SURVEYING AMERICAN AND TURKISH MIDDLE SCHOOL STUDENTS’ EXISTING KNOWLEDGE OF EARTHQUAKES BY USING A SYSTEMIC NETWORK

DISSERTATION
Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By
Ayse Oguz, B.S., M.S., M.A.

*****
The Ohio State University
2005

Dissertation Committee:
Professor Karen Irving, Co-advisor
Professor Christopher Andersen, Co-advisor
Professor Thomas Nygren

Approved by

Co-Advisors
College of Education
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Global environmental events are becoming increasingly important, because most of them enter our daily lives and somehow shape our everyday activities. Earthquakes are one of the most important environmental events affecting our life. Despite extensive media coverage, the public’s scientific knowledge of earthquakes is limited. The purpose of this study was to design a questionnaire by using a new approach “Systemic Networks” to investigate students’ existing knowledge of earthquakes. Systemic networks categorize features systematically in terms of events and their related actions. In the study, systemic networks were constructed around four possible features of earthquakes: (a) what are earthquakes. (b) how do earthquakes happen?, (c) how can earthquakes affect other things such as objects or living things?, and (d) what can be done to protect from earthquakes?

The questionnaire was administered to 823 students in 5th through 8th grades. Participants included in the sample were chosen from two different locations: Aydin, Turkey, which is in a high-risk Earthquake zone; and Columbus/OH, which is in a low-risk Earthquake zone. In addition, the majority of students in the United States have received formal instruction about earthquakes whereas the majority of students in Turkey have not.
Comprehensive Exploratory Factor Analysis (CEFA version 1.03 for MS Windows) was used to examine students’ patterns of thinking. Ten factors were found based on the students’ common pattern of thinking and all ten factors represented separate themes framed around the features of systemic networks. The research showed similarities as well as differences between the responses in two countries. The US students’ scientific knowledge about earthquakes was significantly higher than Turkish students and they held fewer naive beliefs than Turkish students about the definition of earthquakes and about how earthquakes happen. Over half of the students in both countries do not know about earthquake safety. The results of this study found that students who had experienced an earthquake did not have better knowledge about them. The success of this study also suggests that the network design of the questionnaire might have broader application to different subject matter and concepts.
In memory of Niyazi Özer,
my dear cousin and my colleague
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VITA

1996....................................................B.S. Chemistry Education, 
Dokuz Eylul University, Turkey

1996-1997........................................... 4th Grade Teacher, Guney Elementary School, 
Guney, Burdur

1997-1999 ..........................................Chemistry Teacher, Yesilova High School, 
Yesilova, Burdur

1998....................................................M.S. Chemistry Education, 
Dokuz Eylul University, Turkey

2001…………………………………M.A. Elementary Education, 
The Ohio State University

2001-present………………………...Graduate Student, The Ohio State University

PUBLICATIONS

Akcay, H., Oguz, A., & Karapire, C. (2003). Study of heavy metal pollution and 
speciation in Buyuk Menderes and Gediz river sediments. Water Research, 37, 
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CHAPTER 1

INTRODUCTION

Global environmental issues are becoming increasingly important, because most of them enter our daily lives and somehow shape our everyday activities (Beilfuss, 2004; Bezzi & Happs, 1994; Dove, 1998). Therefore, leaving school with a reasonable understanding of the science behind these issues is important. Only then will students be able to enter into thoughtful debate and to come to rational conclusions. As educators, how much are we preparing our children to deal with real life? What do they know about environmental issues such as earthquakes? How can we measure their existing knowledge on earthquakes to help teachers to give direction to start teaching about them?

Here is a quotation from a 14-year-old student’s journal after he experienced the 7.4 Richter Scale earthquakes in Turkey in August 17th, 1999.

…(T)he day before the earthquake (16th August): there was really oppressive weather, hot and sticky. People who have lived through earthquakes before said that the weather was often like that before earthquakes…(W)hen the earthquake started I thought it was like a train going past, but then it speeded up…(M)y Dad put me under the bed. At that moment I heard the sound of breaking glass coming from the window…(T)he shaking of the earthquake had pushed two beds together…(A)ll the houses had fallen. (Turkey Research Center, 2001).

The quotation gives a sense of some common misconceptions held by students and how this student did not know what action to take without his parent's help.
This research aims to identify what we know about student’s existing knowledge about earthquakes and to propose a new approach to measure their knowledge. The next sections explain the theoretical framework of this research and then present the statement of the problem and purpose of the study along with the research questions.

Theoretical Framework

Over the last two decades, two types of research questions have played a major role in student’s understanding. One identifies students’ existing knowledge, and the other explains the mechanisms that led to particular ways of generating this existing knowledge. From these two types of inquiry, researchers explain the possible effects of these mechanisms in teaching and learning and use them as guidance for creating new teaching styles in education. The major interest of this research is to identify students’ existing knowledge about earthquakes by proposing a new instrument development approach known as a “systemic network”.

Learning a topic does not begin from knowing nothing. Many kinds of learning require transforming existing understanding, especially when one’s understanding needs to be applied in new situations. Teachers have critical roles assisting learners to engage their understanding, building on learners’ understanding, correcting misconceptions, and observing and engaging with learners during the processes of learning.

Along with the learning and development part of cognitive developmental psychology, science education deals with cognitive transitions. Cognitive developmental psychologists and science educators use these models of cognitive transmissions as a
central area of research and theory building, because they capture the dynamics of cognitive change.

Cognitive scientists claim that constructive interactions with the environment create meaning (e.g., Langer, 1994; Ogborn, Mariani, & Martins, 1994; Piaget, 1969; Scholnick & Cookson, 1994). This constructivist theory and nature of meaning in human ontogenesis was argued long ago by Piaget (1969). Piaget proposed that children’s incorporation of new actions into already-existing cognitive structures (assimilation) depends on the significance of actions and the objects of actions. In short, Piaget thought that the actions that children map onto objects are a measure of what they can do with actions and objects to understand the meaning.

In work done towards the end of his life, Piaget developed a theory of the development of the logic of meanings, in which the child’s actions were the fundamental building material.

…there is no difference here between the meanings of objects and the meaning of actions…the meaning of actions consists of success or failure and is thus based on the outcomes of manipulations. The meaning of objects amount to “what can be done with them”, thus referring in all cases to actions performed on them (Piaget & Garcia, 1991, p. 41).

Objects acquire meanings from actions in that an object is what you can do to it and what it is made of, deriving both from meanings and transformations (e.g., squashing or pushing a ball) and part-whole transformations (e.g., putting pieces together) (Langer, 1980). That pushing a ball makes it roll is part of the meaning of “push”. That a ball rolling was pushed is part of the meaning of “roll”. The ball itself has meaning as something that can be rolled and pushed. Pushing implicates rolling, because they share a
meaning in what they make happen: moving a ball. This is neither logical implication nor inductive generalization. Meaningful implication works by the meanings of actions and objects including one another as essential parts.

Similar to Piaget and Garcia, Scholnick and Cookson (1994) described meaning as understanding how the action changes or transforms the world. In contrast, Jackendoff (1989) explained meaning as a fragment of conceptual structure. Langer (1994) suggested that meaning is about what, how, and why. Moreover, meaning is about what works, understanding how, and explaining why. According to Langer, the first stage of meaning has its root from what can be done with actions and objects. The next stage of meaning comes from understanding how about phenomena, which begins with the development of representational cognition. Finally, the most advanced stage of meaning develops when it is informed by reasons why for phenomena. As a result, Langer categorized meaning into three groups: (a) instrumental meaning, what can be done; (b) representational meaning, understanding how and; (c) reasoned meaning, understanding why. In contrast, Bloom (1994) categorized meaning much more simply. In her categorization, there are two groups of meaning: (a) meaning that is public, shared, and conventionally constructed in language and; (b) meaning that is private, personal, and mentally constructed.

The three questions (a) what something is, (b) what something does and, (c) what can be done to something have been suggested by Ogborn, Mariani, and Martins (1994) to be an important ontological framework of meaning. Ogborn et al. used Piaget’s theory of development of meanings to suggest that objects acquire meanings from actions, in
that an object is conceptualized in terms of what one can do to it and what it can do, as well as what it is made of and where it is. Thus, actions have their meaning in what they can make happen, and reasoning is constructed through imagined action. For example, when children conceptualize an earthquake, they think about possible actions done to or by it, as well as what it is and where it has come from.

Mariani and Ogborn (1995) start with the general point that objects and events will be understood by how they share meaning with one another through general related categories of thought such as action, movement, objects, cause, space, and time, as suggested in Piaget’s work on the construction of reality. The features are chosen systematically using a systemic network that categorizes features of events related to actions. In the proposed study, a systemic network (Bliss, Monk, & Ogborn, 1983) of possible features of events was constructed using the three ways of thinking about objects and actions as described earlier: (a) what you can do to them, (b) what they are made of, and (c) what they make happen. For instance, objects are what you can touch and see, movement is what you can start and stop, space is what can be filled, and time is out of reach of actions.

In summary, a network-like structure (in other words, a systemic network) generates descriptive categories that link structure and action. It shows that categories belong within others that are independent and are conditional on the choice of others. The method creates a network between the categories and enables us to understand the structure easily.
Statement of the Problem

Studies demonstrate growing evidence that children have considerable knowledge about the natural and technological world prior to formal science instruction, which means learning has to start from certain already-existing knowledge (Hewson & Hewson, 1988; Klahr, 2000; Kuhn, 2001; Posner, Strike, Hewson, & Gertzog, 1982). However, determining students' ideas, beliefs and understanding is not easy. Interviews are a useful investigative tool, but there are limitations, such as difficulty in analyzing information, problems during reporting the results, difficulty selecting a limited but adequate set of questions (which results in lower test reliability), limited number of subjects, and length of time to transcribe interviews (Osborne & Gilbert, 1980). Alternatively, designing a test by using a systemic network would enable researchers to ask more questions as well as facilitate a statistical analysis of the results. This could provide identification of students’ common patterns of thinking and differences in characteristics such as gender, age, and grade level.

We live in an extremely dynamic world that changes rapidly in many aspects. Children are subject to different kinds of experiences. The systemic network is a way to understand students' beliefs and thoughts about natural events (Boyces & Stanisstreet, 1994, 1999; Mariani & Ogborn, 1995). A systemic network approach enables classifying events as having or not having a number of ontological features. However, the occurrence of natural phenomena such as earthquakes is not always simple or straightforward, because it is sudden, highly disruptive, limited in time, and public.
For hundreds of years, the most common natural hazard in Turkey has been earthquakes. One of the most destructive earthquakes in the history of the world struck on August 17, 1999 and again in November 12, 1999 in Turkey. A 7.4 Richter scale magnitude earthquake struck Turkey and left behind 20,000 deaths and 500,000 homeless. These disasters also caused destruction in businesses and schools. Earthquakes will doubtless continue to play a significant role in human society. Therefore, the earthquake has been chosen as the subject of the network system in this research.

Most people in Turkey are aware of earthquakes, either through direct personal experience or via the news media, where graphic scenes of destruction amply demonstrate their power. Ross and Schuell (1993) stated that students have information about earthquakes regardless of whether they had studied them in school. They also reported that students who had witnessed an earthquake, either by experiencing one directly or being exposed to media reports about them, did not have a better knowledge of them.

The Turkish science curriculum does not include effective discussions of earthquakes. The source of knowledge about earthquakes comes from the media, family, and peer-group discussion. The American Geological Institute (1991) recommended that the study of earthquakes should be introduced as early as third grade, and the building of an understanding of the theory of plate tectonics should be phased in at the beginning of sixth grade. In contrast, the American Association for the Advancement of Science (1993) suggested that earthquakes should be studied in general during the middle school level, and at greater depth in grades nine through twelve. Finally, the National Research
Council (1995) specified the study of earthquakes in grades five through eight and nine through twelve.

Despite many efforts to publicize and implement global environmental issues, only limited related research describes the full meaning of issues such as understanding how the action changes or transforms nature. Furthermore, even in most of the countries suffering from earthquakes, educators do not pay much attention to that issue. Many earthquake studies are about how earthquakes are affecting children’s psychology (e.g., Black, 2001; Deskin & Steckler, 1996; Wilson, 1996), earthquake training programs in emergency operations (Rozanski, 1996), earthquake analysis (Brian, 1998; Espinoza, 2000), and structural damage of earthquakes (Hodder & Peter, 1997). We have little information about students’ existing knowledge of earthquakes. A survey that was focused on students’ perception of earthquakes revealed that children confuse earthquakes and volcanoes (Bezzi, 1989) and those children as well as adults can hold some misconceptions about earthquakes (Ault, 1984; Turner et al., 1986). However, these studies do not describe the nature of students’ everyday practical thinking of earthquakes and the common pattern of their understanding of earthquakes.

Purposes of the Study along with Research Questions

The main purpose of this research was to identify the nature of everyday practical thinking of students about earthquakes and their understanding about the nature of the event. Students classify earthquakes as having or not having several ontological features.
For this research, the features were chosen systematically using a systemic network that categorizes the natural phenomena related to its actions.

The study also aimed to identify common patterns in earthquake thinking based on gender, age, geographic area, experience with earthquakes, and formal instruction. Therefore, the instrument was administered in two different countries, Turkey and the United States. Aydin was chosen as the district in Turkey, because of its location on a high-risk earthquake zone, and for comparison Columbus/OH, where earthquakes are rare.

As a result, the main research question to be addressed in this study is;

1- What is the nature of students’ everyday practical thinking of earthquakes, and what are the common patterns of their understanding about earthquakes?

A systemic network of possible features of events was constructed using the four ways of thinking about earthquakes: (a) what are earthquakes?, (b) why do earthquakes happen?, (c) how can earthquakes affect objects or living things?, and (d) what can be done to protect from earthquakes? The questionnaire that was designed by using these features enables us to find out whether there is a consistency between the natural phenomena and the logical patterns of students’ thinking. Factor analysis was used to explore these themes, because the analysis represents a group of procedures for testing the theory.

Furthermore, the study compared the differences between students’ views about earthquakes that they had experienced, either by being in one or being exposed to media reports about them, but have no formal instruction; and students who have formal
instruction about earthquakes but have not experienced one. Finally, the study was aimed at contributing to a curriculum that is designed to support student’s thinking about natural issues, especially earthquakes.

The research questions related to these issues are:

2- How do the views of earthquakes differ among the students who have experienced earthquakes compared to those who have not experienced earthquakes?

3- How do the views of earthquakes differ among the students who have formal instruction on earthquakes compared to those who have no formal instruction on earthquakes?

4- How do the views of earthquakes differ according to gender and age?

Significance of the Study

No empirical studies of earthquakes exist based on classifying the event using a systemic network. Therefore, this study aims to provide quantitative evidence of students’ thinking about natural phenomena by using a systemic network. Specifically, this research aims to inform teachers by providing descriptive and analytical accounts of students’ ways of thinking and by providing insight into students’ knowledge. In addition, examination of the students’ patterns of thinking about earthquakes is intended to provide insight and empirical evidence for applying the network design of the questionnaire in different subject matters and concepts.

The significance of this study lies in its providing a structural approach to instrument development. A network approach is important to provide an intelligible and well-founded structure against which to judge items in the questionnaire and with which
to evaluate the questionnaire as a whole. Furthermore, at the stage of data analysis, the network provides a representation of the substance of the questionnaire that goes beyond lists of items asked.

In addition, despite much media attention in recent years about the earthquakes in Turkey, the information provided has likely led to a limited even distorted understanding among students. Even though Turkey is a high-risk earthquake zone, little research exists on Turkish students' idea of earthquakes, and the Turkish science curriculum does not include effectively the discussion of earthquakes. This study is intended to draw the attention of researchers, curriculum developers, teachers, and even school ministers and government administrators to the importance of teaching about earthquakes.

Delimitations and Limitations

Boundaries were placed on this study, some decided upon by the researcher (delimitations) and others out of the researcher’s control (limitations).

Delimitations. This research dealt only with the variables of students’ having or not having formal instructions about earthquakes, experiencing or not experiencing earthquakes, grade level, and age and gender differences. Other influencing factors of students’ existing knowledge of earthquakes, such as media, cultural differences, teachers and parents’ background, were left for future research.

Students’ existing knowledge of earthquakes were surveyed in this study. The results revealed the common patterns of earthquake thinking. However, this study could not explain the reasons for this trend, because no follow up interviews and no instructional intervention were applied. These types of studies should have to be more
focused and have fewer participants than the present one. Therefore, first, the reseracher intended to determine the general perspective of students’ views about earthquakes because limited research has been done about earthquake education. Then the reseracher expected to apply these results to future focused studies.

**Limitations.** This is a descriptive study, and the sampling procedure aimed to generalize the findings. The participants in Aydin/Turkey were randomly chosen. However, the students in Columbus/OH were chosen because of their availability. Several e-mails were sent to the schools in Columbus, and only the available schools were used.

In both countries, students participated in the study voluntarily and with their parents’ permission. Students who did not return a signed parental permission form did not participate in the study. Therefore, these limitations of sampling procedure can decrease the generalizability of findings.

**Definitions of Terms**

The purpose of this section is to define and clarify terms used in this study. Some of these terms mean different things to different people. The operational definitions shown here are meanings that apply to this research study.

*Students’ Existing Knowledge.* A considerable volume of research in the last two decades has been generated on students’ understanding of concepts in science. These studies have revealed that students’ conceptions often conflict with scientific thinking. These conceptions have been variously referred to as misconceptions, children’s science, alternative frameworks, etc. Although all these studies are for determining students’
conceptions that conflict with scientific thinking, there are some differences. For instance, the term “misconception” has tended to be used in studies where even when the students’ have formal instruction, they generated incorrect knowledge; whereas “preconception” referred to any knowledge before formal instruction. Collectively, what may be missing is a complementary term rather than mutually exclusive ones. In this study, the term “Students’ Existing Knowledge” (Sutton, 1980) is used, because this research has given more attention to the content of the learner’s thought, whether it was gained from formal instruction or from everyday activities. The important thing is what’s already known.

\[ \text{Earthquake.} \] An earthquake is a sudden, rapid shaking of the earth caused by release of energy stored in rocks (Callister, Coplestone, Consuegra, Stroud, & Yasso, 2002).

\[ \text{Network.} \] A network is a structured pattern of interdependent options (Bliss & Ogborn, 1979). In this study, network serves as the structure between the pattern of related descriptive paradigms (movement, belief, manmade, etc.) and the combinations of features (what are earthquakes?, how do earthquakes happen?, etc.). Combinations of paradigms refer to a particular grouping of features.

\[ \text{Systemic Network.} \] A systemic network categorizes features systematically in terms of events and their related actions (Bliss, Monk, & Ogborn, 1983). Therefore, a systemic network generates descriptive categories that link structure and action.
Paradigm. If we assume that a network is a structure of possibilities (Bliss & Ogborn, 1979) then the certain possible choices of the network are called paradigms of that network (e.g. movement, belief, manmade etc.).
CHAPTER 2

REVIEW OF THE LITERATURE

In keeping with this study’s goal to better understand the students’ existing knowledge of earthquakes, the review of literature focuses on two major themes: the research on earthquake education and the systemic-network technique to identify students’ existing knowledge. This literature review is organized into five sections:

- **Section A: A Natural Hazard: Earthquakes.** One of the central themes of this research is to examine earthquakes as a natural hazard, not a disaster. Therefore, the differences between a natural hazard and a disaster will be presented first. Then, the concept of earthquakes will be described with the same pattern of instrument questions.

- **Section B: Earthquake Education.** The earthquake topic will be examined in regard to earth and space science standards in Ohio, and after briefly describing primary education in Turkey, the Earthquake Education Act will be examined in that country.

- **Section C: Review of Research on Earthquakes.** In this part, studies associated with earthquake concepts will be reviewed.

- **Section D: Students’ Existing Knowledge.** Studies and research techniques for measuring students’ existing knowledge will be examined.

- **Section E: Systemic Network.** The systemic network approach will be discussed theoretically and questionnaire development using a systemic network will be explained with related studies.
Section A: A Natural Hazard: Earthquakes

Nature presents humankind with opportunities and risks. Opportunities include resources, such as raw materials and energy sources. On the other hand, risks consist of a wide range of hazards that put constraints on humankind, such as earthquakes, floods, and droughts. However, can these risks always account for “natural” hazards?

Cannon (1994) emphasizes that hazards are natural, but that in general, disasters are not, and should not be seen as the inevitable outcome of hazards’ impacts. In this chapter, the focus is on conditions that make it possible for a hazard to become a disaster. The subject of disasters includes the technical issue of how society deals with hazards in terms of mitigation and preparedness. In addition, Cannon (1994) identifies the differences by arguing that “…disasters are not ‘natural’ (not even sudden ones) because hazards affect people differently within societies, and may have very different impacts on different societies (e.g., earthquakes of equal energy may cause devastation in one country, but not in another)” (p. 14).

In sum, if people can be made less vulnerable or invulnerable, then a hazard may still occur, but need not produce a disaster. So, reducing disaster is possible only by either modifying the hazard or reducing vulnerability. Although economic factors are significant for reducing the hazard and vulnerability, education is also a major factor for withstanding and preparing for these issues. Furthermore, Cannon (1977, as cited in Cannon, 1994) states that vulnerability is not the same as poverty. For example, a middle-class family living in unsafe housing in an earthquake area may endure high levels of vulnerability, while the poor may be living in dwellings that are so flimsy that their
collapse does not kill or injure many. In consequence, education may save lives and it is as important as economic issues.

The central theme of the following review examines earthquakes as a “natural” hazard. Earthquakes will be explained by answering the following questions: (a) what are earthquakes?; (b) how do earthquakes happen?; (c) how can earthquakes affect other things (objects or living things)?; and (d) what can we do to protect ourselves from earthquakes?

What Are Earthquakes?

Earthquakes are the most poorly understood and poorly predicted of all the natural hazards. Scientists currently understand the dynamics of earth processes based upon Weneger’s plate tectonics theory. According to this theory, the earth’s outer layer contains seven major and some smaller plates that constantly push against, pull away from, or grind past one another. These forces in the crust apply stresses to the rocks. If the rocks are cold and brittle, they will not bend as force is applied. At this point, breakage occurs and energy is suddenly released. This energy radiates throughout the earth as a series of waves, which shake the surface as they pass. These are called earthquakes and they occur in the extreme outer layer of the earth’s crust (Wallace, 1995).

How and Where Earthquakes Happen

The earth’s crust contains two very different types of rocks: oceanic crust and continental crust (see Figure 2.1). The thinner oceanic crust is approximately 10 km thick and mainly underlies the oceans. The thicker continental crust is approximately 40 km
and mainly forms the continental areas. Within these crusts, the rocks are brittle and can fracture to produce earthquakes.

Figure 2.1: Schematic representation of oceanic crust at a continental margin. The stars represent earthquakes (Wallace, 1995, p. 6).

Two-thirds of the world’s large earthquakes have occurred around the Pacific, up the west coasts of South and North America into Alaska, across the Aleutians, down through Japan offshore of the continental landmass, through the Philippines, Indonesia and out through New Zealand. These oceanic plates are pulling away from one another and are forced under continental plates, pushing up mountain ranges. The next most important zone stretches along the plate boundaries from Indonesia, along the Himalayas and the axis of the Mediterranean, through Italy, Greece, Turkey, and Iran and across northern India. These continental plates can also force up mountain ranges and release compression energy in quakes. The major earthquakes of the world are presented in
According to the map, earthquakes rarely occur in Australia or most of Africa (Levy & Salvadori, 1995; Wijkman & Timberlake, 1984).

Figure 2.2: Major earthquakes of the world from 1900 to 2005 (Maps of world, 2005).

**How Earthquakes Can Affect Other Things**

A handclap in the air sends sound waves outward to distant places as the air compresses. In a similar way, a stone thrown into water sends waves spreading across its surface in the form of ripples. So too, rocks have elastic properties that cause them to bend and vibrate when pushed and pulled by forces applied to them. This energy travels through the earth in three basic types of elastic waves. The fastest of these body waves...
are called P- (or Primary) waves. In most earthquakes, the P waves are felt first. These waves, just like sound waves, are able to travel through both solid rock, such as granite mountains, and liquid material, such as volcanic magma and the water of the oceans. When P waves emerge at the surface from deep in the earth, they may transmit into the atmosphere as sound waves and are audible to animals and humans at certain frequencies (Bolt, 1993).

The slower waves through the body of rock are called the S- (or Secondary) waves, which create elastic vibrations in solid substances. S waves arrive with an up-and-down and side-to side motion, shaking the ground surface vertically and horizontally. The third general types of earthquake waves are called surface waves, because their motions are restricted to near the ground surface and they travel much slower than the P- and S-waves. All these motions, shakings and vibrations cause hazards on the ground surface (Bell, 1999).

Ground shaking, land movement, surface rupture, liquefaction, and seiching are some types of hazards resulting from an earthquake (Wallace, 1995). Ground shaking is the most widespread earthquake hazard. Several factors may influence the amount of ground shaking and resulting damage. Land movement can be expected from most moderate to large earthquakes in hilly or mountainous regions. Surface rupture is often associated with shallow earthquakes and may form a surface scarp where the break is simple and sharp, or may consist of a zone of broken and bent ground up to tens of meters wide.

Liquefaction is the process in which soil or sand suddenly loses the properties of solid materials and behaves like a liquid (FEMA, 2002). With liquefaction, the earth
materials involved lose their strength and cannot support weight. Large buildings cannot be supported and sink into the soil. Seiching is the term to describe when earthquakes cause a movement on the surface of an enclosed body of water such as harbors, dams, and lakes.

The instrument called a seismograph measures the magnitude of earthquakes and the magnitude scale is called the Richter’s scale (Richter, 1935). The largest measured earthquakes were 8.9 events in Ecuador (1906) and Japan (1933), but the largest historic earthquakes may have been the 2004 earthquakes in the western end of Indonesia’s Sumatra Island with a measured magnitude of 9.0 (Farley, 1998). Table 2.1 shows approximate equivalent levels on the Richter scale and the number of events for comparison. So far, earthquakes have been explained as a natural hazard. In the next section, earthquake education will be examined in Ohio’s and Turkey’s curricula.
<table>
<thead>
<tr>
<th>Richter Magnitude</th>
<th>Descriptive Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Not felt. Only detected by seismographs.</td>
</tr>
<tr>
<td>2&amp;3</td>
<td>Many people indoors might feel movement but relatively few people outdoors.</td>
</tr>
<tr>
<td>4</td>
<td>Moderate. The earthquake feels like a heavy truck hitting the walls. Most people indoors feel movement. Hanging objects swing. Dishes, windows, and doors rattle.</td>
</tr>
<tr>
<td>5</td>
<td>Rather strong. Almost everyone feels movement, and sleeping people are awakened. Small objects move or are turned over. Trees might shake.</td>
</tr>
<tr>
<td>6</td>
<td>Strong. Everybody feels movement. People have trouble walking. Objects fall from shelves. Furniture moves. Damage is slight in poorly built buildings. No structural damage.</td>
</tr>
<tr>
<td>7</td>
<td>Very strong. People have difficulty standing. Drivers feel their cars shake. Damage is slight to moderate in well-built buildings, considerable in poorly built buildings.</td>
</tr>
<tr>
<td>8</td>
<td>Destructive. Tall structures such as towers and chimneys might twist and fall. Hillsides might crack if the ground is wet. Water levels in wells might change. Tree branches break.</td>
</tr>
<tr>
<td>&gt;8</td>
<td>Disastrous. Most buildings collapse. Objects are thrown into the air. The ground moves in waves or ripple. Large amounts of rock may move.</td>
</tr>
</tbody>
</table>

Table 2.1: Approximate equivalent levels on the Richter scale and number of events are included for comparison (Bell, 1999).
Section B: Earthquake Education

For hundreds of years, earthquakes have been the most common natural hazard in the world. Most people are aware of earthquakes, either through direct personal experience or via the news media, but it is likely that this information has led to a limited, even distorted understanding among most people. This section examines earthquake content in Ohio’s and Turkey’s curricula standards.

*Earth and Space Science Content Standards in Ohio*

Education has no higher purpose than preparing people to lead personally fulfilling and responsible lives. For its part, science education should help students to develop the understandings and habits of mind they need to become compassionate human beings able to think for themselves and to face life head-on. Education should equip them also to participate thoughtfully with fellow citizens in building and protecting a society that is open, decent, and vital (AAAS, 1993).

A report by the National Council on Science and Technology Education was one of the documents that initiated the work on science standards in the United States. In 1993, AAAS published *Benchmarks for Science Literacy*. The former presented “achievable learning goals”, whereas Benchmarks for Science Literacy stated “what students should know and be able to do in science, mathematics, and technology at various grade levels” (AAAS, 1993, p.X).

In addition, *Project 2061: Science for all Americans* (AAAS, 2000) presents a set of recommendations on what understanding and ways of thinking are essential for all
citizens in a world shaped by science and technology. The report gives a basic description of science education and recommends the following basic learning goals for all American children:

1. Be familiar with the natural world and recognize both its diversity and its unity.
2. Understand key concepts and principles of science.
3. Be aware of some of the important ways in which science, mathematics, and technology depend upon one another.
4. Know that science, mathematics, and technology are human enterprises and know what that implies about their strengths and limitations.
5. Have capacity for scientific ways of thinking.
6. Use scientific knowledge and ways of thinking for personal and social purposes.

Similarly, the National Science Education Standards recognize that knowing and understanding science will enable students to make better decisions about themselves and their interactions with the natural world (National Research Council, 1996). Further, Earth System Science is based on the similar idea that students should begin to see connections between basic science and real-world situations, for instance, teaching about natural hazards such as earthquakes and tornadoes and what kind of action students should take when they happen (Gill, 1999). In short, the overall goal is to help students make sense of the scientific world in which they live.

During K-12 schooling, most students in the US learn Earth System Science at some point, usually in the 8th grade. Many middle-school earth science objectives relate to plate tectonics. In terms of the National Science Education Standards (1996), students in the middle grades start building an understanding of plate tectonics. Learning plate
tectonics is important for this research, because students’ awareness and knowledge about earthquakes is based on understanding the theory of plate tectonics.

Part of this study took place in Columbus, OH, as a comparative group. Therefore, examining how and in what grades the subject of earthquakes and related issues are included in Ohio’s education system are crucial. The Ohio State Board of Education readopted statewide academic content standards in science and social studies on December 10, 2002 (Ohio Department of Education, 2002). Ohio’s science content standards emphasize the nature, connections, and historical development of scientific knowledge in the physical, life, and earth and space sciences. Please note that Ohio includes standards for four main areas within earth and space science: (a) the universe, (b) the earth system, (c) processes that shape earth, and (d) historical perspectives and scientific revolutions.

Table 2.2 shows, Ohio middle school standards on Earth and Space Science are shown in comparison with the ‘standards’ from National Science Education Standards and ‘benchmarks’ in Benchmarks for Science Literacy.

Ohio’s Earth and Space Science content standards suggest starting to teach about earthquakes in the 4th grade. In this grade, earthquakes are described as rapid processes that change Earth’s surface. Later, especially in 8th grade, students start learning plate
Students demonstrate an understanding about how earth systems and processes interact in the geosphere, resulting in the habitability of earth. This includes demonstrating an understanding of the composition of the universe, the solar system, and earth. In addition, it includes understanding the properties and the interconnected nature of earth's systems, processes that shape earth and earth's history. Students also demonstrate an understanding of how the concepts and principles of energy, matter, motion, and forces explain earth systems, the solar system, and the universe. Finally, they grasp an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with earth and space sciences.

<table>
<thead>
<tr>
<th>Ohio Science Academic Content Standards</th>
<th>National Science Education Standards</th>
<th>Benchmarks for Science Literacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth and Space Sciences</td>
<td>Earth and Space Sciences</td>
<td>Earth and Space Sciences</td>
</tr>
<tr>
<td>Students demonstrate an understanding about how earth systems and processes interact in the geosphere, resulting in the habitability of earth. This includes demonstrating an understanding of the composition of the universe, the solar system, and earth. In addition, it includes understanding the properties and the interconnected nature of earth's systems, processes that shape earth and earth's history. Students also demonstrate an understanding of how the concepts and principles of energy, matter, motion, and forces explain earth systems, the solar system, and the universe. Finally, they grasp an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with earth and space sciences.</td>
<td>• Properties of Earth materials • Objects in the sky • Changes in earth and sky • Structure of the earth system • Earth's history • Earth in the solar system • Energy in the Earth system • Geochemical evolution • Origin and evolution of the earth system • Origin and evolution of the universe</td>
<td>The Nature of Science • Scientific inquiry • The scientific world view The Physical Setting • The universe • Earth • Processes that shape Earth Historical Perspectives • Moving the continents</td>
</tr>
</tbody>
</table>

Table 2.2: Comparison of Earth and Space Science Content Standards in Ohio Science Academic Content Standards, National Science Education Standards, and Benchmarks for Science Literacy.

tectonics in depth. This might be because the mechanisms causing a geological process within the Earth cannot be observed directly, making the concept difficult to understand at earlier grade levels (Beilfuss, 2004). Ohio’s Earth and Space Science content standards related to this study are listed in Table 2.3.
<table>
<thead>
<tr>
<th>Grade</th>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4th</td>
<td>Processes that shape Earth</td>
<td>10. Describe evidence of changes on earth's surface in terms of slow processes (e.g., erosion, weathering, mountain building, and deposition) and rapid processes (e.g., volcanic eruptions, earthquakes, and landslides).</td>
</tr>
<tr>
<td>8th</td>
<td>Earth System</td>
<td>9. Describe the interior structure of earth and earth's crust as divided into tectonic plates riding on top of the slow moving currents of magma in the mantle.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10. Explain that most major geological events (e.g., earthquakes, volcanic eruptions, hot spots and mountain building) result from plate motion.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11. Use models to analyze the size and shape of earth, its surface, and its interior (e.g., globes, topographic maps, satellite images).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12. Explain that some processes involved in the rock cycle are directly related to thermal energy and forces in the mantle that drive plate motions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13. Describe how landforms are created through a combination of destructive (e.g., weathering and erosion) and constructive processes (e.g., crustal deformation, volcanic eruptions, and deposition of sediment).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14. Explain that folding, faulting and uplifting can rearrange the rock layers so the youngest is not always found on top.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15. Illustrate how the three primary types of plate boundaries (transform, divergent, and convergent) cause different landforms (e.g., mountains, volcanoes, and ocean trenches).</td>
</tr>
</tbody>
</table>

Table 2.3: Ohio Earth and Space Science Standards related to earthquakes. (Available online at http://www.ode.state.oh.us/academic_content_standards/ScienceContentStd/PDF/SCIENCE.pdf).
A Look at the Education System in Turkey

Atatürk’s “Turkish Revolution” is the leading factor affecting the national education system in Turkey. Atatürk stated that one of the main targets of Turkish education was to raise a patriotic generation nourished with a national culture (Republic of Turkey Ministry of National Education, 2002a). The National Education System, determined by National Education Basic Act No. 1739, consists of two main parts, namely “formal education” and “non-formal education” (Republic of Turkey Ministry of National Education, 2002b).

Formal education in Turkey is the standard education conducted within a school for individuals in a certain age group and at the same level, under programs developed in accordance with the purpose. Formal education includes pre-primary education, primary education, and secondary education, along with higher education institutions.

In accordance with the general objectives and basic principles of national education, the goal of non-formal education in Turkey is to give a chance to complete their education to the citizens who have never entered or completed their formal education. After explaining the general education system in Turkey, the primary education system will be examined.

Primary Education in Turkey

Primary education in Turkey involves children in the age group 6 to 14. The objective of primary education is to ensure that every Turkish child acquires the necessary knowledge, skills, behavior, and habits to become a good citizen and is raised in accordance with the concept of national morals, and that he/she is prepared for life and
for the next level of education in accordance with his/her interests, talents, and capabilities. Primary education is compulsory and free for all male and female citizens at state schools. Primary education is provided at eight-year schools (Republic of Turkey Ministry of National Education, 2002b).

During the primary education in Turkey, students take several kinds of courses. Table 2.4 lists the course titles and their credits in terms of grade levels. There is no specific earth science education during primary education in Turkey.

Earthquake Education Act in Turkey

The Turkey Research Center (2001) published a series of essays written by Turkish students about the August 17, 1999 earthquake that killed more than 18,000 people in Yalova, Izmit, Golcuk and Adapazari in Turkey. These essays give an idea about how students were affected by earthquakes emotionally and mentally.

Here is a journal entry of a 7th grade student,

…It was unbelievably hot… I was woken up by our dog howling. Then suddenly the earthquake started. Without understanding what was happening I was looking out of the window... At first I thought that our house had collapsed. It hadn’t, but there was an incredible groaning noise...Then the house was moving from one side to another without stopping. While this was going on there were terrible deep noises coming from the ground… Screams, the noise of breaking glass… Believe me, writing this story I felt like I was living through that day again (Available online at http://www.turkeyresearch.com/earthquake/PinarOnuk.html).
<table>
<thead>
<tr>
<th>Courses/Grades/Credits</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turkish</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>5</td>
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<td>Math</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<tr>
<td>Life Sciences</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
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<tr>
<td>Science</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Social Science</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>3</td>
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<td>3</td>
<td>-</td>
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<tr>
<td>Civil and human rights</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>T.C. History of Reform and Atatürk’s Ideology</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Foreign Language</td>
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<td>-</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<tr>
<td>Religion and Moral Codes</td>
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<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
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</tr>
<tr>
<td>Drawing</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
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<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Music</td>
<td>2</td>
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<td>2</td>
<td>1</td>
<td>1</td>
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<td>1</td>
<td>1</td>
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<tr>
<td>Physical Education</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Business Education</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
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<tr>
<td>Traffic and First-aid Training</td>
<td>-</td>
<td>-</td>
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<td>1</td>
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<tr>
<td>Individual and Collective Activities</td>
<td>3</td>
<td>3</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Elective Courses</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total Credits</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 2.4: The Courses and Duration in Primary Education Curriculum. (Available online at [http://www.meb.gov.tr/stats/apk2001ing/Section_4/CompulsoryEducation1.htm#4s12](http://www.meb.gov.tr/stats/apk2001ing/Section_4/CompulsoryEducation1.htm#4s12)).

Obviously this child did not know how to act during the earthquake, because even though it is very dangerous to do so, she was looking out of the window during the earthquake. Unfortunately, according to an International Federation of Red Cross and Red Crescent Societies report (2002), the number of deaths from the Turkish quakes would have been dramatically less if the country had educated people and enforced
building regulations. Although there have been laws about building regulations since 1939, the laws have been ignored. Thus, raising public awareness of threats and how to react depends mostly on educating people.

Right after this great tragedy in Turkey, a project protocol called ABCD Basic Disaster Awareness training in primary and secondary schools all over Turkey was signed between the Kandilli Observatory, the Earthquake Research Institute, and the Republic of Turkey Ministry of Education (BU-KRDAE) (BU-KRDAE, 2000). The objective of this project was to increase disaster awareness in order to be prepared against possible disasters, to spread the idea that disaster risks can be reduced by taking small preparedness steps and to increased preparedness in order to help people around us as well as ourselves after a disaster. To help attain this goal, 25,000 teachers will provide training to other teachers, school staff, students, and parents in their schools, reaching more than 5 million children by the end of 2005. Efforts are being made to incorporate this training project into the curriculum of grades 1 to 8.

In addition, Ahmet Metin Isikara, director of the Kandilli Observatory (and for thousands of children and their parents, he is “Grandpa Earthquake”), started an education campaign called the Kandilli Project (Kandilli Observatory, 2000). Isikara stars in a series of short cartoon films that show children and adults exactly how to react in an earthquake. According to Isikara, the worst possible reaction to earthquakes is panic. Therefore, this campaign is against fear. The message is beginning to get across: It does not matter how big it is, what counts is “Are you ready?” However, the education act program only deals with how to react in an earthquake. A scientific explanation of
earthquakes has not been included effectively in the program. And at this time, the program has not been included in the curriculum of every school.

Having given all this information about earthquakes and earthquake education in both countries (Columbus OH, USA and Turkey), the next section will review the research studies related to students’ thoughts on earthquakes and the earthquake topics in the curriculum.

Section C: Review of Research on Earthquakes

Although for hundreds of years, the most common natural hazard in the world has been earthquakes, research on students’ views about earthquakes has been limited. Cavalcante (2002) claimed that the area of children’s conceptions about earthquakes is largely unexplored. The science curriculum does not effectively include the discussion of earthquakes. The origin of knowledge about such things usually comes from the media, family, and peer-group discussion.

In this section, studies related to students’ views about earthquakes will be examined. First, the review opens with comparative views about earthquakes by students who have experienced them and those who have not. Then the review continues with students’ views about earthquakes and several other issues such as plate tectonics, volcanoes, and weather conditions. Finally, the part ends with a review of studies about origins of students’ beliefs about earthquakes.

Students’ Views about Earthquakes Based on Their Experience

One of the main research objectives of this study was to search students’ views about earthquakes based on their experience. The first study related to this issue was done
by Ross and Shuell (1993). The researchers interviewed 91 students in grade K-6 to reveal their beliefs about earthquakes. Students were from two different geographic locations: New York and Utah. In contrast with New York, Utah is located in an area of moderate to high seismic activity. The researchers focused on five questions in their interviews: (1) what is an earthquake?; (2) what causes an earthquake?; (3) what happens when there is an earthquake?; (4) have you ever been in an earthquake? If so, what happened?; (5) what should a person do if he or she is in an earthquake? Across all the responses, approximately two thirds of the students responded that an earthquake is a shaking/trembling of the earth or ground. At least one student in each study used the word eruption in a comparative description of an earthquake and a volcano. Students also thought that core movement, pressure, and volcanoes cause earthquakes. In addition, some students believed that heat from the sun on the earth, thunder, rain, wind, and mountains cause earthquakes. None of the students mentioned the terms seismic waves or ground failure when asked, “What happens below the surface when there is an earthquake?” The most frequently given response was “I don’t know.” In this study, Ross and Shuell did not find differences between the students who had experienced earthquakes and the students who had not.

In another study designed to observe whether experiencing an earthquake or observing the mass media version of the story influences introductory geology students' understanding about earthquakes, Barrow and Haskins (1996) examined 186 college students’ understanding of earthquakes by using an open-ended questionnaire. The author found no statistically significant difference in perceived earthquake knowledge between the group who experienced an earthquake and the group that did not. The results also
indicated that students had limited knowledge about the theory of plate tectonics, so they were not aware of the relationship between earthquakes and tectonic activities.

Students’ Views about Earthquakes and Plate Tectonics Theory

In a multiple-case study, Skinner (2001) selected three seventh grade students to determine their alternative conceptions about plate tectonics and to discover how these conceptions change during instruction. Data were collected and analyzed from concept maps, interviews, and classroom artifacts. The researcher observed that three major categories of alternative conceptions kept reoccurring in the data: visualizing plate tectonics, recreating theories, and coping with dissonance. In addition, the researcher also found patterns of students’ conceptual changes concerning plate motions, earthquakes, volcanoes, and mountains. This study confirmed the importance of presenting visually the abstract concepts of plate tectonics in different formats such as models, drawings, graphic organizers, and videos.

Similarly, Beilfuss (2004) believed that understanding plate tectonics, earthquakes, and volcanoes requires an understanding of the models that scientists use to describe the Earth’s interior. Thus, the researcher designed a study that used student-generated drawings and interviews to examine students’ understanding of the Earth’s interior. The researcher conducted 92 semi-structured interviews with non-science major college students enrolled in an entry-level geology course at a large Midwestern university. Students were asked to draw a picture of earth’s interior and to provide explanations of their drawings. Results indicated that students’ understanding or cognitive levels ranged from simple views such as “The interior of earth consists of
horizontal layers of rock and dirt”, to complex views, such as “Earth’s interior is composed of concentric layers with unique physical and chemical characteristics.”

In another related study, Marques and Thompson (1997) examined the misconceptions of Portuguese students aged 16-17 for the following concepts: Continent, ocean, permanence of ocean basins, continental drift, the earth’s magnetic field, and plates and plate motions. In this study, interviews were carried out and a questionnaire was administered to 270 students after they had been trained in a course designed to take a constructivist approach. The results revealed that the students held a considerable number of misconceptions on plate tectonics. Some students believed that magnetic polar wandering causes the motions of plates. When the students were asked the nature and origin of plates, and particularly their boundaries, 20% answered that continents’ boundaries and plates’ boundaries are the same. In short, both plates and continents are identified by external observable features that relate to students’ own experiences of the seacoast. Similarly, Barrow and Haskins (1996) declared that a major misconception about the theory of plate tectonics is that “continents are not moving.” On the other hand, in a multiple choice questionnaire about understanding earthquakes and oil in the United Kingdom, Leather (1987) claimed that of the 14-year-olds, 28% mentioned plate movements as a cause of earthquakes, and this figure increased to 50% among the older group.

Wampler (2002) found several misconceptions in an elementary seismology textbook about the relations between tectonics plates and earthquakes. The writer stated that since the plate tectonic theory has only thirty years of history, the researchers had not integrated new findings effectively.
In sum, despite many efforts to spread and implement tectonic theory, very limited related research was found to describe the issues. More research is needed to examine the implications of plate tectonics in students understanding of earthquakes, because this concept has become widely established only in the last 35 years.

Students’ Views about Earthquakes and Volcanoes

Marques and Thompson (1997) stated that volcanoes and earthquakes are quite familiar to students, both exposure from school and from mass media. Similarly, several studies have noted the tendency for students to confuse earthquakes with volcanic activity. For instance, Sharp, Mackintosh, and Seedhouse (1995) found that some children thought an earthquake occurred when a volcano becomes hot and shakes the ground. Correspondingly, Happs (1982), in a study of 11- to 17-year-olds’ knowledge of mountains in New Zealand, found that some students believed that mountains could become volcanoes if shaken by earthquakes.

Ross and Shuell (1990) prepared a 60-item true-false test of knowledge and misconceptions about earthquakes. The Earthquake Information Test (EIT) was administered to 194 students in grades 4 through 6 in Salt Lake City UT and Buffalo NY. The EIT was administered after most students had received some instruction about earthquakes. The results revealed that further exploration of conceptual understanding of tectonic processes and the explanation of the differences between earthquakes and other natural hazards such as volcanoes and tornadoes is needed. In the next section, students’ beliefs about earthquakes and weather conditions will be examined.
Leather (1987) administered a multiple-choice questionnaire to 200 students aged 11 to 17. The researcher stated that of the 11-year-olds, 28% referred to a hot climate or hot weather conditions as being the cause of earthquakes. Other causes given included collapsing ground, thunderstorms, and pushing and pulling of the sea. The researcher also asked why some countries have more earthquakes than others. Over half the 11 and 14-year-olds believed that earthquakes are located in only hot countries. In parallel, Sharp, Mackintosh, and Seedhouse (1995), in a small study of 9 to 10-year-olds’ understanding of earthquakes in the United Kingdom, found that some children thought earthquakes were found in hot countries. In the next section, more studies related to students’ beliefs about earthquakes and their locations will be summarized.

Philips (1991) examined a list of over 50 earth science misconceptions among K-12 students, college students, and adults. Results indicated that adults and college students held the idea that “Chicago could not be severely damaged by an earthquake in the near future.” However throughout history severe earthquakes have occurred in Chicago. Similarly, Schoon (1989, 1992, 1995), in a wide-ranging study conducted in the United States involving over 1200 undergraduates and school children aged 5-18, found that 36% thought Chicago was unlikely to be affected by an earthquake. In addition, 15.4% believed that earthquakes can be accurately predicted by observing the behavior of wild animals, though there is no scientific study to support this. Collectively, based on
the results of studies on earthquakes, Table 2.5 summarizes students’ views about earthquakes.

<table>
<thead>
<tr>
<th>Students’ Existing Knowledge</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earthquakes do not happen in the UK</td>
<td>Leather, 1987</td>
</tr>
<tr>
<td>Earthquakes do not happen in Chicago</td>
<td>Philips, 1991; Schoon, 1992</td>
</tr>
<tr>
<td>Earthquakes occur in hot countries</td>
<td>Leather, 1987</td>
</tr>
<tr>
<td>Earthquakes occur when the sun heats Earth’s surface, causing cracks</td>
<td>Leather, 1987</td>
</tr>
<tr>
<td>Earthquakes occur when shaken by volcanoes</td>
<td>Ross &amp; Shuell, 1990,1993</td>
</tr>
<tr>
<td>Earthquakes are eruptions</td>
<td>Ross &amp; Shuell, 1993</td>
</tr>
<tr>
<td>Earthquakes are caused by hot climate</td>
<td>Leather, 1987; Ross &amp; Shuell, 1993 ; Sharp, Mackintosh &amp; Seedhouse, 1995</td>
</tr>
<tr>
<td>Earthquakes are caused by volcanic activity</td>
<td>Leather, 1987; Marques &amp; Thompson, 1997; Ross &amp; Shuell, 1990, 1993; Sharp, Mackintosh &amp; Seedhouse, 1995</td>
</tr>
<tr>
<td>Earthquakes are shaking/trembling of the earth or ground</td>
<td>Barrow &amp; Haskins, 1996; Ross &amp; Shuell, 1990, 1993</td>
</tr>
<tr>
<td>Heat from the sun, thunder, rain, wind, and mountains cause earthquakes</td>
<td>Ross &amp; Shuell, 1990, 1993</td>
</tr>
<tr>
<td>Earthquakes can be accurately predicted by observing the behavior of the wild animals</td>
<td>Schoon, 1989,1992,1995</td>
</tr>
</tbody>
</table>

Table 2.5: Students’ Existing Knowledge about Earthquakes.
Origins of Students’ Beliefs about Earthquakes

Possible origins for the beliefs in earth science topics (e.g., earthquakes, rocks, volcanoes, earth’s structure, landforms, weathering, erosion, soil) are founded on various pedagogical practices, such as the imprecise use of language, oversimplification of concepts, use of rote learning, and stereotyping of landforms, as well as on the inadequate use of prerequisite knowledge of students and the abstract nature of some of the subject matter in earth science (Dove, 1998).

In a regional study, Cavalcante (2002) focused on the experiences and views of primary teachers’ thoughts on earthquakes after the 1986 earthquake series in Joao Camara, Brazil. The study examined the teachers’ experiences and their use of a particular teaching/learning methodology based on Paulo Freire’s principles of problem-posing education. Data derived from the interviews were discussed from two perspectives: 1) understanding the implications of the job of education in conceptual change; and 2) the concept of earthquakes that is addressed within conceptual change. According to the study, teachers’ conceptions of earthquakes show that they do not differ much from the conceptions of the students and the conceptions of general population in the area.

In the same way, Schoon (1995) suggested that many misconceptions originate in the classroom and that pre-service elementary education teachers have many of the same misconceptions that their future students will have. Despite their scientific knowledge, when they were faced with the unknown, these teachers used commonsense.
In the next section, the techniques that have been used to determine students’ existing knowledge will be discussed.

Section D: Students’ Existing Knowledge

A considerable volume of research in the last two decades has been generated on students’ understanding of concepts in science. These studies have revealed that students’ conceptions often conflict with scientific thinking (Wandersee, Mintzse, & Novak, 1994). These conceptions have been variously referred to as “misconceptions” (Novak, 1988), “children’s science” (Osborne, Bell, & Gilbert, 1983), “alternative frameworks” (Driver and Easley, 1978), “preconceptions” (Osborne and Freyberg, 1985), “untutored beliefs” (Hills, 1989), “intuitive notions” (Bar, 1989), “alternative conceptions” (Atwood and Atwood, 1996, Hewson, 1981), and “ideas” (Kuiper, 1994). Although all of these studies were designed to determine students’ conceptions that conflict with scientific thinking, there are some differences. For instance, the term “misconception” has tended to be used when students generate incorrect knowledge after formal instruction (Driver and Easley, 1978), whereas “preconception” referred to any knowledge acquired before formal instruction. Abimbola (1988) has also categorized all these terms into two groups. The first category includes the kinds of knowledge that the researchers consider as “wrong” knowledge like misconceptions, misunderstanding, and erroneous ideas. The second category includes those kinds of knowledge that the researchers believe arrived from non-formal settings such as superstitions, and folk beliefs. Collectively, what may be missing is a complementary term rather than mutually exclusive ones.

In this study, the term “Students’ Existing Knowledge” (Sutton, 1980) is used, because this research has given more attention to the content of the learner’s thought,
whether gained from formal instruction or from everyday activities. The important thing is what’s already known. In the literature, many studies were found concerning the approach of teachers who try to discover what students already know, (e.g., Erickson & Tiberghien, 1993; Klein, 1982; Nussbaum & Novak, 1976) because this helps teachers to find ways of connecting new knowledge to old.

This section reviews the earlier studies on concept formation, especially from Vygotsky’s and Piaget’s perspectives, the discussion of their studies related to conceptualizations, and finally, experimental methods that attempt to examine the already-formed concepts of students.

**Earlier Studies on Children’s Concept Formation**

Early studies on children’s concept formation can be examined in two groups. The first group is the definition method that examined the already formed concepts of children. However, examining an already finished product of concept formation and studying the corresponding concept separately made this method inadequate for studying the process of concept formation in depth.

The second traditional method was group comparisons. The child was required to discover some common trait in a series of discrete impressions, abstracting it from all the other traits with which it was perceptually fused. The role of language in concept formation was again ignored in this method. Further, this clinical method isolated children from their everyday life (Sakharov, 1994).

In addition to explaining these earlier methods, a review of some experiments that facilitated further studies on concept formation can be useful. For instance, Ach (1921, as
cited in Vygotsky, 1986) showed that concept formation was a creative, not a mechanical passive process. Concept formation covers a complex operation that aims at problem solving. In his view, the decisive factor in concept formation is determining tendency. He demonstrated that children differ from adults not in the way they comprehend the aim, but in the way, their minds work to achieve it. In contrast, Dmitri Usnadze’s (1929, as cited in Vygotsky, 1986) studies showed that preschool children’s method of approaching a problem was the same as adults, but they approach the solution in a naïve way. Moreover, Usnadze claimed that words took over the function of concepts in a child’s mind and might serve as a means of communication long before they reached the level of concepts characteristic of fully developed thought. Researchers concluded that a child grasps a problem, and visualizes the goal at early ages, because the tasks of understanding and communication are essentially similar for the child and the adult.

*Studies on Children’s Concept Formation: Vygotsky’s Perspective*

As with many other researchers, the lack of an experimental method on concept formation was also a handicap for Vygotsky to observe the inner dynamics of the process (Vygotsky, 1986). In a series of investigations on the process of concept formation, Vygotsky explored concept formation beginning in earliest childhood. Vygotsky’s experimental studies proved concept formation is a complex activity that covers all basic intellectual functions such as attention, selecting distinctive features, analyzing and synthesizing. Moreover, from Vygotsky’s perspective, language and other tools facilitate solving a problem by giving direction through our mental functions.
Real concepts are impossible without words, and thinking in concepts does not exist beyond verbal thinking. That is why the central moment in concept formation, and its generative cause, is a specific use of words as a functional “tool” (Vygotsky, 1986, p. 107).

In terms of sociohistorical theory, the developmental mechanism of concept formation cannot be explained solely based on a cultural task per se. The goal should be to understand the intrinsic bonds between an external task and the developmental dynamics, and to view concept formation as a function of the adolescent’s total social and cultural growth, which affects not only the content but also the thinking process (Vygotsky, 1994). Vygotsky (1986) explained concept formation in three basic stages and several substages (see Table 2.6). These stages will be examined next.

<table>
<thead>
<tr>
<th>Syncretic heap</th>
<th>Complex thinking</th>
<th>Abstraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial-and error</td>
<td>Associative type</td>
<td>Maximally similar grouping</td>
</tr>
<tr>
<td>Visual field</td>
<td>Collections</td>
<td>Potential concepts</td>
</tr>
<tr>
<td>Incoherent coherence</td>
<td>Chain complex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diffuse complex</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pseudoconcept</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.6: Concept Formation: Vygotsky’s Perspective

*Syncretic Heap.* In the first stage, children tend to merge the most diverse elements into one by perception, thinking and acting. Children put together a number of
objects without any basis. The stage is called “syncretic heap”, because in this early age many words have the same meaning in children’s minds. The first stage of concept formation has three distinct substages. The first one is “trial-and error”. Objects are added to the group by guess or trial. Children replace the object when the guess is proven wrong by an adult’s confirmation. During the next substage, known as “organization of the child’s visual field”, the composition of the group is determined largely by the spatial position of the objects. The syncretic image or group is formed as a result of the child’s immediate perception. In the last substage “incoherent coherence”, syncretic images become more complex and there are no intrinsic bonds between the objects.

*Complex Thinking.* The second stage of concept formation, which includes many different types of thinking is called “thinking in complexes”. In this stage children try to unify objects with real concepts although the unifying does not reflect the relations between things in the same way as real conceptual thinking. In his investigation, Vygotsky observed five types of complexes during the development of this stage. The first one is called “associative type”. In this substage, children bring together the objects in terms of their color, size, or other attribute. The second type of complex thinking is “collections”. Objects are placed together on the basis of some one trait in which they differ and consequently complement one another, such as, a group of blocks each of a different color. After the “collections” substage, a “chain complex” substage took place from the results of Vygotsky’s experiments. He used a yellow triangle as an experimental sample. The child picked out a few triangular blocks until the blue blocks of any shape caught his attention, such as angular, circular, semicircular. This in turn was sufficient to change the criterion again, obviously of color. Then the child began to choose rounded
blocks. The decisive attribute kept changing during the entire process. Researchers could not find any consistency in this type of link. This chain formation enabled the researcher to grasp the essential difference between complexes and concepts. In a complex, no hierarchical organization of the relations was found.

The fourth type of complex thinking was called “diffuse complex” by Vygotsky. Diffuse complex means indefinite or limitless, like multiplying forever or like the stars in the sky or the sands of the sea. In Vygotsky’s experiment, when a yellow triangle was given to the child, he picked out trapezoids as well as triangles, because according to Vygotsky trapezoids made the child think of triangles with their tops cut off. Trapezoids lead the child to squares, squares to hexagons, hexagons to semicircles, and finally circles.

The fifth type of complex thinking called “pseudoconcept”, involves a generalization formed of the concept in the children’s mind that is very different from the real concept. To find a borderline separating a pseudoconcept from a real concept is not easy because they look alike as a whale looks like a fish. Therefore, a conflict occurs between the child and an adult. This moment of mutual understanding plays a decisive role in turning words into concepts. Vygotsky claimed that verbal communication with adults thus becomes a powerful factor in the development of the child’s concepts. The pseudoconcepts served as a connecting link between thinking in complexes and thinking in concepts. In Vygotsky’s words “…the child begins to operate with concepts, to practice conceptual thinking, before he is clearly aware of the nature of these operations. The concept-in-itself and the concept-for-others are developed in the child earlier than the concept-for-myself” (Vygotsky, 1986, p. 124).
Abstraction. This stage is more than unification. To form such a concept the child has to abstract, to separate the elements, and to view the abstracted elements apart from the earlier concrete experiences. This stage is also subdivided into several stages. The first step toward abstraction is “maximally similar grouping”, such as objects that are small and round, or red and flat. During the next stage of abstraction the grouping of objects based on the maximum similarity is turned to grouping on the basis of a single attribute, e.g., only round objects or only flat ones. These substages were called “potential concepts”. This kind of abstraction that combines with advanced complex thinking enables children to progress to the formation of genuine concepts. Vygotsky argued that even though adults have learned to produce concepts, solving daily problems does not advance beyond the level of pseudoconcepts. In all stages, the use of the word is an integral part of the developing process, and the word maintains its guiding function in the formation of genuine concepts.

Studies on Children’s Concept Formation: Piaget’s Perspective

In the first half of the 20th century, behaviorism was the dominant learning theory in education. During the last 20 or so years since the introduction of Piagetian ideas of learning, educators and cognitive/developmental psychologists have been working in parallel trying to understand how initial concepts about the physical world develop and how they change as students are exposed to the teaching.

Piaget’s original training in biology influenced his views about knowledge construction in that he drew on analogies to adaptation of living beings to their environment. This may seem obvious in his distinction between assimilation and
accommodation and the idea of equilibration. Assimilation is the process of the 
incorporating of new information into an already existing cognitive structure. On the 
other hand, accommodation is adjusting of these concepts to new information. 
Assimilation and accommodation are always intimately interrelated. If the inputs do not 
fit then a cognitive conflict occurs, which Piaget calls this equilibrium.

Siegler (1998) explained that equilibration is a mechanism that Piaget proposed to 
explain how children shift from one stage of thought to the next. The shift occurs as 
children experience cognitive conflict or disequilibrium in trying to understand the world. 
Eventually, they resolve the conflict and reach equilibrium of thought.

For example, newborns reflexively suck everything that touches their lips. By 
sucking different objects, infants learn about the nature of these objects, such as their 
taste, texture, and shape. This is assimilation. After several months of experience, they 
construct their understanding of the world differently. Some objects, such as fingers and 
the mother’s breast, can be sucked, and others, such as fuzzy blankets, should not. This is 
accommodation. Piaget sees this as the “contraction of a scheme” (von Glasersfeld, 1991, 
p. 291) which, like all schemes, consists of three parts:

1. recognition of a certain situation (e.g., the presence of an object);
2. association of a specific activity with that kind of item (e.g., tasting);
3. expectation of a certain results (e.g., sucking milk).

During the sensory-motor level, the child’s construction of a scheme will come to 
involve a large variety of objects. There will be cups and spoons, building blocks and 
pencils, rag dolls and teddy bears. All these objects are seen, manipulated, and become 
familiar as components of diverse action schemes. But there may be also kittens and
perhaps a dog. Though the child may at first approach these items with action schemes that assimilate them to teddy bears, their unexpected reactions will quickly cause novel kinds of inevitable accommodation. The child realizes that these new entities radically differ from the other familiar objects. The child’s interactions with kittens or dogs introduces the properties of the ability to move on their own, the ability to see and to hear, and eventually also the ability to feel pain. These properties help the child to construct reliable schemes (von Glasersfeld, 1991). More details on action schemes will be presented in the next chapter.

*Discussion of Vygotsky’s and Piaget’s Perspectives of Children’s Concept Formation*

The problem of how new concepts, in general, are formulated and how they relate to existing concepts has interested researchers for years. Understanding student development of scientific concepts is necessary to prepare successful instruction for their systematic knowledge. Piaget’s studies on child concepts led to some important questions for Vygotsky. Piaget grouped a child’s concepts into spontaneous and nonspontaneous. Spontaneous referred to a child’s ideas of reality developed mainly through his own mental efforts, and nonspontaneous referred to those that were decisively influenced by adults. Piaget found that both spontaneous and nonspontaneous concepts have deep roots in the child’s thinking and both of them resist suggestion (Confrey, 1995).

According to Vygotsky three major problems exist with the study (Vygotsky, 1986). First, Piaget believed that spontaneous concepts alone could enable us to understand the quality of the child’s thought. However, he mentioned nothing about the development of nonspontaneous concepts. The second error was an extension of the first
one. Even though Piaget attempted to present spontaneous and nonspontaneous concepts differently, he failed to see the interaction between these two types of concepts and bond them into a total system. The final error was that if Piaget’s views on the nature of nonspontaneous concepts are correct, then the socialization of thought such as school learning was unrelated to the inner development processes. According to Vygotsky, the idea conflicted with Piaget’s theory that claimed progressive socialization of thinking is the very essence of the child’s development.

In contrast, Hooper (1968) said that four independent factors in Piaget’s research shaped education: maturation, experience, social transmission, and equilibration. As children experience these factors, they develop concepts about the world. Hooper provided three points of contact between Piagetian studies and education: first, when a certain content or subject area should be taught; second, what content-subject matter is most important, and the third; how it may be best presented to the student.

Collectively, Piaget’s works are basically about the development of intelligence in children. Piaget’s theory has two aspects. First, it is a theory of intelligence: Piaget believes that the development of intelligence consists in the development of an ability to perform logical operations (Piaget, 1957). Second, Piaget claims that as children grow older certain specific groups of logical operations develop in the average child at given ages (Piaget, 1963).

The notion that the nature of intelligence lies in the performance of logical operations is not new in psychology. For example, Spearman’s (1923, as cited in Sigel, 1968) and Moore (1929, as cited in Sigel, 1968) focused on the intelligence with its relations to education and Von Domarus (1944, as cited in Sigel, 1968) attempted to
describe logical models for schizophrenic thinking. In contrast, Piaget’s theory of intelligence is different from those previous studies, because he aims to give description of the development of intelligence. Even though some of his ideas have been questioned, his contribution to educational research is undeniable (Kuhn, 1997).

*Research Methods for Students’ Existing Knowledge: Practical Consequences*

During the past decade there has been a growing interest among educators as well as many cognitive psychologists in students’ existing knowledge on several different topics. A rapidly growing body of research reveals that students come to classrooms with specific notions about the content of instruction. Therefore, the growing interest in developing curricula is to facilitate conceptual change (e.g., Hewson & Hewson, 1988; Hewson & Thorney, 1989; Posner, Hewson, & Gertzog, 1982). However, there are still some problems in terms of data gathering about students’ conceptions. Driver and Ericson (1983) summarized these problems as follows:

…[U]ntil recently little systematic attention has been directed toward the notion that pupils do possess “invented ideas”…[E]ducators in a number of subject areas have been utilizing various techniques in an effort to capture some aspects of these ideas. This diversity of approaches has, as might be expected, created a proliferation of terms, techniques, and supporting theoretical rationales for describing pupils’ cognitive commitments. The net results of this situation are: considerable confusion over the types of commitments which should be identified and described, a debate over appropriate data gathering and data analysis techniques, and difficulties in extending or even replication of existing studies (1983, p.2).

In addition, in spite of the concentrated research efforts on students’ existing knowledge, Hashweh (1988) claimed that many studies are still characterized by a misfit between the purpose of the study and the methodology used in the study, by diagnosis
and conceptualization problems, and by validation problems. The researcher differentiates the studies in students’ conceptions into three groups: descriptive studies, explanatory studies, and studies that “test” the explanatory studies. According to the author, descriptive studies should aim to identify and describe student preconceptions. Explanatory studies should aim to explain conceptual stability and change. And the last group of studies should test the explanations offered by the second kind of research, explanatory studies. Hashweh also identified the need for a formal validation phase of research in which the researcher puts his or her theory to the test. The author continued to say that this will enable researchers to predict the students’ performance on another set of tasks and tests these predictions.

Similarly, Selman, Krupa, Stone, & Jaquette (1982), suggested two stages of research: an explanatory one aiming at identifying patterns of responses, and a validation stage that uses cross-sectional samples or longitudinal studies of cross-sectional samples to determine whether the patterns or explanations can be found again. In exploring the link between students’ scientific and nonscientific conceptions, Palmer (1999) has also agreed on the importance of being systematic for obtaining students’ knowledge fragments.

In parallel to that, Osborne and Gilbert (1980) have also mentioned the importance of being systematic for investigating students’ understanding of the concept. The researcher developed a method called “Interview about Instance” (I.A.I.) (p.312) which uses a set of approximately 20 cards for each concept, each card depicting an instance or non-instance of the concept under consideration. The student categorizes each instance and explains the basis on which the categorization has been made. The
Researchers concluded that the method would appear to have considerable potential, particularly because the method can lead researchers to make generalizations from those few instances, which happen to come to mind at that moment.

Collectively, all the studies provided a step toward developing a method of determining students’ existing knowledge. In the next part, methodological approaches that the researchers categorized will be examined.

Methodological Approaches to Determine Students’ Existing Knowledge

The initial state of children’s cognition has been tested in three main areas in science education: (a) misconceptions, preconceptions, and alternatives for science concepts that mostly emphasis analogy construction and conceptual change (Smith, diSessa, & Roschelle, 1993), (b) everyday versus scientific knowledge (Gilbert & Watts, 1983), and (c) understanding of the scientific enterprise (Klahr, 2000).

Before instruction, every teacher would like to quickly determine students’ existing knowledge to make connections to new one. Sutton (1980) discussed four different approaches: (a) clinical interviews with individual students, (b) word association or word-sorting tasks, (c) asking learners to write definitions and asking learners to choose preferred statements from several correct ones, and (d) tasks which involve bipolar dimensions on which an idea is rated. Sutton examined the theoretical assumptions underlying these approaches and considered how easily they could be adapted in the classroom as part a diagnostic approach to teaching.

The clinical interview method is a particularly promising research tool, especially during initial phases of research, due to the method’s flexibility. The method, however,
has problems associated with its subjectivity. Piaget (1972), the first to use the method for cognitive research, described the advantages of the method as well as the possible difficulty of using it. According to him one needs extensive practice in using it.

Solomon (1993) categorized studies on children’s knowledge about scientific matters into four basic themes:

1- *The ethnographic approach.* The main goal of this approach is to ask children to explain their ideas and then listen to their words in the verstehen tradition that is adopted from sociological perspectives by Gilbert and Watts (1983). Jean Piaget’s (1929) early work about young children’s ideas about an animistic nature inspired these sort of studies. This group of researchers commonly used the terms alternative frameworks (Driver and Easley, 1978), children’s science (Osborne, Bell, & Gilbert, 1983), misconceptions (Novak, 1988). The ethnographic line of research began with a simple descriptive objective with no clear purpose of determining what kind of action should be taken in the future. Therefore, the author Solomon claimed that the ethnographic approach does not easily generate a guide to the daily practice of teaching.

2- *Misconceptions.* In this frame, the research is more concentrated on the learning of school science than an ethnographic study. It examined the difficulties students have with particular topics, catalogue their mistakes, and may suggest remedial action. What is missing in this kind of research is exploration of mental representations of students’ ideas.
Cultural effects. This kind of study is concerned with the children’s ideas about science related to the social influences rather than school instruction. The researchers demonstrate the deep cultural significance of students’ prior conceptions (e.g., Rogoff, 1990; Wertsch, 1995). Solomon argued that this takes us far beyond the initial assertion that children have personal ideas of their own about scientific matters.

Mental representation. Even though the subject of research in this frame is children’s notions, the focus of interest has moved from the substance of these notions to the way in which they operate within the child’s mind. Mental representation has its roots in Piaget’s later studies. Piaget (1978) reflected upon two kinds of knowledge – “knowing how.” which is contextually bound pre-operational thought, and “knowing that,” which is propositional, formal thought. In this frame of research, concept mapping is one of the techniques used to show how an individual relates the meaning of one concept to that of another. Larkin, McDermott, Simon, and Simon (1980) carried this work further by observing how recognition of patterns often evokes from memory stored information about actions and strategies that may be appropriate in the context in which the pattern is present. Solomon (1993) states that “cognitive psychology should be able to provide valuable insights into how prior notions of children interact with new knowledge in this research perspective” (p. 12).
Regardless of the techniques used to determine children’s existing knowledge, the researchers classify the data after collection. These classifications form the foundation of systemic network (e.g., Mariani & Ogborn 1990, 1995). Ideally, a systemic network would provide a set of diagnostic procedures to use at the beginning of any topic, to give teacher and students a better insight into the students’ thoughts.

Section E: Systemic Network

In educational studies, the network-like structure was first used by Bliss and Ogborn (1979) for analyzing qualitative data. They began to develop a system for handling data gathering from interview transcripts, free questionnaire responses, observational material, or documentary evidence. The goal was a structured pattern with interdependent options. In another words, the idea was simply to invent realization rules for the descriptive network. Bliss and Ogborn (1979) explained,

It is clear that the network describes, not the data, but an interpretation of the data for a purpose. Its paradigms are what analysts want to extract. For this reason, we found it useful… in which the analyst says what he sees (p.433).

Koulaidis and Ogborn (1988) used the systemic network as a basis for the construction of a questionnaire. They argued that systemic networks have potential value in questionnaire construction in such problematic areas, offering help in dealing with both construct reliability and validity. According to the researchers, there are two beneficial aspects in using systemic networks: (1) Researchers can observe the items from two perspectives – items that belong within others and items independent from
others; (2) an individual’s conceptual system can be located as a given set of choices in the network.

The aim of the questionnaire constructed by the systemic network is to ask respondents to agree or disagree with the main distinctions made in the network. Respondents are not forced into one such packaged opinion, but can reveal views that combine elements of prevailing opinions in unforeseen ways. Finally, the authors concluded that the use of systemic networks offers a form of assistance to our thinking.

**Piagetian Theory: The Role of Action in the Logic of Meaning**

The theoretical starting point of using a systemic network for measuring students’ common-sense reasoning (Mariani & Ogborn, 1990) has derived from previous studies in the psychogenesis and sociogenesis of knowledge by Piaget and Garcia (Piaget, 1972; Piaget & Garcia, 1991). Even though “meaning of meanings” has been discussed several times (e.g., McDonough, 1919; Ogden & Richards, 1936), the implications between actions and meanings was first discussed by Piaget and Garcia (1991). For these researchers, action and movement are the primitives for the first conceptualizations of childhood.

In his last book “Toward Logic of Meanings,” Jean Piaget collaborated with Rolando Garcia (1991) to open a new perspective on the logic of meaning. Basically, they responded both to current concerns with meaning and representation in psychology, and to a renewed interest in the issue of relevance in the area of contemporary logic.

Piaget characterized a theory of meaning in natural logic. Such logic could only be a logic of meaning where implications are not restricted to statements. From the
subject’s view, every action or operation is endowed with meaning. From Piaget’s perspective, a participant is first dealing with systems of implications among the meanings of actions, and then among the meaning of operations. The meaning of actions and the causality of actions are distinguished by the participant’s early inferences. The form of inference is the action implication, which creates the meaning of actions.

In his early works, Piaget studied the four fundamental categories of the psychogenesis – causality, object, time, and space (Piaget, 1929, 1957, 1963,1972, 1978). In these studies, he examined the categories by dividing them into two subgroups: (1) static (space, object), and (2) dynamic (time, causality) (see Figure 2.3).

![Figure 2.3: Piaget’s account of the development of fundamental categories (Mariani & Ogborn, 1990, p.52).](image)

Piaget sees cause arising out of action as the child tries to make a link between his action and its effect. In the study of meanings and implications in instrumental behavior, Piaget, de Caprona and Ritter (1991) described the formation of meanings and action implications in the behavior. They took up the classic study by W. Köhler (1927) with chimpanzees: the use of various objects as “instruments” to reach what the hand cannot.
Thus, the researchers aimed to observe children’s understanding of the relation of hitting or pushing with an instrument. This is referred to “what can be done” with an instrument. What they found about the first level is that young subjects need active explorations before they notice them. They concluded that meanings are attributes of actions to objects.

In a study concerning relations within an object, Piaget, Zunel and Merzaghi (1991) examined what the object concept involves from the viewpoints of meanings and action implications. They analyzed children’s reactions to randomly presented pieces of several puzzles. There were 23 variously shaped cards showing 13 parts of apples that can be assembled to form four complete red apples, with the two remaining green parts isolated, plus five double sided pieces forming an elephant inside a boa constrictor on one side and a hat on the other. Three pieces were not part of any puzzle. The instruction was simple: “Try to make something and tell me what it is.” With this study, the researchers showed that the two meanings of an object are, subjectively, “what can be done with it” and, objectively, “what it is made of or how it is composed.” The meanings of objects are thus subordinate to meanings of actions. What can be done mentally is to classify or seriate objects, and so on, which again subordinates them to meanings of actions or operations. The meaning of an object is also, “what it is made of” or “how it is composed” which is subordinate to actions.

Von Glaserfeld (1991) categorized the model of Piaget’s action scheme into three elements: (1) a recognized situation, (2) an activity that has been associated with this situation, and (3) an expected result. The recognition of a situation involves assimilation.
If the expected result does not occur, the formation of a new action scheme accommodation may occur. According to the author:

The fact that accommodation does not take place unless something unexpected happens, is important for any learning theory, and it relates Piaget’s scheme theory to the notion of the feedback-loop in control theory. There, too, certain activities are triggered when a perceived condition is not compatible with a given reference value (p. 286).

As a result, Piaget believes that at all levels of development there are implications between actions and meanings. For instance, fluids flow, solid things move from place to place, invisible influences cause changes. All his studies above allow a better understanding of the logic of actions and the various phenomena linked to an attribution of meanings in the child’s cognitive activity.

*A Look at Studies on Questionnaire Development by Using a Systemic Network*

Mariani and Ogborn (1990, 1991, and 1995) used a Piagetian structuralist and constructivist view as a starting point for their questionnaire development. In an exploratory study, Mariani and Ogborn (1990) looked at the basic ontology of things that are conserved in the common-sense reasoning of 14-17- year-old students. A questionnaire was given to 84 students in which they were asked to classify a list of different things into several ontologically different categories. The researchers identified three ways of thinking about things, as objects or causes, in terms of (a) what you can do to them, (b) what they are made of, and (c) what they make happen. The theoretical analysis from this study affirmed that there are two ways of thinking of something as conserved. The first is if something is “out of the reach of actions” (p.62). The second
way of thinking of something as conserved it is still possible to “identify the entity” (p.62) throughout all possible imagined actions performed on it.

Correspondingly, Mariani and Ogborn (1991) surveyed another 38 high school students’ common-sense reasoning by asking them to classify a list of different conceptual entities by several ontological features. They developed a questionnaire in which students are asked basic ontological questions about nine concepts. The concepts selected were matter, energy, time, space, movement, heat, light, sound, and force. The features related to these concepts were selected in terms of Piagetian theory. For instance, features concerning “what it is like” (its nature) included resembling kinds of substances (gas, fluid, solid, particles), and others concerned resembling cause, movement, or place (being immaterial, like a force, like a place, like wave, being only movement). The results suggest the form of a fundamental “ontological space” (p. 70) and locate some scientific concepts in this space.

In a later paper, Mariani and Ogborn (1995) compared two groups: 14-16-year-old secondary students and primary teachers in Britain. They were asked to classify events as having or not having several ontological features. The features again were chosen systematically using a systemic network categorizing features of events related to actions. The result of the analysis in both cases is an “ontological space” in which entities or events, and their features, can be related to a small number of interpretable dimensions. These dimensions are shown to be closely related to those previously found for entities.

In their study related to earth science, Boyes and Stanisstreet (1999) examined high school students’ perception of the ozone layer. Students’ ideas formed around the
ideas “what something is,” “what something does,” and “what can be done to something” which are the ontological frameworks of Piaget’s theory of development of meaning. The researchers concluded that students construct their knowledge of the ozone layers in ways similar to those in which they construct knowledge based on their experiences of the physical world.

Collectively, a systemic network organizes categories in relation to one another. When creating the instrument, the statement should be linked to features and paradigms. Any one entity will be assigned just one allowed combination. In the methodology chapter of this dissertation, designing a questionnaire by using a systemic network is presented in detail with an example under the title of “constructing the instrument.”

Summary

The central theme of the literature review was to look at studies on earthquake education, and to examine techniques about identifying students’ existing knowledge. The review opened with the explanation of the following questions: (a) what are earthquakes?, (b) how do earthquakes happen?, (c) how can earthquakes affect other things (objects or living things)?, and (d) what can we do to protect ourselves from earthquakes? Then the review drew attention to earthquake content in Ohio’s and Turkey’s curriculum standards. The review showed that Ohio’s Earth and Space Science content standards suggest starting to teach about earthquakes in the 4th grade, and by 8th grade students start learning plate tectonics in depth. However, the earthquake education act in Turkey was very limited in schools, and the content was only about how to react in an earthquake.
The review of the studies related to students’ views about earthquakes examined five themes: (a) students’ views about earthquakes based on their experience, (b) students’ views about earthquakes and plate tectonics theory (c) students’ views about earthquakes and volcanoes (d) students’ views about earthquakes and weather conditions, and finally (d) students’ views about earthquake locations. The studies revealed that students tended to hold naïve beliefs about earthquakes. Since the plate tectonic theory has only 35 years of history, new studies are needed to examine the implications of the theory in schools.

The second theme of the literature review was the studies and research techniques for measuring students’ existing knowledge. First, the earlier studies on concept formation, especially from Vygotsky’s and Piaget’s perspectives were examined, and then the methodological approaches to measuring students’ knowledge were categorized. Collectively, all the studies provided a step toward developing a method of determining students’ knowledge. However, the lack of reliability of these instruments leads researchers to look for more effective techniques. Therefore, towards the end of the literature review, the systemic network approach was discussed theoretically, and questionnaire development using a systemic network was explained with related studies. In the methodology chapter of this dissertation, designing a questionnaire by using a systemic network is presented in detail with an example under the title of “constructing the instrument.”
CHAPTER 3

METHODOLOGY

This section provides a description of the research methodology and procedures used in this study, including the research design, instrument development, setting for the study, and data analysis procedures (both descriptive and inferential statistics). The section opens with a description of the research design.

Research Design

Identifying the Research Design and Labeling Variables

In this study, criterion-group design was used. A criterion group design provides a format for contrasting the characteristics of one state with those of its opposite (Tuckman, 1999). A criterion group is composed of people who display a certain characteristic that differentiates them from others. For example, in this study the research question number two “how do the views of earthquakes differ among the students who have experienced earthquakes with respect to who have not experienced earthquakes?” is a comparison of the concept of earthquakes between students who had experienced earthquakes and those who have not.
Independent variables were selected as students who have experienced earthquakes and students who have not, and students who have formal instruction on earthquakes and students who have not. Age, gender, and the geographic area are the control variables and the task performance is the dependent variable. The summary of variables is shown in Table 3.1.

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Dependent variable</th>
<th>Control variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Students who have experienced earthquakes/students who have not experienced earthquakes</td>
<td>- Students’ instrument score</td>
<td>- Gender</td>
</tr>
<tr>
<td>- Students who have formal instruction about earthquakes/students who have no formal instruction about earthquakes</td>
<td></td>
<td>- Age</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Geographic area</td>
</tr>
</tbody>
</table>

Table 3.1: The summary of independent, dependent, and control variables of the study.

Instrument Development

This study proposed to use a questionnaire to measure what someone knows, what someone believes or what experiences have taken place in a person’s life. Interviews may also be a beneficial investigative tool for this kind of research. However, the main purpose of this study was to determine students’ common patterns of understanding of
earthquakes. Explaining this pattern by interviewing limited number of subjects with limited questions would be very difficult.

In the next part, the development of the questionnaire in terms of the theoretical background is followed with an outline of the questionnaire in detail.

*Theoretical Framework: Thinking About the Physical World through Actions*

One of the outstanding problems in teaching is the difficulty of deciding on an adequate starting point for teaching a concept. Determining a student’s existing knowledge might help teachers to decide where to start teaching. However, how are we going to measure a student’s existing knowledge? The answer is simple, just by asking! But asking what kind of questions?

This study uses a systemic network approach for handling these problems. This method is an effective starting point to understand students' ideas, because systemic networks are interested in description and representation of meaning. Students’ ideas may have value for those of us who wish to be able to say what an examination question is for, or what a teacher intends by a question.

A systemic network is a notion, not a theory or a methodology (Bliss, Monk, & Ogborn, 1983). Sometimes a good notion provides very important thoughts. The notion has been employed in educational research in many ways (e.g., Bliss & Ogborn, 1979; Bliss, Monk, & Ogborn, 1983; Boyes, & Stanisstreet, 1994). If we assume a network is a structure of possibilities (Bliss & Ogborn, 1979), it allows certain possible choices, which is called a paradigm (p. 430) of that network. Koulaidis and Ogborn (1988) argued that a network could provide an intelligible and well-founded structure against which to
evaluate items in the questionnaire and with which to assess the questionnaire as a whole. In this study, systemic network was an approach that categorizes the questionnaire items into features by linking these features to the structures of possible paradigms.

To link the network, the researcher also modified the theory of the development of logic of meaning through actions (Piaget & Garcia, 1991) in order to connect the networks. The theory showed the structures of possible paradigms of my questionnaire, which allowed me to link the network into interdependent combinations of items. As a result, in this study, a systemic network provided a framework for developing the questionnaire and the Piagetian sense of the ways of thinking through action offers a method for selecting the paradigms for the questionnaire. Move, relocate, attach, fasten, secure, tie down, anchor, replace, remove, change, eliminate, and run are the some of the action verbs that were used for designing the questionnaire.

The Questionnaire

A questionnaire, rather than an interview, was chosen in this study, because the interest lies mainly in relations between patterns of answers, not the answers themselves. Furthermore, something that is common to groups of people is not much affected by individual differences (Mariani & Ogborn, 1990). The theoretical starting points of the study which have already been discussed, which derived from two aspects. First, a Piagetian structuralist and constructivist view of the three aspects of meaning: what something is, what it can make happen, and what something is made of. And second, systemic network approaches, which organize features in relation to one another.
In this study, earthquakes have been chosen as the subject because, despite many efforts to publicize global environmental issues and implement initiatives, there are very limited studies that describe the meaning of issues. In addition, this concept was chosen because of the large influence that earthquakes have on human life in Turkey. The network was then used to guide the selection of items for a questionnaire examining the ontological features of earthquakes, extrapolated from Piagetian theory. From this, the four questions emerge: (a) what are earthquakes?, (b) how do earthquakes happen?, (c) how can earthquakes affect other things (objects or living things)?, and (d) what can we do to protect ourselves from earthquakes? (See Figure 3.1).

For “What are earthquakes?” I took Piaget’s general idea of thought about reality, time, object, and cause, which can be constructed from action and movement. Then, the fundamental categories of the first phenomena are organized under the features of movement, kind, and belief. For instance, the questionnaire item “Earthquakes are an eruption” is under the features of movement, “Earthquakes are a kind of tornadoes” is under the features of kind, and “Earthquakes are disasters that happen only at night” is under the features of belief.

Other features of “How do earthquakes happen?” came from the aspects of earthquake can be caused by atmospheric conditions, earth movements, and manmade. For instance, the questionnaire item “Earthquakes are caused by foggy weather ” is under the features of atmospheric condition, while “Earthquake are caused by the release of energy stored in rocks” is under the features of earth movement, and “Earthquakes are caused by toxic waste” is under the features of manmade.
For the feature “How can earthquakes affect other things (objects or living things)?” the entities of objects and living things were used. For instance, in the questionnaire, the item “Earthquakes can push the houses into the soil” is under the features of objects, and “Earthquakes can make people have trouble walking” is under the features of living things.

The last feature “What can we do to protect ourselves from earthquakes?” can be categorized under the three main entities before earthquakes, during earthquakes, and immediately after earthquakes. For instance, in the questionnaire, the item “Before earthquakes we should build earthquake-resistant wood frame houses” is under the features of before earthquakes, “During earthquakes we should get near the window” is under the features of during earthquakes, and “Immediately after earthquakes we should wear shoes and gloves” is under the features of immediately after earthquakes. For more examples, please look at Appendix A.

After constructing the systemic network, the items for each section were randomly sequenced for the questionnaire. Another section in the questionnaire focused on basic demographic characteristics of the participants, including gender, grade, age and questions about whether the students have experienced earthquakes and whether they have received instructions about earthquakes (See Appendix B).

The instrument consists of 60 author developed items. The questionnaire items were derived from earlier studies on earthquakes (Barrow & Haskin, 1996; Hodder, 2001; Ross & Schuell, 1990; Wallace, 1995; Wampler, 2002) and scientifically accurate phrases, generated from a nationally recognized curriculum on earthquakes for students in grades K-6 (Callister, Coplestone, Consuegra, Stroud, & Yasso, 2002) and for
Figure 3.1: The network for the questionnaire.
students in grades 7-12 (Beven, Crowder, Dodds, Vance, Marran, Morse, Sharp, & Sproull, 1995). Items for the questionnaire also included common ideas that students had raised in the interviews in Ross and Schuell’s (1993) study. The students’ journals that were published in the Turkey Research Center web page (2001) were also included in creating the items. Students wrote these journals after the August 17, 1999 earthquakes that killed 18,000 people in Yalova, Izmit, Golcuk, and Adapazari. The children’s essay gave an idea of their perspectives, thoughts and knowledge about earthquakes.

All questionnaire items were initially evaluated for scientific accuracy by two geology professors, one from The Ohio State University and one from The Istanbul Technical University. Another professor who has been teaching environmental education classes for more than 25 years at The Ohio State University also reviewed the items. Then, two professors, one from science education and one from elementary education at The Ohio State University, evaluated the questionnaire. Finally, the questionnaire was examined by four teachers from each country and by a science editor. Suggestions from all individuals and the results of pilot studies in Winter 2005 were incorporated into the questionnaire. The questionnaire was translated into Turkish and the translation reviewed for accuracy by a committee of experts at The Dokuz Eylul University.

Setting for This Study

Participants

The questionnaire was issued to 823 students 5th through 8th grade ages 11-16. Participants in the sample were chosen from two different cities. One was Aydin, Turkey,
which is located a in high-risk earthquake zone. And for comparing the differences, the other one was Columbus/OH, which is located in a non-risk earthquakes zone.

The other general difference between the participants is whether they have received earthquake instruction in schools. Ohio’s Earth and Space Science content standards suggest starting to teach about earthquakes in 4th grade. In this grade, earthquakes are described as rapid processes that change Earth’s surface. Later, especially in 8th grade, students start learning plate tectonics in depth (Ohio Department of Education, 2002). However, in Turkey, teaching about earthquakes was limited to some safety drills.

The researcher selected a stratified sampling procedure, because this sampling method permitted researchers to select participants in turns of the research interest and to control for internal validity related to selection factors (Tuckman, 1999). The study compared whether there was a difference between students’ logic of thinking about earthquakes who had experienced one, either by actually being in one or being exposed to media reports about them, but have no formal instruction, and students who have formal instruction about earthquakes, regardless of whether they have experienced one. The study was restricted the population to 5th through 8th grades.

For selecting participants in Aydin/Turkey, the first step was writing the names of all middle schools from the cluster that was taken from Aydin Department of Education, and then drawing a random sample. After selecting the schools, the researcher contacted the principal. There were 871 students 5th through 8th grades in this randomly selected school. Since the goal was gathering around 500 completed instruments from each country, the researchers again randomly selected four periods from each grade level.
The sampling procedure for students in Columbus had some differences. First, several e-mails were sent to teachers and principals in Columbus Public Schools. Then, the researcher contacted teachers and principals who had responded to the e-mails. The questionnaire was eventually administered at five Columbus schools.

823 students participated to the study. 317 students were from Columbus and 506 students were from Aydin. In sum, 38.5% of students were from the USA and 61.5% of students were from Turkey. Table 3.2 shows the sample population by country, grade level, and gender.

<table>
<thead>
<tr>
<th>Country</th>
<th>Grade Level</th>
<th>Gender Female/Male</th>
<th>Total</th>
<th>Percent Female/Male</th>
<th>Percent Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>Grade 5</td>
<td>52/36</td>
<td>88</td>
<td>59.1/40.9</td>
<td>27.8</td>
</tr>
<tr>
<td></td>
<td>Grade 6</td>
<td>60/47</td>
<td>107</td>
<td>56.1/43.9</td>
<td>33.8</td>
</tr>
<tr>
<td></td>
<td>Grade 7</td>
<td>32/21</td>
<td>53</td>
<td>60.4/39.6</td>
<td>16.7</td>
</tr>
<tr>
<td></td>
<td>Grade 8</td>
<td>35/34</td>
<td>69</td>
<td>50.7/49.3</td>
<td>21.8</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>179/138</td>
<td>317</td>
<td>56.5/43.5</td>
<td>100</td>
</tr>
<tr>
<td>TURKEY</td>
<td>Grade 5</td>
<td>61/62</td>
<td>123</td>
<td>49.6/50.4</td>
<td>24.3</td>
</tr>
<tr>
<td></td>
<td>Grade 6</td>
<td>60/66</td>
<td>126</td>
<td>47.6/52.4</td>
<td>24.9</td>
</tr>
<tr>
<td></td>
<td>Grade 7</td>
<td>54/68</td>
<td>122</td>
<td>44.3/55.7</td>
<td>24.1</td>
</tr>
<tr>
<td></td>
<td>Grade 8</td>
<td>62/73</td>
<td>135</td>
<td>45.9/54.1</td>
<td>26.7</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>237/269</td>
<td>506</td>
<td>46.8/53.2</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 3.2: The number of students by country, grade levels, and gender.
Table 3.3 shows the number of students, by country and grade level, who did/did not experience earthquakes and who had/had not formal instruction about earthquakes.

<table>
<thead>
<tr>
<th>Country</th>
<th>Grade Level</th>
<th>Experienced Earthquakes</th>
<th>Not Experienced Earthquakes</th>
<th>Have Formal Instruction about Earthquakes</th>
<th>Have no Formal Instruction about Earthquakes</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>Grade 5</td>
<td>2/2.3</td>
<td>86/97.7</td>
<td>83/94.3</td>
<td>5/5.7</td>
</tr>
<tr>
<td></td>
<td>Grade 6</td>
<td>2/1.9</td>
<td>105/98.1</td>
<td>99/92.5</td>
<td>8/7.5</td>
</tr>
<tr>
<td></td>
<td>Grade 7</td>
<td>3/5.7</td>
<td>50/94.3</td>
<td>40/75.5</td>
<td>13/24.5</td>
</tr>
<tr>
<td></td>
<td>Grade 8</td>
<td>7/10.1</td>
<td>62/89.9</td>
<td>69/100</td>
<td>0/0</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>14/4.4</td>
<td>303/95.6</td>
<td>291/91.8</td>
<td>26/8.2</td>
</tr>
</tbody>
</table>

| TURKEY  | Grade 5     | 96/78.0                  | 27/22.0                     | 88/71.5                                  | 35/28.5                                     |
|         | Grade 6     | 101/80.2                 | 25/19.8                     | 0/0                                      | 126/100                                     |
|         | Grade 7     | 97/79.5                  | 25/19.8                     | 0/0                                      | 122/100                                     |
|         | Grade 8     | 114/84.4                 | 21/15.6                     | 0/0                                      | 135/100                                     |
| TOTAL   |             | 408/80.6                 | 98/19.4                     | 88/17.4                                  | 418/82.2                                    |

Table 3.3: Comparison of the sample population who had or had not experienced earthquakes and had or had not received formal instruction about earthquakes, by country and grade levels.
80.6% of participants had experienced earthquakes in Aydin, while only 4.4% of participants had experienced one in Columbus. Possibly the small number of students who had experienced earthquakes moved to Columbus from high-risk earthquake zones such as California, Japan, and India. 91.8% of participants in Columbus had formal instruction about earthquakes, while only 17.8% of participants in Aydin had formal instruction about earthquakes. The participants who had formal instruction in Aydin were all 5th grade level, because the earthquakes education act in Turkey had recently started with elementary schools and the content is about protection from earthquakes (BU-KRDAE, 2000).

Data collection

The researcher administered the pencil and paper questionnaire. Completing the instrument took 20 minutes or less. The researcher gave the instrument during a non-instructional period. Before administering the questionnaire, the researcher explained the study to the students (See Appendix C). Then the demographic data section was completed as a class to avoid students’ being confused by any of the questions. There were no missing data in this study, because the researcher checked all the responses and asked students to complete any missing data.

The students were instructed to emphasize the following points prior to starting the test: no names should be put anywhere on the test paper; each question should be answered, even if the student was not sure of the response; if unsure of a word, the student should raise his or her hand and ask.
Students’ participation was entirely voluntary. Students’ grades were not affected by their decision to participate or not to participate in this study. The results of this study were not used to evaluate students’ behavior or performance. Even though the students could withdraw from the study at any time without consequences of any kind, none of the students quit the study. All the information collected from this study remained confidential and was used only for the purpose of the research. The researchers planned to share the results of the study through publication in academic journals and presentation at academic conferences. No names were put anywhere on the instrument paper. No reference was made in written and oral reports that could be linked to the students or to the school. At the end of the study, the raw data were destroyed.

Parent/guardian letters and consent forms both in English and in Turkish and the approval from Institutional Review Board (IRB) and the approval from Turkish Government Department of Education can be seen in Appendix D. Table 3.4 summarizes the timeline of the study.

<table>
<thead>
<tr>
<th>Dates</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr. 2005 – May 2005</td>
<td>Data Collection</td>
</tr>
</tbody>
</table>

Table 3.4: Timeline.
Data Analysis

Constructing the Instrument: Pilot Study

In the previous section the procedure for selecting the pool of potential items for the questionnaire was described. In this section, the procedure for selecting questionnaire items from this pool will be explained.

In autumn 2004 and winter 2005, several pilot studies were undertaken in Turkey and USA to determine survey item reliability and to refine the data collection protocol. The pilot data were subjected to item analysis using the Statistical Package for the Social Sciences (SPSS ver. 13.0 for MS Windows).

Coding and Checking the Data

The researcher coded categorical or nominal responses in terms of response count (Tuckman, 1999). For example, respondent’s gender was coded male as 1, female as 2. When the item represented a scale, each point on the scale was assigned a score. For example, the researcher assigned “disagree” a score of 1, “undecided” a score of 2, and “agree” a score of 3. Only three interval scales were used, because elementary and middle school level students did not effectively differentiate between strongly agree and agree, or strongly disagree and disagree (Gay & Airasian, 1996).

From the results of the first pilot study, there were some missing data. Then the researcher decided to use a motivational speech before giving participants the questionnaire and checked each entire questionnaire after the participants finished. This method succeeded, because the questionnaire was administered group by group and in each group, there were only about 26 students.
Item Analysis

Item analysis examines the responses on a test to judge the performance of each item (Tuckman, 1999). Through item analysis, items were revised to improve a test’s overall reliability.

This analysis yielded two kinds of information about each item:

1. **Difficulty index**, which is the percentage of test-takers who gave correct answers. A difficulty index between 50 and 75 is recommended.

2. **Discrimination index**, which is the difference between the percentage of high performers on the total test and low performers on the total test who correctly answered a specific item. A discrimination index above 20 is recommended (Tuckman, 1999).

Consider the data item “Earthquakes are caused by hot weather.” This item had a difficulty index of 63.4 and a discrimination index of 36.6, making it a good addition to the survey. In contrast, the item “Earthquakes are seismic waves” had a difficulty index of 27.3 and a discrimination index of 6.4. Because of the potential lack of reliability of this item, it was discarded and replaced by a new item. The item “During earthquakes we should get under something sturdy” had a difficulty index of 73.1 but the discrimination index was only 10.5. Thus, the item was replaced by “During earthquakes we should get under something sturdy like a table or desk”. The new item had a difficulty index of 70.3 and a discrimination index of 21.3, which made it a good addition to the instrument.
Test Reliability

Test reliability means that a test gives consistent measurement (Fowler, 2002). In this study, Cronbach’s (1984) Coefficient Alpha was used for measuring the test reliability, which Kline (2000) regards as the best index of internal consistency. The internal consistency of the final instrument was calculated after the items were modified. The results are an alpha coefficient of .800 for USA data and .797 for Turkish data (See Table 3.5).

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>Cronbach’s Alpha Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>.800</td>
</tr>
<tr>
<td>TURKEY</td>
<td>.797</td>
</tr>
</tbody>
</table>

Table 3.5: Cronbach’s alpha coefficients for each country: USA and Turkey.

The results are an alpha coefficient is generally increasing in 5th through 8th grades for both countries. Table 3.6 summarizes the results.

<table>
<thead>
<tr>
<th>Country</th>
<th>Grade levels</th>
<th>Cronbach’s Alpha Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>Grade 5</td>
<td>.742</td>
</tr>
<tr>
<td></td>
<td>Grade 6</td>
<td>.809</td>
</tr>
<tr>
<td></td>
<td>Grade 7</td>
<td>.767</td>
</tr>
<tr>
<td></td>
<td>Grade 8</td>
<td>.829</td>
</tr>
<tr>
<td>TURKEY</td>
<td>Grade 5</td>
<td>.775</td>
</tr>
<tr>
<td></td>
<td>Grade 6</td>
<td>.792</td>
</tr>
<tr>
<td></td>
<td>Grade 7</td>
<td>.782</td>
</tr>
<tr>
<td></td>
<td>Grade 8</td>
<td>.810</td>
</tr>
</tbody>
</table>

Table 3.6: Cronbach’s alpha coefficients for each country and grade level.
Descriptive Statistics

Descriptive statistics are statistical procedures used to summarize, organize, and simplify data in preparation for performing inferential statistics. Some of the descriptive data have been already presented, such as the number of students in each country; grade levels and gender (See Table 3.2), and a comparison of the number of students who had or had not experienced earthquakes and had or had not received formal instruction about earthquakes by country and grade levels (See Table 3.3). In addition, the results chapter will present participants’ overall frequency distribution tables and graphs for each country and grade.

Inferential Statistics

Inferential statistics consist of techniques that allow researchers to study samples and then make generalizations about the populations from which they were selected (Gravetter & Wallnau, 2000). In the following, the analysis for each research question will be discussed.

Research Question. What are the students’ views about the nature of everyday practical thinking of earthquakes and what are the common patterns of their understanding about earthquakes?

Factor analysis was used to explore this question. Factor analysis consists of a number of statistical techniques, the aim of which is to simplify complex sets of data (Kline, 1993). In this study, the objective of factor analysis was to uncover and understand the structure that produces the correlations in the data. Exploratory factor analysis was used, because there have been no prior studies using this instrument, so the researcher has no prior idea of the number or the loading of factors.
Comprehensive Exploratory Factor Analysis (CEFA ver 2 for MS Windows) (a new exploratory factor analysis program) was employed in this research (Browne, Cudeck, Tateneni, & Mels, 2004). This program can fit the exploratory factor analysis model using several discrepancy functions as well as a noniterative PACE (conditional maximum likelihood using partitional method for estimation of unique variance) (Browne & Krishna, 1997), rotate the factor matrix according to several simplicity criteria, and obtain standard errors for rotated factor loadings (Browne & MacCallum, 2002).

Older software packages offer two types of principal factoring methods: principal factors with prior communality estimate, and iterative principal factors. However, CEFA is able use the partitioning method to estimate communalities and unique variance by using PACE instead of principal factors (MacCallum, 1983). This has the advantage that it is noniterative and also that Heywood cases (i.e., cases with communality bigger than 1 or unique variance smaller than 0) seldom occur.

The rest of the research questions were to examine the significant differences of students’ existing knowledge based on their life experiences and whether they had received formal instruction about earthquakes. The purpose of these research questions was to provide information about the relative position of two groups with respect to the questionnaire results, such as students who had experienced earthquakes with respect to the comparison group, and students who taken formal instruction in earthquakes with respect to the comparison group. The analysis of the second research question “How do the significant levels of perspectives differ among the students who have experienced earthquakes with respect to who have not experienced earthquakes?” will be explained as an example.
In this design, students’ questionnaire scores served as the dependent variables, and the students who have experienced earthquakes and students who have not experienced earthquakes serve as the independent variable. The model of ANOVA is:

\[ Y_{ij} = \mu_T + \alpha_i + \varepsilon_{ij} \]

where

- \( Y_{ij} \): one of the observations in the experiment,
- \( \mu_T \): the overall mean of the population,
- \( \alpha_i \): the treatment effect at level \( a_i \) (students who have experienced earthquakes or students who have not experienced earthquakes)
- \( \varepsilon_{ij} \): error component associated with each observation

The hypothesis associated with ANOVA is:

\[ H_0: \mu_{\text{experience}} = \mu_{\text{not experience}} \]

The assumptions underlying ANOVA are (1) interval/ratio scale for independent variable, (2) random sampling and random assignment, (3) independence of scores, (4) normally distributed treatment populations, and (5) homogeneity of variance (Keppel, 1991).

**Interval/ratio scale for independent variable.** In this study, each type of item was scored on a particular point scale. Students’ total scores are obtained by adding the points students get for each item. These characteristics of test scores indicated that dependent variable is measured on an interval scale (Moore, & McCabe, 1998). Therefore, this assumption is satisfied.

**Random sampling and random assignment.** Classes were selected randomly for Turkey data. Therefore, this assumption is satisfied for Turkish data but not USA data.
Independence of scores. In this design, this assumption was not satisfied because data were collected from the students in the same classrooms in which they might interact with each other.

Normally distributed treatment populations. In this study, because the sample size was large, the researcher assumed a normal distribution of participants.

Homogeneity of variance. This assumption can be tested by examining the group variance. Therefore, Levene’s test of equality of variance was applied for each analysis. The results will be presented on the next chapter (Moore, & McCabe, 1998).
CHAPTER 4

RESULTS

Consistent with the research questions, the results are presented in two parts. First, the chapter opens with a graphical description of each statement in the questionnaire, then the results of the significant differences of two countries students’ existing knowledge about earthquakes are provided based on their experiences and formal instruction on earthquakes.

In the second part, common-patterns of students thinking are presented based on the results of factor analysis. After each statement in the questionnaire was examined, factor analysis was used to provide generalizations. In short, the logic of the results perspective is framed around inductive through deductive application.

Part I: Comparison of Questionnaire Items by Country and Grade Levels

The data are shown graphically in order to show the features of systemic network structure in this study as follows: Figure 4.2 “What are earthquakes?”, Figure 4.3 “How do earthquakes happen?”, Figure 4.4 “How can earthquakes affect other things?” and Figure 4.5 “What can we do to protect ourselves from earthquakes?” The ordinate in each graph represents the percentage of students showing particular responses, and the
abscissa represents the grades 5 through 8 levels. On each graph the lower heavily shaded area corresponds to the percentage of students who disagreed with the statement; the next lightly shaded area corresponds to those who were undecided about the statements and the upper lightly shaded area to those who agreed with the statement. This enables one to compare the percentages of students’ responses on earthquakes in different countries and in different grade levels. Above each graph is a description of the statement and a number that corresponds to each statement. The significance of any differences between the two countries, the United States and Turkey, was tested by an independent samples t-test and is indicated by the number of asterisks in the heading of each statement (*p<0.05).

The significance of any grade level trend is indicated by the number of asterisks in the heading of each graph of the figure above the country names (***p<0.01, **p<0.05), and was tested using a Spearman correlation coefficient. The data analyses were done using the Statistical Package for the Social Sciences (SPSS version 13.0 for MS Windows).

An example of the calculation and the interpretation of the graphs are presented next for statement B2 “Earthquakes are caused by release of energy stored in rocks.” Figure 4.1 shows the percentage students’ particular responses of 5 through 8 in the United States and Turkey.
Figure 4.1: Graphs showing the percentages of student responses to statements concerning how earthquakes happen. Each graph is numbered according to the instrument. Significance in trend with country and grade levels is indicated by the asterisks. The ordinate represents the percentage of students showing particular responses; the abscissa represents the grades: 5, 6, 7, 8; the column represents the countries: US, Turkey. The coding is as follows:

- **Agree**
- **Undecided**
- **Disagree**

The numbers of United States and Turkish students who disagree with the idea are shown in Table 4.1. According to Table 4.1, 275 students disagree with the statement B2.

<table>
<thead>
<tr>
<th>DISAGREE</th>
<th>5th grade</th>
<th>6th grade</th>
<th>7th grade</th>
<th>8th grade</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>25</td>
<td>29</td>
<td>13</td>
<td>13</td>
<td>80</td>
</tr>
<tr>
<td>Turkey</td>
<td>36</td>
<td>43</td>
<td>43</td>
<td>34</td>
<td>156</td>
</tr>
<tr>
<td>TOTAL</td>
<td>61</td>
<td>72</td>
<td>56</td>
<td>47</td>
<td>236</td>
</tr>
</tbody>
</table>

Table 4.1: The number of the US and Turkish students who disagree with the statement B2.
For example, the calculation of the students’ percentage by countries and by grade levels is presented in Table 4.2. According to Table 4.2 only 10.59% of the United States 5th grade students disagree with the idea that “Earthquakes are caused by release of energy stored in rocks” whereas 15.25% of Turkish 5th grade students disagree. Similarly, 12.29% of the United States 6th grade students disagree with the idea that “Earthquakes are caused by release of energy stored in rocks” whereas 18.22% of Turkish 6th grade students disagree.

In Figure 4.1 the lower heavily shaded area corresponds to the percentage of students who disagreed with statement B2. According to the lower heavily shaded area, 33.90% of students in the United States disagree with the idea “Earthquakes are caused by release of energy stored in rocks” whereas 66.10% of students in Turkey disagree. In other words, more Turkish students disagree with the idea that “Earthquakes are caused by release of energy stored in rocks” than United States students.

<table>
<thead>
<tr>
<th>DISAGREE</th>
<th>5th grade</th>
<th>6th grade</th>
<th>7th grade</th>
<th>8th grade</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>(25/236) x 100 = 10.59 %</td>
<td>(29/236) x 100 = 12.29 %</td>
<td>(13/236) x 100 = 5.51 %</td>
<td>(13/236) x 100 = 5.51 %</td>
<td>(80/236) x 100 = 33.90 %</td>
</tr>
<tr>
<td>Turkey</td>
<td>(36/236) x 100 = 15.25 %</td>
<td>(43/236) x 100 = 18.22 %</td>
<td>(43/236) x 100 = 18.22 %</td>
<td>(34/236) x 100 = 14.41 %</td>
<td>(156/236) x 100 = 66.10 %</td>
</tr>
<tr>
<td>TOTAL</td>
<td>(61/236) x 100 = 25.85 %</td>
<td>(72/236) x 100 = 30.51 %</td>
<td>(56/236) x 100 = 23.73 %</td>
<td>(47/236) x 100 = 19.91 %</td>
<td>100 %</td>
</tr>
</tbody>
</table>

Table 4.2: The percentage of the US and Turkish students who disagree with the statement B2.
For more examples, the numbers of the United States and Turkish students who are undecided and agree with the idea that “Earthquakes are caused by release of energy stored in rocks” are shown in Table 4.3 and Table 4.4 respectively.

<table>
<thead>
<tr>
<th>UNDECIDED</th>
<th>5th grade</th>
<th>6th grade</th>
<th>7th grade</th>
<th>8th grade</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>30</td>
<td>32</td>
<td>11</td>
<td>23</td>
<td>96</td>
</tr>
<tr>
<td>Turkey</td>
<td>54</td>
<td>50</td>
<td>52</td>
<td>63</td>
<td>219</td>
</tr>
<tr>
<td>TOTAL</td>
<td>84</td>
<td>82</td>
<td>63</td>
<td>86</td>
<td>315</td>
</tr>
</tbody>
</table>

Table 4.3: The number of the US and Turkish students who undecided with the statement B2.

<table>
<thead>
<tr>
<th>AGREE</th>
<th>5th grade</th>
<th>6th grade</th>
<th>7th grade</th>
<th>8th grade</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>33</td>
<td>46</td>
<td>29</td>
<td>33</td>
<td>141</td>
</tr>
<tr>
<td>Turkey</td>
<td>33</td>
<td>33</td>
<td>27</td>
<td>38</td>
<td>131</td>
</tr>
<tr>
<td>TOTAL</td>
<td>66</td>
<td>79</td>
<td>56</td>
<td>71</td>
<td>272</td>
</tr>
</tbody>
</table>

Table 4.4: The number of the US and Turkish students who agree with the statement B2.

**What are Earthquakes?**

The first section of the questionnaire contained 15 questions that were related to description of earthquakes (see Figure 4.2). Even though more students in the United States than in Turkey thought “Earthquakes are an eruption” (item A1) (49.9% vs. 11.5%), a significant number of students in the United States were aware that earthquakes are a release of energy stored in rocks (items A2, A7, and A13). Here are the significant differences of results respectively: $t(821) = 5.24, p < .05$; $t(821) = 6.70, p < .05$; $t(821) = 2.91, p < .05$. Similarly, more students in the United States agreed that earthquakes are sliding of the earth crust (item A9, $t[821] = 2.74, p < .05$).
Figure 4.2: Graphs showing the percentages of student responses to statements concerning what earthquakes are. Each graph is numbered according to the instrument. Significance in trend with country and grade levels is indicated by the asterisks (see text). The ordinate represents the percentage of students showing particular responses; the abscissa represents the grades: 5, 6, 7, 8; the column represents the countries: US, Turkey. The coding is as follows:

- **Agree**
- **Undecided**
- **Disagree**
A10 Earthquakes are release of energy stored in rocks.

A10 Earthquakes occur on faults.

A11 Earthquakes are a sliding of the earth's crust.

A11 After earthquakes there is a chance of another earthquakes.

A12 Earthquakes can occur under the ocean.

A12 Earthquakes are disasters that happen only night.

A13 Earthquakes are sudden ground motion produced by a rapid release of stored-up energy.

A13 Earthquakes create seismic waves.
However, fewer students in the United States compared to Turkey thought that earthquakes occur on faults (item A10) (37.5% vs. 62.3%). On the other hand, the Spearman correlation for this item indicated that the data show a positive trend in both countries: $r = .179$, $n=317$, $p< .01$, two-tails for United States; $r = .201$, $n=506$, $p< .01$, two-tails for Turkey.

Although a significant number of students’ in both countries (87.4% in US; 68.6% in Turkey) disagreed with the statement that earthquakes are kinds of tornado (item A4), more students in Turkey compared to the United States thought that they are (15.0% vs. 4.1%). Interestingly, 19.9% of students in the United States compared to 3.0% of students in Turkey believed that earthquakes occur in winter (item A15). On the other hand, although the majority of students did not agree with the idea that earthquakes are the hand of God to punish people (item A5), only 11.9% of Turkish students compared to 4.7% of the United States students agreed with this idea. For more information, Table 4.5 lists the mean, standard deviation, t-score, and 95% confidence interval of each item in part A.
## Table 4.5: Summary of the t statistics for section A: What are earthquakes?  
* These items showed significant differences between the two countries (p < .05).

<table>
<thead>
<tr>
<th>Item #</th>
<th>Mean USA/Turkey</th>
<th>SD USA/Turkey</th>
<th>t-score</th>
<th>95% Confidence Interval Lower/Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>2.09/1.42 .942/.688</td>
<td>10.86 .544/.784</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>1.95/1.64 .879/.734</td>
<td>5.24 .194/.427</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>1.99/2.23 .914/.886</td>
<td>-3.80 -.373/-.119</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>1.17/1.46 .471/.742</td>
<td>-7.03 -.380/-.214</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A5</td>
<td>1.26/1.48 .539/.698</td>
<td>-5.01 -.302/-.132</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A6</td>
<td>1.56/1.56 .792/.797</td>
<td>.109 -.105/.118</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A7</td>
<td>2.27/1.90 .796/.723</td>
<td>6.70 .261/.477</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A8</td>
<td>1.09/1.12 .352/.444</td>
<td>-.927 -.081/.029</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A9</td>
<td>2.69/2.57 .604/.684</td>
<td>2.74 .035/.214</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A10</td>
<td>2.13/2.49 .776/.715</td>
<td>-6.66 -.466/-.245</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A11</td>
<td>2.58/2.70 .650/.581</td>
<td>-2.69 -.208/-.033</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A12</td>
<td>2.79/2.45 .539/.722</td>
<td>7.81 .258/.431</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A13</td>
<td>2.55/2.39 .704/.772</td>
<td>2.91 .050/.255</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A14</td>
<td>2.32/2.11 .710/.633</td>
<td>4.41 .119/.311</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A15</td>
<td>1.65/1.11 .792/.401</td>
<td>11.17 .441/.629</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How do Earthquakes Happen?

The second section of the instrument posed the question “How do earthquakes happen?” (See Figure 4.3). According to network the structure of this study, the fundamental phenomena were earth movement, manmade, and atmospheric condition. There were eight questions related to earth movement (see Appendix A). In the first
Figure 4.3: Graphs showing the percentages of student responses to statements concerning how earthquakes happen. Each graph is numbered according to the instrument. Significance in trend with country and grade levels is indicated by the asterisks (see text). The ordinate represents the percentage of students showing particular responses; the abscissa represents the grades: 5, 6, 7, 8; the column represents the countries: US, Turkey. The coding is as follows:

- **Agree**
- **Undecided**
- **Disagree**
Figure 4.3 continued

B9 Earthquakes are caused by volcanoes

B10 Earthquakes are caused by toxic waste

B11 Earthquakes are caused by foggy weather

B12 Earthquakes are caused by the earth turning the opposite way

B13 Earthquakes are caused by deep noises coming from under the ground

B14 Earthquakes are caused by tides

B15 Earthquakes are caused by bad vibrations
section, I have already mentioned that there was a general tendency for the United States students who thought that earthquakes are a release of energy stored in rocks also believed that earthquakes are caused by release of the energy stored in rocks (item B2). It appears to be known by over 44.5% of all students in the United States compared with only 25.9% of students in Turkey (t [821] = 4.27, p < .05). Again, parallel to the first section (item A10) a significant number of Turkish students believed earthquakes are caused by movements along faults (item B1, t [821] = -3.19, p < .05). Volcanoes (items B6 and B9) were not seen as cause of earthquakes by 50% of students in both countries. However, still over 25% of students in both countries believed the idea.

There were two items suggesting that earthquakes were manmade (items B3 and B5). In the Unites States, the figures for these items were slightly lower in comparison to Turkey. Fewer students in the United States than in Turkey (5.5% compared with 19%) believed that “Earthquakes are caused by construction workers taking down a building” (item B3) and similarly fewer students in the United States thought “Earthquakes are caused by nuclear testing” (item B5) (7.6% vs. 12.6%).

Five items constructed by the researcher (items B4, B7, B8, B10, and B11) were related to the atmospheric condition phenomenon. Over 65% of students in both countries agreed that the reasons for earthquakes are not related to atmospheric conditions. However, 7.3% of the United States students compared to 4.3% of Turkish students believed wrongly, “Earthquakes are caused by thunder” (item B8). The summary of the t statistic results is provided in Table 4.6.
<table>
<thead>
<tr>
<th>Item #</th>
<th>Mean USA/Turkey</th>
<th>SD USA/Turkey</th>
<th>t-score</th>
<th>95% Confidence Interval</th>
<th>Lower/Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1*</td>
<td>2.27/2.44</td>
<td>.768/.707</td>
<td>-3.19</td>
<td>-3.19</td>
<td>-.276/-0.66</td>
</tr>
<tr>
<td>B2*</td>
<td>2.19/1.95</td>
<td>.814/.752</td>
<td>4.27</td>
<td>.131/.353</td>
<td></td>
</tr>
<tr>
<td>B3*</td>
<td>1.17/1.47</td>
<td>.493/.794</td>
<td>-6.73</td>
<td>-.390/-0.214</td>
<td></td>
</tr>
<tr>
<td>B4</td>
<td>1.44/1.41</td>
<td>.642/.687</td>
<td>.69</td>
<td>-.060/.125</td>
<td></td>
</tr>
<tr>
<td>B5*</td>
<td>1.38/1.69</td>
<td>.623/.685</td>
<td>-6.62</td>
<td>-.398/-0.216</td>
<td></td>
</tr>
<tr>
<td>B6*</td>
<td>1.89/2.01</td>
<td>.855/.728</td>
<td>-2.04</td>
<td>-.232/-0.005</td>
<td></td>
</tr>
<tr>
<td>B7</td>
<td>1.16/1.18</td>
<td>.453/.481</td>
<td>-.571</td>
<td>-.084/.046</td>
<td></td>
</tr>
<tr>
<td>B8*</td>
<td>1.28/1.18</td>
<td>.591/.486</td>
<td>2.58</td>
<td>.024/.180</td>
<td></td>
</tr>
<tr>
<td>B9</td>
<td>1.73/1.78</td>
<td>.813/.802</td>
<td>-.91</td>
<td>-.167/.061</td>
<td></td>
</tr>
<tr>
<td>B10</td>
<td>1.25/1.27</td>
<td>.536/.554</td>
<td>-.53</td>
<td>-.097/.056</td>
<td></td>
</tr>
<tr>
<td>B11*</td>
<td>1.15/1.41</td>
<td>.457/.508</td>
<td>-2.25</td>
<td>-.144/-0.010</td>
<td></td>
</tr>
<tr>
<td>B12</td>
<td>1.50/1.41</td>
<td>.719/.601</td>
<td>1.69</td>
<td>-.013/.177</td>
<td></td>
</tr>
<tr>
<td>B13*</td>
<td>1.56/2.01</td>
<td>.763/.855</td>
<td>-7.83</td>
<td>-.561/-0.336</td>
<td></td>
</tr>
<tr>
<td>B14*</td>
<td>1.58/1.84</td>
<td>.718/.722</td>
<td>-5.01</td>
<td>-.360/-0.157</td>
<td></td>
</tr>
<tr>
<td>B15</td>
<td>2.06/2.02</td>
<td>.836/.792</td>
<td>.66</td>
<td>-.076/.154</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.6: Summary of the t statistic for section B: How do earthquakes happen?
* These items showed significant differences between the two countries (p < .05).

**How can Earthquakes affect other things?**

The third section of the questionnaire investigated “How can earthquakes affect other things?” (see Figure 4.4). The entities for this section were living things and objects (See Appendix A). It appeared that a high percentage of students (over 90% in both
Figure 4.4: Graphs showing the percentages of student responses to statements concerning how earthquakes affect other things. Each graph is numbered according to the instrument. Significance in trend with country and grade levels is indicated by the asterisks (see text). The ordinate represents the percentage of students showing particular responses; the abscissa represents the grades: 5, 6, 7, 8; the column represents the countries: US, Turkey. The coding is as follows:

- **Agree**
- **Undecided**
- **Disagree**
C7 Earthquakes can change the water level in wells

C8 Earthquakes can shape the physical features of land

C9 Earthquakes can make the Earth turn faster

C10 Earthquakes can damage trees

C11 Earthquakes can raise the temperature

C12 Earthquakes can damage inside of buildings

C13 Earthquakes can cause volcanoes

C14 Scientist can predict earthquakes
groups) though that “Earthquakes can kill people” (item C1). Correspondingly they also realized that earthquakes could make people have trouble walking (item C5) (69.4% students in the United States compared with 62.8% students in Turkey).

In both countries over 55% of students believed that “Earthquakes could cause dogs to bark just before it happens” (item C3). The belief trend increased from 5th through 8th grade levels in Turkey (r [506] = .223, p< .01). There was a consistency in the responses in that 44.2% students in the United States and 69.0% of students in Turkey agreed that animals can predict earthquakes (item C15), and again Turkish students agreement was increasing 5th through 8th grade levels (r [506]= .096, p< .05). Over half of the students in both countries believed that “Scientists can predict earthquakes” (item C14) and interestingly 28.1% of students in the United States compared with 18.8% of students in Turkey also believed that “Some people can sense that earthquakes are about the happen” (item C16). Consistent with the item B7 (earthquakes are caused by rain), a majority of students in Turkey and in the United States did not believe that “Earthquakes can cause rain” (item C4) (65.0% vs. 48.6%). However, across 5th through 8th grade levels there was a positive trend in the United States data (r [317] = .162, p< .05). On the
other hand, although about half of the students in both countries did not believe that “Earthquakes can raise the temperature” (item C11), on average, around one fourth of Turkish students in 8th grades believed the idea and the Spearman correlation indicated that the data in Turkey showed a positive trend ($r = .10, p< .05$).

With respect to ideas linked with the effect of earthquakes on physical features of the earth (items C6, C7, and C8), over half of the students in both countries recognized the fact that earthquakes can change the physical shape of land.

There was a consistency in the responses to item B12 “Earthquakes are caused by the earth turning the opposite way” and item C9 “Earthquakes can make the earth turn faster.” In general, students did not believe the idea (61.5% students in the US vs. 54.9% students in Turkey), however over 12.6% of students in the United States agreed with the statements and the Spearman correlation indicated that the data in the United States showed a positive trend ($r = .182, p< .01$). More data about this section can be seen in Table 4.7.

What can we do to protect ourselves from Earthquakes?

The last section of the questionnaire contained fourteen questions that were related to actions to be taken before, during, and immediate after earthquakes (See Figure 4.5). Consistent with the statement C14 “Scientist can predict earthquakes” both countries’ students again wrongly believed that “Scientists can accurately predict earthquakes before it happens” (item D6) (38.5% in the US vs. 36.2% in Turkey). Over 75% of Turkish students agreed that “During earthquakes we should get under something
<table>
<thead>
<tr>
<th>item #</th>
<th>Mean USA/Turkey</th>
<th>SD USA/Turkey</th>
<th>t-score</th>
<th>95% Confidence Interval Lower/Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>2.93/2.92</td>
<td>.326/.350</td>
<td>.450</td>
<td>-.036/.058</td>
</tr>
<tr>
<td>C2*</td>
<td>2.39/2.67</td>
<td>.660/.545</td>
<td>-6.30</td>
<td>-.366/-1.192</td>
</tr>
<tr>
<td>C3</td>
<td>2.39/2.32</td>
<td>.791/.844</td>
<td>1.22</td>
<td>-.043/.182</td>
</tr>
<tr>
<td>C4*</td>
<td>1.72/1.41</td>
<td>.780/.596</td>
<td>6.03</td>
<td>.208/.410</td>
</tr>
<tr>
<td>C5*</td>
<td>2.56/2.44</td>
<td>.716/.785</td>
<td>2.20</td>
<td>.012/.221</td>
</tr>
<tr>
<td>C6*</td>
<td>2.56/2.71</td>
<td>.690/.599</td>
<td>-3.20</td>
<td>-.240/-0.058</td>
</tr>
<tr>
<td>C7</td>
<td>2.43/2.43</td>
<td>.710/.690</td>
<td>-1.77</td>
<td>-.108/.090</td>
</tr>
<tr>
<td>C8*</td>
<td>2.70/2.60</td>
<td>.607/.656</td>
<td>2.17</td>
<td>.009/.186</td>
</tr>
<tr>
<td>C9</td>
<td>1.51/1.53</td>
<td>.710/.642</td>
<td>-4.2</td>
<td>-.117/.076</td>
</tr>
<tr>
<td>C10*</td>
<td>2.92/2.76</td>
<td>.337/.582</td>
<td>4.76</td>
<td>.090/.216</td>
</tr>
<tr>
<td>C11</td>
<td>1.72/1.71</td>
<td>.721/.730</td>
<td>.20</td>
<td>-.091/.112</td>
</tr>
<tr>
<td>C12</td>
<td>2.84/2.85</td>
<td>.453/.464</td>
<td>-3.26</td>
<td>-.075/.054</td>
</tr>
<tr>
<td>C13*</td>
<td>1.98/2.20</td>
<td>.785/.738</td>
<td>-3.92</td>
<td>-.323/-1.07</td>
</tr>
<tr>
<td>C14</td>
<td>2.39/2.38</td>
<td>.774/.754</td>
<td>.177</td>
<td>-.098/.118</td>
</tr>
<tr>
<td>C15*</td>
<td>2.17/2.58</td>
<td>.831/.673</td>
<td>-7.54</td>
<td>-.527/-0.309</td>
</tr>
<tr>
<td>C16*</td>
<td>1.91/1.70</td>
<td>.767/.767</td>
<td>3.79</td>
<td>.103/.325</td>
</tr>
</tbody>
</table>

Table 4.7: Summary of the t statistic for section C: How can earthquakes affect other things?
* These items showed significant differences between the two countries (p < .05).

sturdy like table or desk” (item D8) and “We should cover the back of our neck with one hand” (item D11) while only 43% of United States students agreed with the idea. In contrast, 42.3% of students in the United States thought that “Immediately after earthquakes we should wear shoes and gloves” (item D13) whereas 11.7% Turkish students agreed the idea.
D1 Before earthquakes we should build earthquakes resistance wood frame houses

D2 Before earthquakes we should move heavy objects to high shelves because objects can withstand quakes

D3 Before earthquakes we should fasten water heaters to the wall

D4 Before earthquakes we should place beds by large windows so one can easily escape from the window

D5 Before earthquakes we should move heavy objects away from exit routes in our houses

D6 Scientist can accurately predict earthquakes before it happens

Figure 4.5: Graphs showing the percentages of student responses to statements concerning what we can do to protect ourselves from earthquakes. Each graph is numbered according to the instrument. Significance in trend with country and grade levels is indicated by the asterisks (see text). The ordinate represents the percentage of students showing particular responses; the abscissa represents the grades: 5, 6, 7, 8; the column represents the countries: US, Turkey. The coding is as follows:

- Agree
- Undecided
- Disagree

continued
During earthquakes we should hold on something metal.

D8 During earthquakes we should get under something sturdy like table or desk.

D9 During earthquakes we should get near the window.

D10 During earthquakes we should stand under a tree.

D11 During earthquakes we should cover the back of our neck with one hand.

D12 During earthquakes if you find yourself indoors it is usually better to rush outside.

D13 Immediately after earthquakes we should wear shoes and gloves.

D14 Immediately after earthquakes we should turn on the radio or TV for instruction.
For more data, the summary of t statistic results is provided in Table 4.8.

<table>
<thead>
<tr>
<th>Item #</th>
<th>Mean USA/Turkey</th>
<th>SD USA/Turkey</th>
<th>t-score</th>
<th>95% Confidence Interval Lower/Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>1.99/2.09</td>
<td>.859/.853</td>
<td>-1.70</td>
<td>-.225/0.016</td>
</tr>
<tr>
<td>D2*</td>
<td>1.53/1.67</td>
<td>.753/.796</td>
<td>-2.56</td>
<td>-.249/-0.033</td>
</tr>
<tr>
<td>D3*</td>
<td>1.74/2.13</td>
<td>.781/.808</td>
<td>-6.86</td>
<td>-.500/-0.278</td>
</tr>
<tr>
<td>D4*</td>
<td>1.75/1.47</td>
<td>.844/.771</td>
<td>4.86</td>
<td>0.169/0.399</td>
</tr>
<tr>
<td>D5</td>
<td>2.59/2.52</td>
<td>.686/.723</td>
<td>1.33</td>
<td>-.032/0.166</td>
</tr>
<tr>
<td>D6</td>
<td>2.15/2.10</td>
<td>.773/.780</td>
<td>.840</td>
<td>-.062/0.156</td>
</tr>
<tr>
<td>D7</td>
<td>1.68/1.77</td>
<td>.772/.745</td>
<td>-1.54</td>
<td>-.191/0.023</td>
</tr>
<tr>
<td>D8*</td>
<td>2.01/2.88</td>
<td>.924/.418</td>
<td>-15.78</td>
<td>-.980/-0.763</td>
</tr>
<tr>
<td>D9</td>
<td>1.32/1.40</td>
<td>.624/.706</td>
<td>-1.65</td>
<td>-.170/0.15</td>
</tr>
<tr>
<td>D10*</td>
<td>1.16/1.41</td>
<td>.446/.651</td>
<td>-6.43</td>
<td>-.321/-0.171</td>
</tr>
<tr>
<td>D11*</td>
<td>2.05/2.68</td>
<td>.890/.655</td>
<td>-10.76</td>
<td>-.736/-0.509</td>
</tr>
<tr>
<td>D12*</td>
<td>1.87/1.58</td>
<td>.849/.786</td>
<td>5.00</td>
<td>.180/0.412</td>
</tr>
<tr>
<td>D13*</td>
<td>2.12/1.56</td>
<td>.842/.693</td>
<td>9.98</td>
<td>.453/0.675</td>
</tr>
<tr>
<td>D14*</td>
<td>2.51/2.30</td>
<td>.749/.869</td>
<td>3.81</td>
<td>.106/0.330</td>
</tr>
</tbody>
</table>

Table 4.8: Summary of the t statistic for section D: What we can do to protect ourselves from earthquakes?
* These items showed significant differences between the two countries (p < .05).

**Summary**

In this study, the questionnaire items were connected into the features (e.g., what are earthquakes? and how do earthquakes happen?) by linking these features to the
structure of possible paradigms (e.g., movement, belief, and etc.). Therefore, items were correlated with each other and listed below are the general patterns within the data:

1- Seven items were directly linked to relationships between earthquakes and weather conditions (items A15, B4, B7, B8, B11, C4, and C11). In general over 50% of students in both countries did not believe that there are relationships.

2- Five items were related to earthquake predictions (items C3, C14, C15, C16, and D6). In general, half of the students in both countries held wrong beliefs about the statements.

3- Four items were associated with the scientific definition of earthquakes (items A2, A7, A13, and B2). The results indicated that the United States students’ scientific knowledge about the statements were significantly higher than Turkish students.

4- Four items were connected to relationships between earthquakes and volcanoes (items A1, B6, B9, and C13). More than one-fourth of students in both countries thought that volcanoes cause earthquakes.

5- Three questions described earthquakes connection with faults (items A10, B1, and C2). A significant number of Turkish students believed that earthquakes occur on faults.

6- Two questions were related to the idea that human beings cause earthquakes (items B3 and B5). Over half of the students in both countries did not agree that there are such relationships.

7- Two questions were linked with relationships between earthquakes and earth spin (items B12 and C9). More than half of the students in both countries disagreed
with the idea; over 13% of students in United States compared with 6% of students in Turkey believed there are relationships.

8- The last part of the questionnaire described actions one should take before, during, and immediately after earthquakes. In general, it appeared that around half of the students in both countries knew the actions, but Turkish students’ scores were slightly higher than the United States students. This may be a result of safety drills in Turkey. However, still over half of the students held wrong ideas about protection from earthquakes.

Comparisons

1- How do the significant levels of perspectives differ among the students who have experienced formal instruction about earthquakes with respect to those who have not experienced formal instruction of earthquakes and who have experienced earthquakes with respect to who have not experienced earthquakes?

The number of participants, means, and standard deviations for the 2x2 factorial design are presented in Table 4.9. The main effect of having taken instruction was not significant (F [1,822] = .138, p = .71), nor was the main effect of experienced earthquakes category, (F [1,822] = 1.19, p = .276). The interaction of having taken instruction and experiencing earthquakes, however, was significant, (F [1,822] = 4.44, p = .035).
Table 4.9: Descriptive statistics for 2x2 factorial design.

<table>
<thead>
<tr>
<th>Instruction</th>
<th>ExpEQ</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>140.73</td>
<td>8.49</td>
<td>106</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>141.50</td>
<td>8.69</td>
<td>338</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>141.31</td>
<td>9.64</td>
<td>444</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>142.61</td>
<td>9.79</td>
<td>295</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>140.17</td>
<td>9.44</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>142.07</td>
<td>9.75</td>
<td>379</td>
</tr>
<tr>
<td>total</td>
<td>No</td>
<td>142.11</td>
<td>9.49</td>
<td>401</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>141.24</td>
<td>8.85</td>
<td>422</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>141.66</td>
<td>9.17</td>
<td>823</td>
</tr>
</tbody>
</table>

One of the main purposes of this study was to compare the two countries students’ perspectives on earthquakes who have taken formal instruction but have not experienced earthquakes (students in the United States) with respect to those who have not taken instruction but have experienced earthquakes (students in Turkey). After splitting the data by countries and by these factors, independent sample t-tests were applied. The 277 participants in the United States (M = 143.08, SD = 9.70) and 330 participants in Turkey (M=141.94, SD = 8.69), demonstrated a significance differences in perspective (t [613] =2.13, p= .033); as expected, students have formal instruction of earthquakes but have not experienced it have significantly higher score than the students who have not taken formal instruction of earthquakes but have experienced it.
2- How do the students’ view of earthquakes differ according to gender and age?

*Gender:* The number of the participants, means and standard deviations by country and gender are presented in Table 4.10. No significant differences were found in the US and Turkish data.

<table>
<thead>
<tr>
<th>Country</th>
<th>Gender</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>Female</td>
<td>179</td>
<td>141.96</td>
<td>9.36</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>138</td>
<td>143.61</td>
<td>10.58</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>317</td>
<td>142.68</td>
<td>9.93</td>
</tr>
<tr>
<td>Turkey</td>
<td>Female</td>
<td>237</td>
<td>141.69</td>
<td>7.76</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>269</td>
<td>142.08</td>
<td>9.67</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>506</td>
<td>141.89</td>
<td>8.82</td>
</tr>
</tbody>
</table>

Table 4.10: Descriptive statistics for independent samples t-test by country and gender.

*Age:* The number of participants, means and standard deviations by country and age are presented in Table 4.11. There were significant differences among the United States students in terms of their age ($F [4,316] = 2.72$, $p = .03$), whereas no significant differences were found among Turkish students ($F [4,505] = 2.315$, $p = .06$).

Effect size was calculated for quantifying the differences between two groups. Generally, the larger the effect size, the greater is the impact of an intervention. In the current study, the effect size was 0.1, which indicated a nonoverlap of 7.7% in two distributions (US vs. Turkey). According to Cohen (1988), an effect size of 0.5 indicates a large effect, 0.3 indicates a moderate effect, and 0.1 indicates a small effect.
Table 4.11: Descriptive statistics for 2x5 factorial design.

The results of post-hoc Tukey tests revealed those 11-year old United States students’ scores are significantly lower than 12-year old at the .01 level. Table 4.12 presented the mean differences, standard error, significant levels and 95% confidence level of results for this age group.

<table>
<thead>
<tr>
<th>Country</th>
<th>Age</th>
<th>N</th>
<th>Mean</th>
<th>Std. deviation</th>
</tr>
</thead>
<tbody>
<tr>
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<td>52</td>
<td>138.46</td>
<td>8.24</td>
</tr>
<tr>
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<td>144.08</td>
<td>8.67</td>
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<td>13</td>
<td>71</td>
<td>142.48</td>
<td>9.66</td>
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<tr>
<td>USA</td>
<td>14</td>
<td>72</td>
<td>142.56</td>
<td>12.87</td>
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<tr>
<td>USA</td>
<td>15</td>
<td>22</td>
<td>142.75</td>
<td>10.21</td>
</tr>
<tr>
<td>USA</td>
<td>total</td>
<td>317</td>
<td>142.36</td>
<td>10.14</td>
</tr>
<tr>
<td>Turkey</td>
<td>11</td>
<td>107</td>
<td>141.44</td>
<td>9.15</td>
</tr>
<tr>
<td>Turkey</td>
<td>12</td>
<td>131</td>
<td>141.46</td>
<td>8.15</td>
</tr>
<tr>
<td>Turkey</td>
<td>13</td>
<td>125</td>
<td>143.90</td>
<td>8.63</td>
</tr>
<tr>
<td>Turkey</td>
<td>14</td>
<td>129</td>
<td>141.06</td>
<td>8.97</td>
</tr>
<tr>
<td>Turkey</td>
<td>15</td>
<td>14</td>
<td>139.42</td>
<td>10.97</td>
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<td>Turkey</td>
<td>total</td>
<td>506</td>
<td>141.93</td>
<td>8.82</td>
</tr>
</tbody>
</table>

Table 4.12: Tukey comparisons for 11-years old United States students.

* The mean difference is significant at the .01 levels.
Part II: Factor Analysis

In this study, factor analysis was an exploratory statistical tool that was used to summarize relationships between individual statements. There are actually two discrete classes of factor analysis: exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). EFA was preferred in this study because the researcher did not have any specific explanations regarding the number or the nature of underlying constructs or factors (Thompson, 2004). After exploring the factors, each factor was examined for any significant differences between countries. Finally, for the instrument validity, CFA was applied.

*Exploratory Factor Analysis*

Exploratory factor analysis was performed using CEFA version 2 for MS Windows (Browne, Cudeck, Tateneni, & Mels, 2004). Ten factors were found based on the students’ common-pattern of thinking. The fit indexes supported the measurement. According to the root mean square error approximation (RMSEA) a measurement smaller than 0.05 indicates a close fit, 0.05-0.08 indicates a reasonable fit, 0.08-0.1 indicates a mediocre fit, and a value higher than 0.1 indicates unacceptable fit (Browne and Cudeck, 1992). In the current study the RMSEA value was 0.023 which indicates the close fit. Another index that was used for determining the number of factors was the Tucker-Lewis index (TLI). A TLI value above 0.90 indicates a good fit (Browne & MacCallum, 2002). In this study, the TLI was 0.93, which also supported ten factors. The last index for factor analysis that was used was root mean square residual (RMR) which was a kind of generalized standard deviation. The closer the RMR is to zero for a model being tested,
the better the model fit. In the current study, RMR was 0.09, which also confirmed a close fit.

All ten factors represented separate themes framed around the features of systemic networks and the results are shown in Table 4.13. Here, the statements are shown down the side, and the numbers in the body of the table indicate loadings of each statement on to the ten extracted factors. Only those loadings that were greater than 0.220 are presented (Stevens, 2003). The order of the statements was adjusted to illustrate the groupings of the statements, with the highest loading first.

Factor 4 centered on the scientific explanation of earthquakes. All four statements that loaded on this factor described what earthquakes are. Factors 1, 5, and 9 were related to features of how earthquakes happen. Each factor viewed a different opinion. The statements with high loadings in Factor 1 had to do with beliefs on how earthquakes happen. Factor 5 asked for relationships between earthquakes, sound, and vibration whereas Factor 9 was concerned with the connection between earthquakes and faults.

Factors 2, 6, 8, and 10 seem to relate more to how earthquakes affect other things. Factor 2 was centered on the proper facts about the result of earthquakes, whereas Factor 6 was concerned with myths. Factor 8 was all about earthquake prediction and Factor 10 was about associations between earthquakes and animals.

Factors 3 and 7 were linked to what we can do to protect ourselves from earthquakes. Factor 3 had to do with beliefs on that issues, whereas factor 7 was related the accurate facts.
<table>
<thead>
<tr>
<th>Statements</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earthquakes are caused by thunder</td>
<td>.613</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earthquakes are caused by foggy weather</td>
<td>.606</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earthquakes are caused by rain</td>
<td>.531</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Earthquakes are caused by toxic waste</td>
<td>.526</td>
<td></td>
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<td></td>
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<tr>
<td>Earthquakes are disasters that happen only at night</td>
<td>.386</td>
<td></td>
<td></td>
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<tr>
<td>Earthquakes are caused by tides</td>
<td>.377</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td>.250</td>
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<tr>
<td>Earthquakes are caused by hot weather</td>
<td>.372</td>
<td></td>
<td></td>
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<tr>
<td>Earthquakes are caused by construction workers</td>
<td>.368</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>taking down a building</td>
<td></td>
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<tr>
<td>Earthquakes are caused by nuclear testing</td>
<td>.353</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Earthquakes are caused by volcanoes</td>
<td>.334</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Earthquakes are caused by the Earth turning the opposite way</td>
<td>.321</td>
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<tr>
<td>Earthquakes can make the Earth turn faster</td>
<td>.309</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Earthquakes can damage trees</td>
<td></td>
<td>.503</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Earthquakes can make people have trouble walking</td>
<td></td>
<td>.394</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Earthquakes can push houses into the soil</td>
<td></td>
<td></td>
<td>.332</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Earthquakes can change the water level in wells</td>
<td></td>
<td></td>
<td></td>
<td>.329</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earthquakes can damage inside of buildings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.326</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Earthquakes can occur under the ocean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.236</td>
<td></td>
<td></td>
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</table>

Table 4.13: CF-Varimax Rotated Exploratory Factor Analysis statements and loadings.
Table 4.13 continued

<table>
<thead>
<tr>
<th>Statements</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. During earthquakes, we should get near a window.</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
</tr>
<tr>
<td>2. During earthquakes, we should stand under a tree.</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
</tr>
<tr>
<td>3. Before earthquakes, we should build earthquake-resistant wood frame houses.</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
</tr>
<tr>
<td>4. Earthquakes are caused by the release of energy stored in rocks.</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
</tr>
<tr>
<td>5. Earthquakes are sudden ground motion produced by a rapid release of stored-up energy.</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
</tr>
<tr>
<td>6. Earthquakes are deep noises coming from under the ground.</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
</tr>
<tr>
<td>7. Earthquakes are caused by the deep noises coming from under the ground.</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
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<td>112</td>
</tr>
<tr>
<td>8. Earthquakes are caused by the Earth's core moving.</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
</tr>
<tr>
<td>9. Earthquakes are caused by the deep noises coming from under the ground.</td>
<td>112</td>
<td>112</td>
<td>112</td>
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<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
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</tr>
<tr>
<td>10. Earthquakes are caused by the Earth's core moving.</td>
<td>112</td>
<td>112</td>
<td>112</td>
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<td>112</td>
<td>112</td>
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</tr>
<tr>
<td>Statements</td>
<td>1</td>
<td>2</td>
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<td>---------------------------------------------------------------------------</td>
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<tr>
<td>During earthquakes we should get under something sturdy like table or desk</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.546</td>
</tr>
<tr>
<td>During earthquakes we should cover the back of our neck with one hand</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>.364</td>
</tr>
<tr>
<td>Immediately after earthquakes we should wear shoes and gloves</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>.322</td>
</tr>
<tr>
<td>Scientist can predict earthquakes</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.983</td>
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<tr>
<td>Scientist can accurately predict earthquakes before it happens</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<td>.490</td>
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<tr>
<td>Some people can sense that earthquakes are about to happen</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>.253</td>
</tr>
<tr>
<td>Earthquakes are caused by movement along faults</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>.734</td>
</tr>
<tr>
<td>Earthquakes occur on faults</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.610</td>
</tr>
<tr>
<td>Earthquakes can move faults</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td>.428</td>
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<tr>
<td>Earthquakes can cause dog to bark just before it happens</td>
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<td></td>
<td></td>
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<td></td>
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<td>.887</td>
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<tr>
<td>Animals can predict earthquakes</td>
<td></td>
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<td></td>
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<td>.441</td>
</tr>
</tbody>
</table>
Factor Comparisons

The following part describes responses to individual statements within the factors in which the country comparisons were found to be significant. Independent sample t-test comparisons were applied after getting total scores for each factor. As with the questionnaire, the means were the results of coding scale: agree=3, undecided=2, and disagree=1. Comparisons are presented consistent with the features of systemic network structure.

What are Earthquakes?

Four statements in the questionnaire were related to scientific explanations of earthquakes that loaded on Factor 4. The 317 participants in United States (M=2.24, SD=.53) and the 506 participants in Turkey (M=1.97, SD=.50), demonstrated significance different in score (t [821] =7.33, p < .001); as expected, United States students’ scientific based knowledge on earthquakes was higher than Turkish students.

How do Earthquakes Happen?

The comparison of Factors 1, 5, and 9 that were related to features of how earthquakes happen is given in Table 4.14. All factors showed significant differences (p< .05).
Table 4.14: Comparisons of the US and Turkish students’ factor scores for the features how earthquakes happen.

In comparisons of students’ beliefs (factor 1), while the scores of both groups were close to disagree, the United States students relatively held less alternative concepts than Turkish students. Naïve beliefs claimed that cause of earthquakes are linked to deep sounds or bad vibrations (e.g., earthquakes are caused by the deep noises coming under the ground and earthquakes are caused by bad vibrations) were under the factor 5. Both group of students tended to undecided with the idea, but again United States students hold significantly less alternative concepts than Turkish students. All the statements related to faults were loaded under the factor 9 while the scores of both groups fell to between undecided and agree, Turkish students’ scores were significantly higher than United States students.
How can Earthquakes Affect Other Things?

The comparison of the Factors 2, 6, 8, and 10 that related to feature of how earthquakes can affect other things is given in Table 4. All factor were showed significant differences (p< .05).

In comparisons of the proper facts on effects of earthquakes (factor 2), while the score of both groups were close to agree, the United States students received relatively higher scores than did Turkish students. Myths that asserted that earthquakes could affect weather conditions and could produce explosions were loaded under the factor 6. Both groups of students fell between “undecided” and “disagree” choices with some slight suggestion that United States students have moved toward a less disagreement view. Statements linked to earthquake prediction were under the factor 8. In today’s technology scientists cannot predict earthquakes accurately. But both groups of students fell between “undecided” and “agree”, with the United States students somewhat more agree, while Turkish students’ fell the side of undecided.

The last factor of this feature was connected to animals having a sense about earthquakes. Both countries students mean scores were above the undecided point, but Turkish students were relatively closer to the agree point than United States students. In short, even though the United States students’ scientific knowledge was reasonably higher than Turkish students and they held less naïve beliefs than Turkish students on definition of earthquakes and about how earthquakes happen, they held comparatively more myths about earthquakes prediction, earthquakes could affect weather conditions, and it can be an explosion. On the other hand, most of the Turkish students believed animals could predict earthquakes.
<table>
<thead>
<tr>
<th>Factor</th>
<th>US</th>
<th>SD</th>
<th>T</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor 2 (scientifically accurate facts)</td>
<td>2.68</td>
<td>.32</td>
<td>3.11</td>
<td>.002</td>
</tr>
<tr>
<td>US</td>
<td>2.60</td>
<td>.35</td>
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<td></td>
</tr>
<tr>
<td>Turkey</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 6 (myths)</td>
<td>1.77</td>
<td>.54</td>
<td>7.19</td>
<td>.001</td>
</tr>
<tr>
<td>US</td>
<td>1.52</td>
<td>.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 8 (myths on earthquakes prediction)</td>
<td>2.15</td>
<td>.57</td>
<td>-2.31</td>
<td>.003</td>
</tr>
<tr>
<td>US</td>
<td>2.06</td>
<td>.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factor 10 (myths on relations earthquakes and animals)</td>
<td>2.28</td>
<td>.69</td>
<td>-3.16</td>
<td>.001</td>
</tr>
<tr>
<td>US</td>
<td>2.45</td>
<td>.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td></td>
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</tbody>
</table>

Table 4.15: Comparisons of the US and Turkish students' factor scores for the features how Earthquakes can affect other things.

*What can we do to protect ourselves from Earthquakes?*

The comparison of the factors 3 and 7 that were related to the feature of protection from earthquakes is given in Table 4.16. All factors were showed significant differences (p< .05).
Table 4.16: Comparisons of the US and Turkish students’ factor scores for the features how earthquakes can affect other things.

<table>
<thead>
<tr>
<th>Factor 3 (beliefs)</th>
<th>M</th>
<th>SD</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>1.53</td>
<td>.41</td>
<td>-4.14</td>
<td>.001</td>
</tr>
<tr>
<td>Turkey</td>
<td>1.64</td>
<td>.40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor 7 (accurate facts)</th>
<th>M</th>
<th>SD</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>2.06</td>
<td>.55</td>
<td>-9.76</td>
<td>.001</td>
</tr>
<tr>
<td>Turkey</td>
<td>2.37</td>
<td>.36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Beliefs about the actions one should take during the earthquakes loaded under the factor 3. The score of both groups felt to between undecided and disagree while United States students were relatively held less alternative concepts than Turkish students. Factor 7 was all about the protection from earthquakes while the score of both groups felt to between undecided and agree; Turkish students had relatively higher scores than United States students.

**Validation of the Test**

The validity of a test is the extent to which the instrument measures what it claims to measure (Tuckman, 1999). After applying EFA to decide on the number of factors and the positions of fixed zero loadings, the researcher used CFA to determine the validity of the model. However, checking a model obtained by means of EFA could only be done by using new data (Browne & MacCallum, 2002). Therefore, for validity of the instrument the data were separated by country. After applying EFA with United States data, the obtained model was checked for Turkish data by carrying out a CFA.
Ten factors were found from EFA based on the United States students’ common-pattern of thinking on earthquakes (CEFA ver 1.03 for MS Windows). The following fit indexes support the measurement: Root Mean Square Error of Approximation (RMSEA) = 0.031, Tucker-Lewis Index (TLI) = 0.90, and the root mean square residual (RMR) = 0.131. All ten factors represented parallel statements around the same themes as in previous EFA (see Appendix E). Only those loadings were greater than 0.250 are shown (Stevens, 2003).

The model obtained from United States data by applying EFA was checked for Turkish data by carrying out CFA. In the path diagram of the model, all the manifest variables are represented by the number of the statements while all the latent variables are symbolized by the number of the factors. All unique factors are characterized by letter “u”. One sided arrows show the directional influence of the factor loading from one variable to another. The path diagram of the model is listed in Table 4.17.

<table>
<thead>
<tr>
<th>F1</th>
<th>→</th>
<th>B11, uB11</th>
<th>F2</th>
<th>→</th>
<th>C10, uC10</th>
<th>F4</th>
<th>→</th>
<th>D10, uD10</th>
<th>F7</th>
<th>→</th>
<th>B1, uB1</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>→</td>
<td>B8, uB8</td>
<td>F2</td>
<td>→</td>
<td>C12, uC12</td>
<td>F4</td>
<td>→</td>
<td>D9, uD9</td>
<td>F7</td>
<td>→</td>
<td>A10, uA10</td>
</tr>
<tr>
<td>F1</td>
<td>→</td>
<td>B7, uB7</td>
<td>F2</td>
<td>→</td>
<td>C6, uC6</td>
<td>F4</td>
<td>→</td>
<td>D7, uD7</td>
<td>F7</td>
<td>→</td>
<td>C2, uC2</td>
</tr>
<tr>
<td>F1</td>
<td>→</td>
<td>B3, uB3</td>
<td>F2</td>
<td>→</td>
<td>A12, uA12</td>
<td>F4</td>
<td>→</td>
<td>D12, uD12</td>
<td>F8</td>
<td>→</td>
<td>C14, uC14</td>
</tr>
<tr>
<td>F1</td>
<td>→</td>
<td>B10, uB10</td>
<td>F2</td>
<td>→</td>
<td>C5, uC5</td>
<td>F5</td>
<td>→</td>
<td>A1, uA1</td>
<td>F8</td>
<td>→</td>
<td>D6, uD6</td>
</tr>
<tr>
<td>F1</td>
<td>→</td>
<td>B5, uB5</td>
<td>F2</td>
<td>→</td>
<td>C7, uC7</td>
<td>F5</td>
<td>→</td>
<td>A6, uA6</td>
<td>F8</td>
<td>→</td>
<td>C16, uC16</td>
</tr>
<tr>
<td>F1</td>
<td>→</td>
<td>B4, uB4</td>
<td>F3</td>
<td>→</td>
<td>A3, uA3</td>
<td>F5</td>
<td>→</td>
<td>A2, uA2</td>
<td>F9</td>
<td>→</td>
<td>C11, uC11</td>
</tr>
<tr>
<td>F1</td>
<td>→</td>
<td>A8, UA8</td>
<td>F3</td>
<td>→</td>
<td>B6, uB6</td>
<td>F6</td>
<td>→</td>
<td>B2, uB2</td>
<td>F9</td>
<td>→</td>
<td>C4, uC4</td>
</tr>
<tr>
<td>F1</td>
<td>→</td>
<td>B14, uB14</td>
<td>F3</td>
<td>→</td>
<td>B13, uB13</td>
<td>F6</td>
<td>→</td>
<td>A7, uA7</td>
<td>F10</td>
<td>→</td>
<td>C3, uC3</td>
</tr>
<tr>
<td>F1</td>
<td>→</td>
<td>C9, uC9</td>
<td>F3</td>
<td>→</td>
<td>B15, uB15</td>
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<td>→</td>
<td>A13, uA13</td>
<td>F10</td>
<td>→</td>
<td>C15, uC15</td>
</tr>
<tr>
<td>F1</td>
<td>→</td>
<td>B9, uB9</td>
<td>F3</td>
<td>→</td>
<td>B12, uB12</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Table 4.17: The path diagram of CFA.
The model for Turkish data was conducted using the computer program RAMONA for CFA. RMSEA = .054 indicated that it is a reasonable fit (Browne & Cudeck, 1993). Measures of the fit of the model are presented in Table 4.18.

It can be concluded that the instrument created by using a systemic network to understand students’ existing knowledge on earthquakes measured the characteristic that the researcher would like to evaluate. Even though the validity of the instrument can still be increased by some modifications; the results indicated that the validity of the instrument is reasonable.

<table>
<thead>
<tr>
<th>Measures of fit of the model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Discrepancy Function Value</td>
</tr>
<tr>
<td>Population discrepancy function value, ( F_0 )</td>
</tr>
<tr>
<td>Bias adjusted point estimate</td>
</tr>
<tr>
<td>90% confidence interval</td>
</tr>
<tr>
<td>Root mean square error of approximation</td>
</tr>
<tr>
<td>Steiger-Lind : ( \text{RMSEA} = \sqrt{\frac{F_0}{df}} )</td>
</tr>
<tr>
<td>Point estimate</td>
</tr>
<tr>
<td>90.000 percent confidence interval</td>
</tr>
<tr>
<td>Expected cross-validation index</td>
</tr>
<tr>
<td>Point estimate</td>
</tr>
<tr>
<td>90% confidence interval</td>
</tr>
<tr>
<td>CVI (modified AIC) for the saturated model</td>
</tr>
<tr>
<td>Test statistic:</td>
</tr>
<tr>
<td>Exceedance probabilities:</td>
</tr>
<tr>
<td>( H_0: ) perfect fit (RMSEA = 0.0)</td>
</tr>
<tr>
<td>( H_0: ) close fit (RMSEA &lt;= 0.050)</td>
</tr>
<tr>
<td>Multiplier for obtaining test statistic = 505.000</td>
</tr>
<tr>
<td>Degrees of freedom = 991</td>
</tr>
<tr>
<td>Effective number of parameters = 90</td>
</tr>
</tbody>
</table>

Table 4.18: Measures of fit of the model for Turkish data.
CHAPTER 5

DISCUSSION AND CONCLUSIONS

Consistent with the goal of this research, the Discussion and Conclusions chapter is presented in three major sections. First, the chapter opens with a discussion and conclusions about students’ existing knowledge on earthquakes, then continues with the implications of the systemic-network technique for instrument development, and ends with future directions of the research. Additionally, the strengths and limitations of the study and contributions for education are discussed within these themes.

Discussion and Conclusions of Students Existing Knowledge of Earthquakes

According to the U.S. Geological Survey, earthquakes are sudden ground motions produced by a rapid release of stored-up energy (USGS, 2005). Four statements in the questionnaire (A2, A7, A13, and B2) were parallel to this description: in general, American students’ responses tended to agree with the USGS definition while Turkish students disagreed. As American students progress from fifth through eight grades, their knowledge of earthquakes increased significantly, whereas Turkish students showed no significant improvement. This difference may result from Ohio’s Earth and Space Science content standards, which suggest initial teaching about earthquakes in fourth grades and by eighth grades start teaching plate tectonics in depth. Instead of
agreeing that earthquakes are a release of energy stored in rocks, Turkish students’ are more likely to believe that earthquakes are caused by movement along faults (A10, B1, and C2). “fault” is a word that is commonly used in Turkey when someone talks about earthquakes, such as North Anatolia fault zones, East Anatolia fault zone, fault length, and fault map. Almost all Turkish people hear and use the word “fault” even though they might interpret it differently than a scientist (Gilbert & Osborn, 1980). According to Ross and Shuell’s (1993) study, faults, earth movement, and heat are the alternative answers given by students when they do not know about tectonic plates.

Only in the last 35 years has the concept of plate tectonics causing of earthquakes become widely accepted. In a study by Leather (1987), 28% of 14-year-olds mentioned plate movements as a cause of earthquakes and this figure increased to 50% among the older group which is similar to the current study. On the other hand, the results of several different studies indicated that students have limited knowledge about the theory of plate tectonics, so they were not aware of the relationship between earthquakes and tectonic activities (e.g., Barrow & Haskins, 1996; Marques & Thompson, 1997; Philips, 1991; Skinner, 2001).

Four items in the questionnaire were connected to relationships between earthquakes and volcanoes (items A1, B6, B9, and C15). In both countries, students’ mean scores were near the undecided point. In particular, over one-fourth of students in both countries thought that volcanoes cause earthquakes. Similarly, several studies have noted the tendency for students to confuse earthquakes with volcanic activity. For instance, Happs (1982) discussed some students’ beliefs that mountains could become volcanoes if shaken by earthquakes. Likewise, Sharp, Mackintosh, and Seedhouse (1995)
found that some children thought an earthquake occurred when a volcano became hot and shook the ground. Correspondingly, in Ross and Shuell’s (1993) paper at least one student in each study used the word “eruption” in a comparative description of an earthquake and a volcano. Students in that study also thought that core movement, pressure, and volcanoes cause earthquakes. Finally, Marques and Thompson (1997) concluded that students’ confusion about earthquakes and volcanoes might be the reason that volcanoes and earthquakes are perceived to be quite familiar to students both from exposure in school and the mass media.

The majority of students in both countries did not agree on the relationships between earthquakes and weather conditions. However, even though a majority of students in both countries did not believe that earthquakes are caused by hot weather, rain, or thunder (B4, B7, and B8), more students agreed with or were undecided on the idea that earthquakes can raise the temperatures and can cause heavy rain (C11 and C4). As a result, even though students think that earthquakes cannot be affected by weather condition, more of them agree or are undecided that weather conditions can be affected by earthquakes.

In Leather’s (1987) study of 11-year-olds, 28% referred to a hot climate or to weather conditions as being the cause of earthquakes. Other causes given included collapsing ground, thunderstorms, and pushing and pulling of the sea. In addition, Ross and Shuell (1993) found that students believe heat, thunder, rain, wind, and mountains cause earthquakes. In contrast, a current study revealed that in general most students did not agree that earthquakes are caused by hot weather or rain. However, a few students
agreed (average 10%) or were undecided (average 30%) about earthquakes as a cause of hot weather or rain.

Students in the United States tended to agree (46.4%) while students in Turkey tended to be undecided (58.9%) when they were asked, “Earthquakes create seismic waves” (A14). Ross and Shuell (1993) stated that none of the students mentioned the words seismic waves when asked, “What happens below the surface when there is an earthquake?” The most frequently given response was “I don’t know.”

Students in both countries scores were either “undecided” or “agreed” that scientist can accurately predict earthquakes (C14 and D6) and, interestingly more students in the US (28.1% compared with 18.8% of students in Turkey) also believed that “Some people can sense that earthquakes are about to happen” (item C16). Furthermore, in regard to the statements connected to “Animals have sense about earthquakes” (C3 and C15), students in both countries tended to agree, but Turkish students were relatively closer to the agree point than the US students. Similarly, Schoon (1989, 1992, and 1995) found that 15.4% of participants in his study believed that earthquakes could be accurately predicted by observing the behavior of wild animals, though there is no scientific study to support this. This common belief may come from anecdotes that have been published in the mass media.

When asked to consider the statement, “Earthquakes are deep noises coming from the ground” (A3), 41.0% in the US and 53.6% in Turkey agreed with the idea. However, in a related but slightly different statement, fewer students (16.7% vs. 37%) agreed that earthquakes are caused by the deep noises coming from under the ground (B13). Interestingly, when asked whether “Earthquakes are caused by bad vibrations” (B15),
students in both countries were evenly divided between agreement, undecided, and disagreement (average 33%) with the idea. Ross and Shuell (1993) observed that almost three fourths of K-3 students mentioned that earthquakes consist of shaking, trembling, or vibration. In a current study, where the age group is older than in the previous one, students were likely to hold to a naïve belief that makes sense and coincides with their everyday experiences or dialogue (Osborne and Gilbert, 1980).

Fewer students in the US than in Turkey (5.0% compared with 19%) believed that “Earthquakes are caused by construction workers taking down a building” (item B3), and similarly, fewer students in the US thought, “Earthquakes are caused by nuclear testing” (item B5) (7.6% vs. 12.6%). In general, even though the students did not believe that “Earthquakes are caused by the Earth turning the opposite way” (B12) (63.7% students in the US vs. 64.6% students in Turkey) and “Earthquakes can make the Earth turn faster” (C9), over 12% students in the US agreed to the statements. Additionally, more students in Turkey believe that “Earthquakes are the hand of God to punish people” (A5) (11.9% in Turkey vs. 4.7% in US). The source of such beliefs may come from the media, family, religious leaders and peer-group discussion (e.g., Gilbert & Watts, 1983; Osborne, Bell, & Gilbert, 1983). However, even though the majority of students in the US received formal education on earthquakes they still hold some of these naïve beliefs. In several studies, the possible origins for these naïve beliefs in Earth science topics’ were linked to various pedagogical practices, such as the imprecise use of language, oversimplification of concepts, use of rote learning, and stereotyping of landforms (e.g., Barrow, & Haskins, 1996; Dove, 1998).
In an unfortunate coincidence, the data collection for this study was soon after the world’s biggest earthquakes in history that happened in Sumatra Island and measured magnitude of 9.0. Conversation with the students revealed that most of the group had watched television coverage of this earthquake. Asked how earthquakes can affect other things, a majority of students in the US and in Turkey respectively, agreed on the following: People are killed (C1) (95.6% vs. 94.9%); buildings collapse or are damaged (C6 and C12) (66.9% vs. 78.1% and 87.4% vs. 89.3%) and physical features of the land change (C7 and C10) (55.5% vs. 54.9% and 93.7% vs. 69.8%). Students knowledge of the destructive power of earthquakes feelings and the helplessness may have been the results of media coverage because the media paid more attention to individual helplessness instead of community preparedness, coping and hazard mitigation (Hoddler, 2001; Simon, 1997). Future studies are needed to analyze how events shown in the media mediate children’s concept formation.

More students in the US than in Turkey knew that earthquakes are not a kind of tornado (A4). The differences between responses may be reflective of the US students’ being geographically closer to tornadoes than are Turkish students. In parallel to that, about half of the students in both countries were aware of what to do in an earthquake; Turkish students’ scores were slightly higher than US students. Ross and Shuell (1993) concluded that students have difficulty remembering what to do for a specific disaster, because all disasters, for instance, earthquakes, tornadoes, volcano, floods, and droughts are grouped together in the curriculum. Students in Turkey have safety drills for earthquakes. Therefore, they specifically have a chance to practice the actions that should be taken in earthquakes. On the other hand, students in the US have safety drills for
tornadoes. The American students might use the knowledge they have learned from

tornado drills while answering the questions about earthquake protection. However, over

half of the students in both countries still do not know about earthquake safety. Further

studies are needed to clarify the teaching styles or curriculum development for

maximizing learning about natural hazards and protection from them.

Overall, the results indicate that there were similarities as well as differences in

the responses of students in both countries. For instance, even though the US students’

scientific knowledge was considerably higher than Turkish students’ and the US students

held fewer naïve beliefs than Turkish students about the definition of earthquakes and

about how earthquakes happen, the US students held comparatively more myths

regarding earthquake prediction. Furthermore, students in Turkey seem to construct their

knowledge about earthquakes based on inappropriate conclusions from their experiences

of the physical world (Gutierrez & Ogborn, 1992) (e.g., earthquakes are deep noises

coming from underground), or cultural beliefs (Bezzi & Happs, 1994) (e.g., wearing

shoes in the house is inappropriate, so immediately after earthquakes, why one should

wear shoes in the house?).

However exploratory, this study may offer some insight into the students

reasoning. Sometimes student relate pieces of information to each other, which may be

correct in part, but may lead to erroneous inferences. (Gelman, Bullock, & Meck, 1980). For instance, the idea that earthquakes are a sudden ground motion produced by a rapid release of stored-up energy, and the stored-up energy radiates throughout the earth as a series of waves, and the waves shake the surface as they pass, might lead to wrong inferences that earthquakes are shaking of earth or earthquakes are caused by bad
vibrations. Perhaps in a similar way students in the current study believed earthquakes are caused by explosions, thunder, nuclear testing, or even taking down buildings, because they all cause shaking, so they might also cause earthquakes. In general, the tendency of students is to relate, sometimes erroneously, bad causes to bad effects via linear causal reasoning (Hogan & Maglienti, 2001). Further research should be undertaken to confirm or deny what kind of reasoning leads students’ knowledge formation about earthquakes.

Finally, previous studies concluded that there were no significant differences of knowledge between the students who had experienced earthquakes and the students who had not experienced earthquakes (Barrow & Haskins, 1996; Ross and Shuell, 1993). The results of this study revealed that students who have formal instruction about earthquakes but have not experienced one have a significantly higher scores than the students who have not received formal instruction about earthquakes but have experienced one. Even though the students who experienced earthquakes and had no formal instruction developed some ideas about the subject; the abstract nature of the earthquake topic led them to hold some naïve beliefs. In general, the findings showed that students who have experience earthquakes do not have a better knowledge of earthquakes. Only education makes a difference.

In addition, Turkish students’ existing knowledge about earthquakes did not show any differences among ages, whereas the US students’ scores increased from 11 through 14 year-olds. The results may be considered as a confirmation of educational differences. Since a majority of Turkish students were not instructed about earthquakes, they did not reveal any differences. On the other hand, the US students’ scores increased overtime, because they have started learning about earthquakes in 4th grade.
Implications for Instrument Development

In this study, a systemic network approach was used as a tool to measure students’ existing knowledge about earthquakes. The network assumed a structure of possibilities that allowed the researcher to choose possible paradigms such as man-made, beliefs, and movement. These paradigms were chosen according to what the researcher wanted to learn from the research and then were linked to the features such as what are earthquakes and how do earthquakes happen. This process helps the researcher to organize a set of choices that can be linked to each other. Thus, the researcher can observe the statements that belong within others and the statements independent from others. In the current study, first the researcher evaluated students’ existing knowledge about earthquakes for each statement, and then combined similar statements under ten factors. The factors appeared around the features “What something is”, “What something does”, “What can be done to something”, and “How it happen” which are the ontological framework of Piaget’s theory of development of meaning (Piaget & Garcia, 1991) and the ontological model of previous studies (Mariani & Ogborn, 1990, 1991, 1995).

Additionally, the systemic network approach was used as an effective starting point to understand a group of students’ existing knowledge, because the networks are interested in description and representation of meaning. According to Langer (1994), the first stage of meaning (instrumental meaning) has its root from the feature “What something is.” In this beginning stage, participants try to understand the meaning of an element by evaluating the physical properties. For instance, “Earthquakes are deep noises coming from ground” or “Earthquakes can push houses into the soil” are the statements
related to what people see, touch or feel. Most of the time, the instrumental meaning depends on everyday experiences or dialogue and could lead participants to hold some naïve beliefs. In the current study, students who had no or poor formal instruction about earthquake could be evaluated at this first stage.

The next two stages of meaning (representational meaning and reasoned meaning) have their roots from the features how and why, respectively. For instance, “How do earthquakes happen?” and “Why do earthquakes happen?”. Daily experiences are not adequate for those advanced stages of meaning. Detailed observation or inquiry is necessary. In the study, only those students who had formal instruction about earthquakes had some idea of how earthquakes happen (e.g., earthquakes are sudden ground motion produced by rapid release of stored-up energy). However, the findings do not imply those students perfectly understand the meaning of earthquakes just because they selected an “agree” response. Further research should be undertaken to evaluate their understanding or reasoning. On the other hand, earthquakes are still poorly understood and poorly predicted of all the natural hazards.

The researcher does not wish to claim too much for the ideas revealed in this study, because it should be noted that this study has examined only students’ existing knowledge about earthquakes. In addition, this study represents the initial study applying a systemic network to earthquake science. On the other hand, the study proposes an instrument development approach to educators as a solution to the difficulty of measuring a group of students’ existing knowledge.

The network represents styles of questions, types of content, types of roles, and types of interconnections between questions. The instrument development with a
systemic network has already been described in the methodology chapter. Here are the summary steps for future applications:

1- Choose a topic (e.g., earthquakes).

2- Select participants (e.g., middle school students who had or had not experienced earthquakes and who had or had not received formal instruction).

3- Identify the styles of questions (e.g., the ontological model of Piaget).

4- Select the phenomena or notions in terms of what is to be measured (e.g., beliefs, movement, manmade).

5- Link the statements.

One may think that any questionnaire, is of course, based on an analysis of the content or nature of the area to be investigated. However, what the use of systemic networks offers is a form of assistance to our thinking (Koulaidis & Ogborn, 1988). In general, the network defines a set of possible combinations of descriptive features. In Figure 5.1 one of these combinations is presented. Assume that statements A, B, and C are linked to phenomenon X and statements D and E are linked to phenomenon Y and both phenomena are linked to the feature Z.

```
Z

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<td>------------------</td>
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</tbody>
</table>
X               Y

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</table>
A               B   C   D   E
```

Figure 5.1: Systemic networks framework
Examination of the students’ patterns of thinking about earthquakes provided insight and empirical evidence, and these results show that the network-design of the questionnaire can be applied to other subject matter and concepts. During the course of the present study, American teachers asked the investigator to prepare a new instrument to measure students’ views about tornadoes. Instrument development for tornado can be done by using the same features and then by choosing new phenomena according to what the researcher or teacher would like to measure.

In conclusion, a network approach is important for providing an intelligible and well-founded structure for judging items in the questionnaire and for evaluating the questionnaire as a whole. The network approach is a promising framework for developing the questionnaire.

Directions for Future Research

This study has examined only middle school students existing knowledge about earthquakes and has identified the common patterns in earthquake thinking between genders, ages, geographic areas, experience with earthquakes, and formal instruction. Specifically, this research provided descriptive and analytical accounts of students’ views about earthquakes.

Taken collectively, the results of this study raise a number of issues for educators addressing students’ existing knowledge about earthquakes and proposing a structural approach to instrument development. Therefore, two avenues for further exploration could complement this study. The first avenue is research about earthquakes education and the second avenue is studies about instrument development.
The first avenue would be to continue to research the earthquakes subject, because while this study paints a general picture of students’ views on earthquakes, more studies would aid in understanding what kind of reasoning led students to make these choices and what sources they used. For instance, what is the relationship between media coverage and students’ concept formation?

A general perspective of students’ knowledge on earthquakes is presented in the current study. The next step should be classroom observations, interviews, and instructional interventions, because these types of studies would allow students to use their own words and phrases to explain their beliefs about earthquakes. As an example, if the students tended to hold beliefs about earthquakes, the researcher could devise follow-up interview questions or activities to try to find the reasons for this trend.

In the study with teachers, Cavalcante (2002) explained that teachers’ conceptions of earthquakes are no differences from the conceptions of their students and the conceptions of the general population in the area. In the same way, Schoon (1995) stated that many naïve beliefs originate in the classroom and that pre-service elementary education teachers have many of the same naïve beliefs that their future students will have. When they were faced with the unknown, students and their teachers, often use commonsense. Therefore, further studies are needed to understand whether the teachers and other adults in the US and in Turkey hold the same views about earthquakes as their students’ or children. Educators and researchers should determine at which level earthquake education should be started and what kind of teaching strategies should be applied.
The second avenue for further exploration of the study would examine the systemic network approach for instrument development. The model of this study provided promising insights and empirical evidence to apply the network-design of the questionnaire to different subject matter and concepts. The goal for further studies should be to provide a guideline for teachers to use a systemic network for assessing their students’ existing knowledge.

In conclusion, this study revealed that even though for hundreds of years, the most common natural hazard in Turkey has been earthquakes, middle school students in Turkey have a very limited understanding of earthquakes. For the many students who do not pursue high school, graduating from middle school means the end of formal education in Turkey. As educators and researchers, one of our goals must be to prepare our children to deal with real life. By examining the results of the current study, as citizens in this modern world, have we managed to do that or have we failed?

This research took one and a half years and within these years two big earthquakes happened. One was in Indonesia (magnitude 9.0 Richter scale) and the other one was in Pakistan (magnitude 7.2 Richter scale). Unfortunately, thousands of people died and were injured. Most of these people were children. While you are reading this paragraph, somewhere in the world an earthquake is happening. People cannot escape from earthquakes but people can learn how to live with earthquakes. Educators, researchers, curriculum developers and most importantly governments should pay more attention to earthquake education and should support earthquake studies. If the twenty first century is named as the century of modern science and technology, citizens in this modern century should do better in the area of earthquake education.
LIST OF REFERENCES


APPENDIX A

THE NETWORK OF THE QUESTIONNAIRE
A: What are earthquakes?

<table>
<thead>
<tr>
<th>MOVEMENT</th>
<th>KIND</th>
<th>BELIEF</th>
</tr>
</thead>
</table>
| • Earthquakes are an eruption.  
• Earthquakes are deep noises coming from under the ground.  
• Earthquakes are explosions.  
• Earthquakes are a sliding of the Earth’s crust.  
• Earthquakes are a sudden ground motion produced by a rapid release of stored-up energy. |  
• Earthquakes are a rock-forming process.  
• Earthquakes are a kind of tornado.  
• Earthquakes are a release of energy stored in rocks.  
• Earthquakes occur on faults.  
• After earthquakes there is a chance of another earthquake.  
• Earthquakes can occur under the ocean.  
• Earthquakes create seismic waves. |  
• Earthquakes are the hand of God to punish people.  
• Earthquakes are disasters that happen only at night.  
• Earthquakes occur in winter. |
### B. How do Earthquakes happen?

<table>
<thead>
<tr>
<th>EARTH MOVEMENT</th>
<th>MANMADE</th>
<th>ATMOSPHERIC CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Earthquakes are caused by movement along faults.</td>
<td>• Earthquakes are caused by construction workers taking down a building.</td>
<td>• Earthquakes are caused by hot weather.</td>
</tr>
<tr>
<td>• Earthquakes are caused by the release of energy stored in rocks.</td>
<td>• Earthquakes are caused by nuclear testing.</td>
<td>• Earthquakes are caused by rain.</td>
</tr>
<tr>
<td>• Earthquakes are caused by the Earth’s core moving to the surface.</td>
<td>• Earthquakes are caused by the Earth turning the opposite way.</td>
<td>• Earthquakes are caused by thunder.</td>
</tr>
<tr>
<td>• Earthquakes are caused by volcanoes.</td>
<td>• Earthquakes are caused by deep noises coming from under the ground.</td>
<td>• Earthquakes are caused by toxic waste.</td>
</tr>
<tr>
<td>• Earthquakes are caused by tides.</td>
<td>• Earthquakes are caused by bad vibrations.</td>
<td>• Earthquakes are caused by foggy weather.</td>
</tr>
</tbody>
</table>
C. How can Earthquakes affect other things (objects or living things)?

<table>
<thead>
<tr>
<th>LIVING THINGS</th>
<th>OBJECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Earthquakes can kill people.</td>
<td>• Earthquakes can move faults.</td>
</tr>
<tr>
<td>• Earthquakes can cause dog to bark just before it happens.</td>
<td>• Earthquakes can cause heavy rain.</td>
</tr>
<tr>
<td>• Earthquakes can make people have trouble walking.</td>
<td>• Earthquakes can push houses into the soil.</td>
</tr>
<tr>
<td>• Scientist can predict earthquakes.</td>
<td>• Earthquakes can change the water level in wells.</td>
</tr>
<tr>
<td>• Animals can predict earthquakes.</td>
<td>• Earthquakes can shape the physical features of land.</td>
</tr>
<tr>
<td>• Some people can sense that earthquakes are about to happen.</td>
<td>• Earthquakes can make the Earth turn faster.</td>
</tr>
<tr>
<td></td>
<td>• Earthquakes can damage trees.</td>
</tr>
<tr>
<td></td>
<td>• Earthquakes can raise the temperature.</td>
</tr>
<tr>
<td></td>
<td>• Earthquakes can damage inside of buildings.</td>
</tr>
<tr>
<td></td>
<td>• Earthquakes can cause volcanoes.</td>
</tr>
</tbody>
</table>
D. What can we do to protect ourselves from Earthquakes?

<table>
<thead>
<tr>
<th>BEFORE EARTHQUAKES</th>
<th>DURING EARTHQUAKES</th>
<th>IMMEDIATELY AFTER EARTHQUAKES</th>
</tr>
</thead>
</table>
| - Before earthquakes we should build earthquakes resistance wood frame houses.  
- Before earthquakes we should move heavy objects to high shelves because heavy objects can withstand quakes.  
- Before earthquakes we should fasten water heaters to the wall.  
- Before earthquakes we should place beds by large windows so one can easily escape from the window.  
- Before earthquakes we should move heavy objects away from exit routes in our houses.  
- Scientist can accurately predict earthquakes before it happens. | - During earthquakes we should hold on to something metal.  
- During earthquakes we should get under something sturdy like table or desk.  
- During earthquakes we should get near a window.  
- During earthquakes we should stand under a tree.  
- During earthquakes we should cover the back of our neck with one hand.  
- During earthquakes if you find yourself indoors it is usually better to rush outside. | - Immediately after earthquakes we should wear shoes and gloves.  
- Immediately after earthquakes we should turn on the radio or TV for instructions. |
APPENDIX B

ENGLISH AND TURKISH QUESTIONNAIRES AS USED IN THE CURRENT STUDY
This is a survey of your knowledge about earthquakes. Each question is followed by three choices. You are to decide which answer is the best one. Read each question and circle the best answer. If you make a mistake, erase completely the answer you wish to change.

Look at the example below:

1. There are four oceans in the World.  
   Agree  Undecided  Disagree

Prepared by
Ayse Oguz
Demographic Information

- Gender        Boy       Girl

- Grade          5       6       7       8

- Date of Birth  Month------ Year------

- I studied earthquakes when I was in  ---------------------- grade(s).

- I experienced an earthquake.        Yes       No

- I studied earthquakes this school year. Yes       No
A: What are earthquakes?

1. Earthquakes are an eruption.  
   AGREE  UNDECIDED  DISAGREE

2. Earthquakes are a rock-forming process.  
   AGREE  UNDECIDED  DISAGREE

3. Earthquakes are deep noises coming from under the ground.  
   AGREE  UNDECIDED  DISAGREE

4. Earthquakes are a kind of tornado.  
   AGREE  UNDECIDED  DISAGREE

5. Earthquakes are the hand of God to punish people.  
   AGREE  UNDECIDED  DISAGREE

6. Earthquakes are explosions.  
   AGREE  UNDECIDED  DISAGREE

7. Earthquakes are a release of energy stored in rocks.  
   AGREE  UNDECIDED  DISAGREE

8. Earthquakes are disasters that happen only at night.  
   AGREE  UNDECIDED  DISAGREE

9. Earthquakes are a sliding of the Earth’s crust.  
   AGREE  UNDECIDED  DISAGREE

10. Earthquakes occur on faults.  
    AGREE  UNDECIDED  DISAGREE

11. After earthquakes there is a chance of another earthquake.  
    AGREE  UNDECIDED  DISAGREE

12. Earthquakes can occur under the ocean.  
    AGREE  UNDECIDED  DISAGREE

13. Earthquakes are a sudden ground motion produced by a rapid release of stored-up energy.  
    AGREE  UNDECIDED  DISAGREE

14. Earthquakes create seismic waves.  
    AGREE  UNDECIDED  DISAGREE

15. Earthquakes occur in winter.  
    AGREE  UNDECIDED  DISAGREE
B. How do Earthquakes happen?

1. Earthquakes are caused by movement along faults.
   - AGREE  UNDECIDED  DISAGREE

2. Earthquakes are caused by the release of energy stored in rocks.
   - AGREE  UNDECIDED  DISAGREE

3. Earthquakes are caused by construction workers taking down a building.
   - AGREE  UNDECIDED  DISAGREE

4. Earthquakes are caused by hot weather.
   - AGREE  UNDECIDED  DISAGREE

5. Earthquakes are caused by nuclear testing.
   - AGREE  UNDECIDED  DISAGREE

6. Earthquakes are caused by the Earth’s core moving to the surface.
   - AGREE  UNDECIDED  DISAGREE

7. Earthquakes are caused by rain.
   - AGREE  UNDECIDED  DISAGREE

8. Earthquakes are caused by thunder.
   - AGREE  UNDECIDED  DISAGREE

9. Earthquakes are caused by volcanoes.
   - AGREE  UNDECIDED  DISAGREE

10. Earthquakes are caused by toxic waste.
    - AGREE  UNDECIDED  DISAGREE

11. Earthquakes are caused by foggy weather.
    - AGREE  UNDECIDED  DISAGREE

12. Earthquakes are caused by the Earth turning the opposite way.
    - AGREE  UNDECIDED  DISAGREE

13. Earthquakes are caused by the deep noises coming from under the ground.
    - AGREE  UNDECIDED  DISAGREE

14. Earthquakes are caused by tides.
    - AGREE  UNDECIDED  DISAGREE

15. Earthquakes are caused by bad vibrations.
    - AGREE  UNDECIDED  DISAGREE
C. How can Earthquakes affect other things (objects or living things)?

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>AGREE</th>
<th>UNDECIDED</th>
<th>DISAGREE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Earthquakes can kill people.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Earthquakes can move faults.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Earthquakes can cause dog to bark just before it happens.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Earthquakes can cause heavy rain.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Earthquakes can make people have trouble walking.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Earthquakes can push houses into the soil.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Earthquakes can change the water level in wells.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Earthquakes can shape the physical features of land.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Earthquakes can make the Earth turn faster.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Earthquakes can damage trees.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Earthquakes can raise the temperature.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Earthquakes can damage inside of buildings.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Earthquakes can cause volcanoes.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Scientist can predict earthquakes.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>Animals can predict earthquakes.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>Some people can sense that earthquakes are about the happen.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
D. What can we do to protect ourselves from Earthquakes?

1. Before earthquakes we should build earthquakes resistance wood frame houses.  
   AGREE  UNDECIDED  DISAGREE

2. Before earthquakes we should move heavy objects to high shelves because heavy objects can withstand quakes.  
   AGREE  UNDECIDED  DISAGREE

3. Before earthquakes we should fasten water heaters to the wall.  
   AGREE  UNDECIDED  DISAGREE

4. Before earthquakes we should place beds by large windows so one can easily escape from the window.  
   AGREE  UNDECIDED  DISAGREE

5. Before earthquakes we should move heavy objects away from exit routes in our houses.  
   AGREE  UNDECIDED  DISAGREE

6. Scientist can accurately predict earthquakes before it happens.  
   AGREE  UNDECIDED  DISAGREE

7. During earthquakes we should hold on to something metal.  
   AGREE  UNDECIDED  DISAGREE

8. During earthquakes we should get under something sturdy like table or desk.  
   AGREE  UNDECIDED  DISAGREE

9. During earthquakes we should get near a window.  
   AGREE  UNDECIDED  DISAGREE

10. During earthquakes we should stand under a tree.  
    AGREE  UNDECIDED  DISAGREE

11. During earthquakes we should cover the back of our neck with one hand.  
    AGREE  UNDECIDED  DISAGREE
12. During earthquakes if you find yourself indoors it is usually better to rush outside.

   AGREE   UNDECIDED   DISAGREE

13. Immediately after earthquakes we should wear shoes and gloves.

   AGREE   UNDECIDED   DISAGREE

14. Immediately after earthquakes we should turn on the radio or TV for instructions.

   AGREE   UNDECIDED   DISAGREE

THANK YOU!

Aşağıdaki örneği inceleyiniz:

1. Dünyada dört tane okyanus vardır. Katılıyorum Katılmıyorum Kararsızım

Hazırlayan
Ayşe Öğuz
Demografik Yapı

- Cinsiyet
  | Erkek | Kız |
- Sınıf  | 5   | 6 | 7 | 8 |
- Doğum tarihi
  | Ay----- | Yıl------ |
- Depremi yaşadım.
  | Evet | Hayır |
- Bu yıl deprem konusunu sınıfta öğrendik
  | Evet | Hayır |
- Deprem konusunu ........... sınıf(lar) da öğrenmiştık.
A: Deprem nedir?
1. Deprem bir püskürmedir. KATILIYORUM KARARSIZIM KATILMIYORUM
2. Deprem bir kaya oluşum sürecidir. KATILIYORUM KARARSIZIM KATILMIYORUM
3. Deprem yeraltının derinliklerinden gelen bir gürültüdür. KATILIYORUM KARARSIZIM KATILMIYORUM
4. Deprem bir çeşit kasırgadır. KATILIYORUM KARARSIZIM KATILMIYORUM
5. Deprem Allah’ın insanlara verdiği bir cezadır. KATILIYORUM KARARSIZIM KATILMIYORUM
6. Deprem bir patlamadır. KATILIYORUM KARARSIZIM KATILMIYORUM
7. Deprem kayaclarda depolanmış enerjinin açığa çıkmasıdır. KATILIYORUM KARARSIZIM KATILMIYORUM
8. Deprem sadece geceleri meydana gelen bir afettir. KATILIYORUM KARARSIZIM KATILMIYORUM
9. Deprem yerkabuğunun kaymasıdır. KATILIYORUM KARARSIZIM KATILMIYORUM
10. Depremler faylarda meydana gelir. KATILIYORUM KARARSIZIM KATILMIYORUM
11. Deprem sonrası başka bir depremin olmaolasılığı vardır. KATILIYORUM KARARSIZIM KATILMIYORUM
12. Depremler sadece Dünyanın kабuğunda meydana gelir. KATILIYORUM KARARSIZIM KATILMIYORUM
13. Deprem depolanmış enerjinin birden açığa çıkmasıyla oluşan ani bir yer hareketidir. KATILIYORUM KARARSIZIM KATILMIYORUM
14. Depremler sismik dalgaları yaratırlar. KATILIYORUM KARARSIZIM KATILMIYORUM
15. Depremler kışın meydana gelir. KATILIYORUM KARARSIZIM KATILMIYORUM
B. Deprem nasıl meydana gelir?

1. Depreme fay boyunca meydana gelen hareketler neden olur.

2. Depreme kayacılarda depolanmış olan enerjinin açığa çıkması neden olur.

3. Depreme binalar yıkan inşaat işçileri neden olur.

4. Depreme sıcak havalardan olur.

5. Depreme nükleer denemeler neden olur.

6. Depreme magmanın açığa çıkması neden olur.

7. Depreme yağmur neden olur.

8. Depreme gök gürültüsü neden olur.


10. Depreme zehirli atıklar neden olur.

11. Depreme sisli havalar neden olur.

12. Depreme Dünyanın ters yönde dönmesi neden olur.

13. Depreme yeraltının derinliklerinden gelen gürültüler neden olur.


15. Depreme kötü titreşimler neden olur.
C. Deprem diğer nesneleri (cisim veya canlılar) ne şekilde etkileyebilir?

<table>
<thead>
<tr>
<th>Sıra</th>
<th>Etki Noktası</th>
<th>Kararlar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Depremler insanların öldürebilir.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>2.</td>
<td>Depremler fay hattını hareket ettirebilir.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>3.</td>
<td>Depremler oluşumundan hemen önce köpeklerin havlamasına neden olabilir.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>4.</td>
<td>Depremler sağanak yağmurlara neden olabilir.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>5.</td>
<td>Depremler insanların yürümesini zorlaştırabilir.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>6.</td>
<td>Depremler evleri toprağın içine gömebilir.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>7.</td>
<td>Depremler kuyulardaki su seviyesini değiştirebilir.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>8.</td>
<td>Depremler yeryüzünün fiziksel yapısını değiştirebilir.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>9.</td>
<td>Depremler Dünyanın daha hızlı dönmesini sağlayabilir.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>10.</td>
<td>Depremler ağaçlara zarar verebilir.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>11.</td>
<td>Depremler sıcaklık artışına neden olabilir.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>12.</td>
<td>Depremler binaların içine zarar verebilir.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>13.</td>
<td>Depremler volkanlara neden olabilir.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>14.</td>
<td>Bilim adamları depremi önceden tahmin edebilirler.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>15.</td>
<td>Hayvanlar depremi önceden tahmin edebilirler.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
<tr>
<td>16.</td>
<td>Bazı insanlar depremin olacağı önceden hissedebilirler.</td>
<td>KATILIYORUM KARARSIZIM KATILMIYORUM</td>
</tr>
</tbody>
</table>
D. Depremden korunmak için neler yapılabilir?

1. Depremden önce depreme dayanıklı ahşap evler inşa etmeliyiz. KATILIYORUM  KARARSIZIM  KATILMIYORUM

2. Depremden önce ağır cisimleri üst raflara yerleştirmeliyiz çünkü ağır cisimler sarsıntıya dayanabilirler. KATILIYORUM  KARARSIZIM  KATILMIYORUM

3. Depremden önce ısıtıcılarını duvara monte etmeliyiz. KATILIYORUM  KARARSIZIM  KATILMIYORUM

4. Depremden önce yatakları pencere yakınına taşımalıyız ki deprem sırasında kolayca pencereden kaçabilelim. KATILIYORUM  KARARSIZIM  KATILMIYORUM

5. Depremden önce evde ağır cisimleri sokak kapısından çıkışımızı engellemeyecek uzak yerlere taşımalıyız. KATILIYORUM  KARARSIZIM  KATILMIYORUM

6. Bilim adamları depremi oluşumundan önce doğru olarak tahmin edebilirler. KATILIYORUM  KARARSIZIM  KATILMIYORUM

7. Deprem sırasında metal bir cisme tutunmalıyz. KATILIYORUM  KARARSIZIM  KATILMIYORUM

8. Deprem sırasında masa veya sira gibi dayanıklı cisimlerin altına girmeliyz. KATILIYORUM  KARARSIZIM  KATILMIYORUM

9. Deprem sırasında pencereye yakın durmalıyız. KATILIYORUM  KARARSIZIM  KATILMIYORUM

10. Deprem sırasında ağaç altında durmalıyz. KATILIYORUM  KARARSIZIM  KATILMIYORUM

11. Deprem sırasında bir elimizle ensemizi korumalıyız. KATILIYORUM  KARARSIZIM  KATILMIYORUM
12. Deprem sırasında eğer içerdeyseniz dışarıya hızla kaçmanız daha uygundur.


14. Depremden hemen sonra bilgi için radyo ve televizyonu açmalıyız.
APPENDIX C

THE EXAMPLE OF ENGLISH AND TURKISH SCRIPT BEFORE ADMINISTERING THE INSTRUMENT
Hello! My name is Ayse Oguz. You can call me Ayse. I am coming from The Ohio State University. I am a PhD student. Right now I am working on a research about students’ perception on Earthquakes. I will give you a survey. I am wondering whether you agree or disagree or undecided with the idea that I am proposing. Read each sentence and circle the best choice. If you make a mistake, erase completely the answer you wish to change. I do not want you to write your name on the paper. Now let’s do the demographic information part together. I will read the question then I want you to circle or write the answer. If you have any questions please do not hesitate to ask me. Now are you ready? (The researcher will read the demographic information part from the survey and answer the questions if the students have).

Demographic Information

<table>
<thead>
<tr>
<th>- Gender</th>
<th>Boy</th>
<th>Girl</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Grade</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>- Date of Birth</td>
<td>Month------</td>
<td>Year------</td>
</tr>
<tr>
<td>- I studied earthquakes this school year.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>- I studied earthquakes when I was in ------ grade.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>- I experienced an earthquake.</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

OK! Now you are ready to answer the questions. Please read them carefully and answer in terms of your thought. Thank you very much!

Demografik Yapı

- Cinsiyet
  - Erkek
  - Kız

- Sınıf
  - 5
  - 6
  - 7
  - 8

- Doğum tarihi
  - Ay-------
  - Yıl-------

- Bu yıl deprem konusunu sınıfta öğrendik
  - Evet
  - Hayır

- Deprem konusunu .......... sınıfta öğrenmiştik.

- Depremini yaşadım.
  - Evet
  - Hayır

TAMAM! Simdi soruları cevaplamaya hazırsınız. Lütfen çok dikkatli okuyunuz ve kendi düşüncenize göre cevaplardırınız. Çok teşekkür ederim!
APPENDIX D

PARENT/GUARDIAN LETTERS AND CONSENT FORMS IN ENGLISH AND IN TURKISH AND THE APPROVAL FROM INSTITUTIONAL REVIEW BOARD (IRB) AND THE APPROVAL FROM TURKISH GOVERNMENT DEPARTMENT OF EDUCATION
Dear Parent/Guardian:
Your child is invited to participate in a survey research study. Dr. Christopher Andersen, an Assistant Professor at The Ohio State University, and Ayse Oguz, a doctoral student at The Ohio State University, will be conducting this study. The purpose of administering this survey is to identify the nature of everyday practical thinking of students about earthquakes. The focus of this study is comparing the children in two different countries, the United States and Turkey. We expect the study to be significant because it will provide teachers and curriculum developers a better understanding of students' misconceptions about earthquakes.

In order for the researchers to conduct the study, one of the researchers, Ayse Oguz, will be in your child’s classroom for administering the questionnaire. During this time, one of your child’s teacher will also help to administer the test and the researcher will answer any student questions. No names will be put anywhere on the test paper. Completing the test will take 30 minutes or less. All the survey data will be stored at a secured location only accessible to the researchers and will be destroyed upon the completion of the study. There is no known or foreseeable risk that might be expected from your child’s participation in this study.

Your child’s participation is entirely voluntary. Your child’s grade will not be affected by his/her decision to participate or not to participate in this study. The results of this study will not be used to evaluate your child’s behavior or performance. Your child may withdraw any time without consequences of any kind. Should your child decide to withdraw, his/her data will be destroyed without penalty or loss of benefits as a student.

All the information collected from this study will remain confidential and will be used only for the purpose of the research. We plan to share the results of the study through publication in academic journals and presentation at academic conferences. No reference will be made in written and oral reports that could be linked to your child or to the school.

If you have questions about your child’s rights as a participant of this study, please contact The Office of Responsible Research Practices, Third Floor, Research Foundation Building, 1960 Kenny Road, Columbus, Ohio 43210-1063; Phone: 688-8457
We have explained the purpose of this study and described what your child’s participation in the study might require. If you are willing to grant permission, and if your child is willing to participate, please sign the consent form attached to this letter and ask your child to return it to the teacher as soon as possible. It is necessary that both you and your child sign the form in the spaces indicated. Keep this letter for your records.

You may have questions or concerns during the time of your child’s participation in this study, or after its completion. If you have any questions regarding this study, please feel free to contact the researchers Dr. Christopher Andersen or Ayse Oguz at the addresses and phone numbers provided below.

Sincerely,

Ayse Oguz
66W 8th Ave. B-3
Columbus/OH 43201
Phone: (614) 298 0071
e-mail: oguz.3@osu.edu

Christopher Andersen
Founders 2048
1179 University Drive
Newark OH 43055
Phone: (740) 366-9304
e-mail andersen.18@osu.edu.
CONSENT FOR PARTICIPATION IN SOCIAL AND BEHAVIORAL RESEARCH

Protocol Title:
Protocol Number:
Researchers: Dr. Christopher Andersen (Principal Investigator)
              Ayse Oguz (Co-Investigator)

I consent to my participation in (or my child’s participation in) in research being
conducted by Christopher Andersen and Ayse Oguz of The Ohio State University.

I have read and understand the information in the attached letter regarding the
purpose of the study, the procedures that will be followed, and the amount of time it will
take. I understand the possible benefits, if any, of my participation (and/or my child’s
participation).

I know that I can (and/or my child can) choose not to participate without penalty.
If I agree to participate, I can (and/or my child can) withdraw from the study at any time,
and there will be no penalty.

I have had a chance to ask questions and to obtain answers to my questions. I can
contact the investigators at andersen.18@osu.edu, (740) 366-9304; or oguz.3@osu.edu,
(614) 298-0071. If I have questions about my rights as a research participant, I can call
the Office of Research Risks Protection at (614) 688-8457.

I understand in signing this form that, beyond giving consent, I am not waiving
any legal rights that I might otherwise have. My signature on this form does not release
the investigator, the sponsor, the institution, or its agents from any legal liability for
damages that they might otherwise have.

I have read this form or I have had it read to me. I sign it freely and voluntarily. A
copy has been given to me.

Print the Name of the Participant

________________________________________
Signed: _____________________________
(Parent or Guardian's Signature) 
Date: ____________

________________________________________
Signed: _____________________________
(Student’s Signature) 
Date: ____________

________________________________________
Signed: _____________________________
(Researcher’s Signature) 
Date: ____________
Sayın Veli:


Araştırma süresince veya araştırma bitiminde bu çalışmaya çocuğunuzun katılmışla ilgili herhangi bir sorunuz veya endişeniz olabilir. Eğer herhangi bir sorunuz olursa lütfen çekinmeden Dr. Christopher Andersen veya doktora öğrencisi Ayşe Oğuz’a aşağıda verilen adres ve telefonlardan ulaşabilirsiniz.

Saygılarımızla

Ayşe Oğuz
Adres: 66W 8th Ave. B-3
Columbus/OH 43201
Telefon: +1 (614) 298 0071
e-mail: oguz.3@osu.edu

Christopher Andersen
Telefon: +1 (740) 366-9304
e-mail: andersen.18@osu.edu.
Araştirmaya Katılım İznı

Protokol Başlığı: 
Protokol Sayısı: 
Araştırmacılar: Dr. Christopher Andersen (Araştırma başkanı) 
Ayşe Öğuz (Araştırmacı)

Ohio State Üniversitesinden Christopher Andersen ve Ayşe Öğuz tarafından yürütülecek çalışmada yer almaya (veya çocukumun katılımına) izin veriyorum. Çalışmanın amacı, uygulanacak süreç ve uygulama süresi ile ilgili ekte sunulan bilgileri okudum ve anladım. Çalışmaya katılımımıla (veya çocuğumun katılımıyla) gerçekleştirebilecek katkıları öğrendim.

Ben (ve/veya çocuğum) araştırmaya katılmama kararı alabilirim. Eğer katılmaya karar verirse, ben (ve/veya çocuğum) hiç bir sorumluluk almadan çalışma esnasında fikir değiştirebilirim. Çalışmaya katılımımıza (veya çocuğumun katılımımıza) ret edebileceğimi biliyorum.


Öğrencinin Adı

________________________________________

İmza: _____________________________  Tarih: ____________

(Velinin İmzası)

İmza: _____________________________  Tarih: ____________

(Öğrencinin İmzası)

İmza: _____________________________  Tarih: ____________

(Araştırmacının İmzası)
BEHAVIORAL/SOCIAL SCIENCES
INSTITUTIONAL REVIEW BOARD
RESEARCH INVOLVING HUMAN SUBJECTS
THE OHIO STATE UNIVERSITY

ACTION OF THE REVIEW BOARD

Research Protocol:

2004B366 A STUDY OF MIDDLE SCHOOL STUDENTS' PERCEPTIONS OF EARTHQUAKES,
Christopher Andersen, Ayse Oguz, School of Teaching and Learning

presented for review by the Behavioral/Social Sciences Institutional Review Board to ensure the proper protection of rights and welfare of the individuals involved with consideration of the methods used to obtain informed consent and the justification of risks in terms of potential benefits to be gained.

The Board APPROVED the protocol.

NOTE: The study has been approved for the participation of minors according to 45 CFR 46.404. Participation in the study (questionnaires) does not place the subjects at greater than minimal risk and adequate provisions are in place for soliciting the permission of each child’s parents, as well as assent from the children as required by 45 CFR 46, section 408.

Approval for proposed research includes all materials submitted by the investigator unless otherwise noted.

It is the responsibility of the principal investigator to retain a copy of each signed consent form for at least three (3) years beyond the termination of the subject’s participation in the proposed activity. Should the principal investigator leave the University, signed consent forms are to be transferred to the Behavioral and Social Sciences Institutional Review Board for the required retention period. This application has been approved for a period of not more than one year. You are reminded that you must promptly report any problems to the Review Board, and that no procedural changes may be made without prior review and approval. You are also reminded that the identity of the research participants must be kept confidential.

Date: December 10, 2004  Signed: [Signature]
Chairperson

In-0259 Biomedical approval letter (08.04)
T.C
AYDIN VALİLİĞİ
İL MILLİ EĞİTİM MÜDÜRLÜĞÜ

SAYI : B.08.4.MEM.4.09.00.06-040/
KONU : Araştırma İzni

AYDIN

39430 20.12.2004

Sayın Ayşe OĞUZ
Sanayi Caddesi Erler Apt.No:19


Bilgilerinizi ve Bakanlığımızda gönderilmek üzere yapılan anket araştırma sonucunun bir örneğinin gönderilmesini rica ederim.

İlker KÖSE
Müşdür a.
Şube Müdürü

EK.1- Bakanlık Emri (1 sayfa)
APPENDIX E

CF-VARIMAX ROTATED EXPLORATORY FACTOR ANALYSIS

STATEMENTS AND LOADINGS FOR ONLY US DATA
<table>
<thead>
<tr>
<th>Statements</th>
<th>Rotated Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td>B7 Earthquakes are caused by rain</td>
<td>.942</td>
</tr>
<tr>
<td>B4 Earthquakes are caused by hot weather</td>
<td>.516</td>
</tr>
<tr>
<td>C9 Earthquakes can make the Earth turn faster</td>
<td>.461</td>
</tr>
<tr>
<td>A8 Earthquakes are disasters that happen only at night</td>
<td>.402</td>
</tr>
<tr>
<td>B9 Earthquakes are caused by volcanoes</td>
<td>.401</td>
</tr>
<tr>
<td>B11 Earthquakes are caused by foggy weather</td>
<td>.390</td>
</tr>
<tr>
<td>B10 Earthquakes are caused by toxic waste</td>
<td>.379</td>
</tr>
<tr>
<td>B5 Earthquakes are caused by nuclear testing</td>
<td>.368 .272</td>
</tr>
<tr>
<td>B8 Earthquakes are caused by thunder</td>
<td>.304</td>
</tr>
<tr>
<td>B14 Earthquakes are caused by tides</td>
<td>.362 .267</td>
</tr>
<tr>
<td>B3 Earthquakes are caused by construction workers taking down a building</td>
<td>.269</td>
</tr>
<tr>
<td>C5 Earthquakes can make people have trouble walking</td>
<td>.766</td>
</tr>
<tr>
<td>C7 Earthquakes can change the water level in wells</td>
<td>.671</td>
</tr>
<tr>
<td>C12 Earthquakes can damage inside of buildings</td>
<td>.611</td>
</tr>
<tr>
<td>C10 Earthquakes can damage trees</td>
<td>.496</td>
</tr>
<tr>
<td>A12 Earthquakes can occur under the ocean</td>
<td>.312</td>
</tr>
<tr>
<td>C6 Earthquakes can push houses into the soil</td>
<td>.264</td>
</tr>
</tbody>
</table>

Table E.1: CF-Varimax Rotated Exploratory Factor Analysis statements and loadings.
Table E.1 continued

<table>
<thead>
<tr>
<th>Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>B13 Earthquakes are caused by the deep noises coming from under the ground</td>
</tr>
<tr>
<td>B6 Earthquakes are caused by the Earth's core moving to the surface</td>
</tr>
<tr>
<td>A3 Earthquakes are deep noises coming from under the ground</td>
</tr>
<tr>
<td>B12 Earthquakes are caused by the Earth's core moving to the surface</td>
</tr>
<tr>
<td>D12 During earthquakes if you find yourself indoors it is usually better</td>
</tr>
<tr>
<td>D7 During earthquakes we should hold on to something metal</td>
</tr>
<tr>
<td>A6 Earthquakes are explosions</td>
</tr>
<tr>
<td>A1 Earthquakes are an eruption</td>
</tr>
<tr>
<td>A2 Earthquakes are a rock-forming process</td>
</tr>
<tr>
<td>A13 Earthquakes are a sudden ground motion produced by the release of</td>
</tr>
<tr>
<td>A7 Earthquakes are a release of energy stored in rocks</td>
</tr>
</tbody>
</table>

180
<table>
<thead>
<tr>
<th>Statements</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>A10 Earthquakes occur on faults</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.438</td>
</tr>
<tr>
<td>B1 Earthquakes are caused by movement along faults</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.330</td>
<td></td>
</tr>
<tr>
<td>C2 Earthquakes can move faults</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.293</td>
</tr>
<tr>
<td>C14 Scientist can predict earthquakes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.607</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D6 Scientist can accurately predict earthquakes before it happens</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.581</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C16 Some people can sense that earthquakes are about the happen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.298</td>
<td></td>
</tr>
<tr>
<td>C4 Earthquakes can cause heavy rain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.585</td>
<td></td>
<td></td>
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<tr>
<td>C11 Earthquakes can raise the temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.282</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C3 Earthquakes can cause dog to bark just before it happens</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.646</td>
<td></td>
</tr>
<tr>
<td>C15 Animals can predict earthquakes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.476</td>
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</table>