilir.	□$_1$	□$_2$	□$_3$	□$_4$
c) Hastalıklarla ilgili alışılmamış tedavi yöntemlerinin etkililik dereceleri bilimsel araştırmalarla incelenmelidir.	□$_1$	□$_2$	□$_3$	□$_4$

(MEB, PISA 2006 Ulusal Ön Rapor, p: 105)

D.I.c Students Support for Scientific Enquiry/Sample Item

ASİT YAĞMURU

Aşağıdaki ifadelere ne derecede katılıyorsunuz?

Her sırada sadece bir kutuyu işaretleyiniz.

	Tümüyle Katılıyorum	*Katılı-yorum*	*Katılmı-yorum*	*Hiç Katıl-mıyorum*
a) Antik harabeleri korumak için alınacak önlemler, hasar nedenlerine ilişkin bilimsel bulgulara dayanmalıdır.	□$_1$	□$_2$	□$_3$	□$_4$
b) Asit yağmurlarının nedenleri hakkında ileri sürülen düşünceler bilimsel araştırmalara dayalı olmalıdır.	□$_1$	□$_2$	□$_3$	□$_4$

(MEB, PISA 2006 Ulusal Ön Rapor, p: 109)

D.2.a Students' Interest in Learning Science /Sample Item

ASİT YAĞMURU

Aşağıdaki konularda verilecek bilgilere ne derecede ilgi duyuyorsunuz?

Her sırada sadece bir kutuyu işaretleyiniz.

		Çok fazla ilgi duyarım	*İlgi duyarım*	*Biraz ilgi duyarım*	*İlgi duymam*
a)	Hangi insan etkinliklerinin asit yağmurlarına en çok katkıda bulunduğunu bilmek	□1	□2	□3	□4
b)	Asit yağmurlarına neden olan gazların çıkışını en aza indirecek teknolojiler hakkında daha çok bilgi edinmek	□1	□2	□3	□4
c)	Asit yağmurundan zarar görmüş olan binaların onarılmasında kullanılan yöntemleri anlamak	□1	□2	□3	□4

(MEB, PISA 2006 Ulusal Ön Rapor, p: 109)

D.2.b Students' Interest in Learning Science / Sample item

GENETİK OLARAK DEĞİŞTİRİLEN GIDA

Aşağıdaki konularda verilecek tamamlayıcı bilgilere ne derecede ilgi duyuyorsunuz?

Her sırada sadece bir kutuyu işaretleyiniz.

		Çok fazla ilgi duyarım	*İlgi duyarım*	*Biraz ilgi duyarım*	*İlgi duymam*
a)	Bitkilerin genetik yapılarının ne yoldan değiştirildiğini öğrenmek	□1	□2	□3	□4
b)	Bazı bitkilerin neden zararlı ot ilaçlarına direnç gösterdiklerini öğrenmek	□1	□2	□3	□4
c)	Bitkilerin çaprazlanması ile bitkilerin genetik yapısının değiştirilmesi arasındaki farkı anlamak	□1	□2	□3	□4

(MEB, PISA 2006 Ulusal Ön Rapor, p: 116)

APPENDIX E

SIGNIFICANT SCHOOL AND STUDENT LEVEL VARIABLES

Table E.1.

Significant School Level Variables for Scientific Literacy Skills of Turkish Students.

SCHOOL LEVEL VARIABLES	SCIENCE	COMPETENCIES			ATTITUDES	
		Identifying scientific issues	Explaining phenomena scientifically	Using scientific evidence	Interest in science - Intercept	Support for scientific inquiry
Proportion of girls at school, **PCGIRL**		✓				
Ratio of computers to school size, **RATCOMP**						
School size, **SCHSIZE**			✓			
School academic selectivity recoded, **SELECT**	✓	✓	✓	✓		
Teacher-student ratio, **STRATIO**						
School activities for learning environmental topics, **ENVLEARN**						
Responsibility for resource allocation - School: Central Authority, **RESPRES**						
Responsibility for curriculum & assessment - School: Central Authority, **RESPCURR**						
School activities to promote the learning of science, **SCIPROM**						
Quality of educational resources, **SCMATEDU**						
Teacher shortage (negative scale) **TCSHORT**	✓		✓	✓		
Mean of index of economic, social and cultural status ,**ESCSMEAN**	✓	✓	✓	✓	✓	✓
Vocational-general high school, **VOCATION**	✓	✓	✓	✓		
Class size, **CLASIZ**						
KAYNAK						
Urban-rural high school, **URBAN**						

✓ Significant variable

Table E.2.

Significant Students Level Variables for Scientific Literacy Skills of Turkish Students.

STUDENT LEVEL VARIABLES	GROUP-MEAN CENTERING					
		Competencies			Attitudes	
	Science	Identifying scientific issues	Explaining phenomena scientifically	Using scientific evidence	Interest in learning science	Support for scientific inquiry
Student information on science-related careers, **CARINFO**						
School preparation for science-related careers, **CARPREP**	✓	✓	✓	✓	✓	
Cultural possessions at home , **CULTPOSS**			✓			
Awareness of environmental issues , **ENVAWARE**	✓		✓	✓		✓
Environmental optimism, **ENVOPT**	✓	✓	✓	✓		
Perception of environmental issues, **ENVPERC**	✓		✓	✓		
Index of economic, social and cultural status ,**ESCS**	✓	✓	✓	✓	✓	
General value of science, **GENSCIE**	✓	✓	✓	✓	✓	✓
Home educational resources, **HEDRES**	✓	✓		✓		
Index of home possessions, **HOMEPOSS**						
Instrumental motivation in science, **INSTSCIE**	✓					
General interest in learning science, **INTSCIE**					✓	✓
Enjoyment of science, **JOYSCIE**		✓		✓	✓	✓
Personal value of science, **PERSCIE**		✓				✓
Responsibility for sustainable development, **RESPDEV**				✓	✓	✓
Science Teaching -Focus on applications or models, **SCAPPLY**						
Science Teaching - Hands-on activities, **SCHANDS**	✓		✓	✓		
Science activities, **SCIEACT**					✓	
Science self-efficacy, **SCIEEFF**	✓	✓	✓	✓	✓	✓
Future-oriented science motivation, **SCIEFUT**						
Science Teaching – Interaction, **SCINTACT**		✓				

✓ Significant variable

TableE.2.a (continued)

Significant Students Level Variables for Scientific Literacy Skills of Turkish Students.

STUDENT LEVEL VARIABLES	GROUP-MEAN CENTERING					
		Competencies			Attitudes	
	Science	Identifying scientific issues	Explaining phenomena scientifically	Using scientific evidence	Interest in science - Intercept	Support for scientific inquiry
Science Teaching - Student investigations, **SCINVEST**			✓		✓	
Science self-concept, **SCSCIE**			✓		✓	
Family wealth, **WEALTH**		✓				
Language at home, **DIL**						
Vocational school, **VOCATION**	✓	✓	✓	✓		✓
Gender, **GENDER**		✓	✓		✓	✓

✓ Significant variable

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Çalışkan, Müfide
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EDUCATION

Degree	Institution	Year of Graduation
MS	METU Educational Sciences	2000
BS	METU Faculty of Education	1983
High School	Mimar Kemal Lisesi	1976

WORK EXPERIENCE

Year	Place	Enrollment
2007, November-Present	MONE-ERDD - Unit of International Assessments Projects, Ankara	Unit Heat
2006, November-Present	MONE-ERDD, Ankara	PISA Turkey National Project Manager
1999, September	MONE-ERDD, Ankara	Education Specialist
1993, June	MONE-ERDD, Ankara	Item Writer
1986, February	Atatürk Anadolu High School, Ankara	Chemistry, Physics Teacher
1983, October	Kadıköy Anadolu High School, İstanbul	Chemistry Teacher

FOREIGN LANGUAGES

Advanced English

HOBBIES

Movies, traveling