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Elementary School Students' Mental Models about Formation of Seasons: A Cross Sectional Study

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Abstract

The purpose of this study is to determine the mental models of elementary school students on seasons and to analyze how these models change in terms of grade levels. The study was conducted with 294 students (5th, 6th, 7th and 8th graders) studying in an elementary school of Turkey's Black Sea Region. Qualitative and quantitative data collection methods were used in the study. The students first were asked 3 open ended questions (one of them was a drawing) in order to determine their mental models on seasons. Following this, the students took an achievement test on seasons that consisted of 4 multiple questions. Quantitative data were analyzed by SPSS 20.0 while the qualitative data were analyzed by the researchers by using content analysis technique. The results of the study showed that the students construct the formation of seasons in various ways in their minds. However, differently from the literature, the presence of some new mental models was found. For a full understanding of the seasons, the necessity of a set of pre-learnings has been recommended. It will be useful to design basic activities based on hands-on and learning by doing which will enable the most effective learning and to put this in the textbooks in the most suitable way. Additionally tangible physical-scale hands-on models, 3D simulation modeling and planetarium environment should be used in students' education about formation of seasons.

Keywords: astronomy education, formation of seasons, mental models, science education

1. Introduction

Astronomy, as one of the oldest sciences, has contributed greatly to the process of understanding oneself and the environment for thousands of years. This process has made the basic natural sciences to emerge and to develop. Especially the first time when Galileo turned his telescope to the sky has become a touchstone in this process. Currently, the concepts of the space age which have become a part of our daily lives with all their dimensions have made astronomy culture indispensable (Türk & Kalkan, 2015). Astronomy has practical applications to timekeeping; calendars; daily, seasonal and long-term changes in climate; and navigation. It deals with the external environmental influences on the earth: the radiation and particles from the Sun, the gravitational influences of the Sun and Moon, the impacts of asteroids and comets (Percy, 2006). Today, astronomy education occurs also outside the class through means such as books, magazines, radio, TV, astronomy clubs, amateur-young groups-camps and the internet (Fraknoi, 1996).

When the literature is reviewed, concepts such as *day-night cycle*, *time zones*, *Moon's rotation*, *Solar and Lunar eclipses*, *Lunar phases*, *seasons*, *Sun overhead at noon*, *dimensions*, *distances*, *center of the universe*, *shape of the Earth*, *artificial satellite*, *constellations* are defined as the basic concepts of astronomy by researchers (Baxter, 1989; Bisard, Aron, Francek, & Nelson, 1994; Kalkan & Kıroğlu, 2007; Klein, 1982; Mant & Summers, 1993; Sharp, 1996; Sneider & Pulos, 1983; Trumper, 2001a, 2001b, 2001c, 2003, 2006a, 2006b; Trundle, Atwood, & Christopher, 2002; Zeilik, Schau, & Mattern, 1998). The researches about these concepts of astronomy that we constantly encounter in our daily lives show that the students have alternative conceptions or mental models different from scientific explanations and that as the students' ages-levels of education increase, these do not change too much (Agan & Sneider, 2003; Bisard et al., 1994; Danaia & McKinnon, 2007; Frede, 2008; Kavanagh, Agan, & Sneider, 2005; Kavanagh & Sneider, 2006a, 2006b; Kikas, 1998; Schoon, 1992; Tsai & Chang, 2005; Vosniadou, 1992; Vosniadou & Brewer, 1992, 1994). Among these concepts, the concept of seasons is especially one that the students have various alternative conceptions and mental models rather than

scientific explanations (Atwood & Atwood, 1996; Baxter, 1989; Frede, 2008; Sharp, 1996). The changing seasonal temperature patterns are the result of the seasonal change in the pattern of the Sun's daily apparent motion, which results in changes in the intensity of sunlight (more intense when Sun is higher in the sky resulting in increased temperatures) and changes in the length of day (longer days when the Sun's path is higher, resulting in increased temperatures). These changes in the Sun's path are the result of the tilt of the Earth on its rotational axis with respect to the plane of its orbit. Because of the Earth remains tilted in a relatively constant direction, observable changes in the Sun's path and the accompanying seasonal temperature changes alternate with the northern and southern hemisphere (Plummer & Maynard, 2014).

Why and for which reasons should seasons be taught? How important is it for science education to learn concept of seasons? Followings are important reasons for students to understand the formation of seasons;

- Understanding seasons includes methods such as observing the Sun's path in the sky, gathering evidence to understand local climate changes and testing and formulating alternative hypotheses about the changing interactions between the Earth and the Sun. Finally, learning to explain the reason for the seasons involves applying spatial thinking and reasoning, a key predictors of future success in science (Wai, Lubinski, & Benbow, 2009).

- Learning about the seasons is an important opportunity to develop and apply an understanding of several crosscutting concepts of science. The Framework for K-12 Science Education recommends that these crosscutting concepts including energy and patterns, that can "help provide students with an organizational framework for connecting knowledge from the various disciplines into a coherent and scientific based view of the world" (NRC, 2012).

- The flow of energy in systems is a crosscutting concept of science. Explaining the seasons involves the application of the relationship between energy and temperature—at a local and global scale (Edelson, Gordin, & Pea, 1999).

- Being able to distinguish the causes of seasonal variation and the atmospheric science of global climate change is another important episode in expanding upon children's ability to develop and differentiate perspectives among or between theoretical models and provides an excellent foundation for future citizen scientists who will likely be called upon to develop and/or ratify political responses to the prospect of global warming in their generation (Sneider, Bar, & Kavanagh, 2011).

- The concept of season encloses a great number of scientific disciplines as shown in Figure 1 (Sneider et al., 2011).

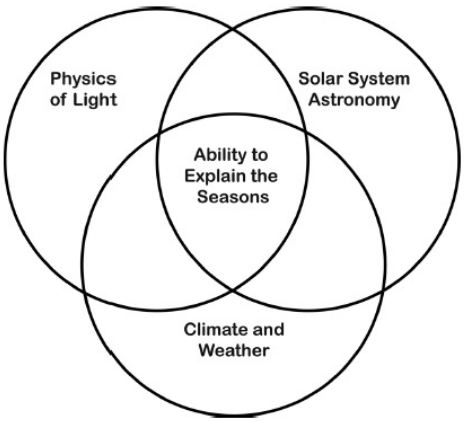


Figure 1. Seasons at the intersection of different disciplines

1.1 Literature on Conception of Seasons

There are various studies in literature about how students, prospective teachers and teachers perceive the concept of seasons. Some interesting results were found in these studies about the formation of the seasons. Baxter (1989) conducted an interview with 20 students between the ages 9-16 and a survey study with 100 students and showed

that the students had various ideas about seasons. In this study, six important thoughts about the seasons came out. These are:

- Cold planets get their heat from the Sun.
- Heavy winter clouds block the heat coming from the Sun.
- The Sun is farther to the Earth in winter.
- The Sun passes to the other side of the Earth to form the summer.
- The changes in plants make up the seasons.
- Seasons are due to Earth's axis being set at an angle to the Sun's axis.

Kikas (1998) conducted a similar study with five graders about the formation of the seasons. Since the formation of seasons is taught in grade five in Estonia, 20 five graders were interviewed at the end of the subject. Kikas stated that 50% of the students gave right answers by explaining the formation of seasons just like in the text books (The sun warms the Southern and Northern Hemispheres differently because the Earth's axis is tilted and the Earth revolves around the Sun) while 7 students confused the day-night formation with the formation of seasons. When the same students were interviewed again 4 years later (when they became 9th graders), it was found that only 4 of the students could explain the formation of seasons correctly. As a conclusion, the researcher emphasized that memorizing the reason for the formation of seasons could be effective only in the short term but would not work in the long term.

Trumper (2001a, 2001b, 2001c, 2003, 2006a, 2006b) conducted a series of studies with students of secondary school, high school, university and prospective teachers on the concepts of basic astronomy (including concept of seasons) in Israel. Although most of the students gave correct answers by stating that seasonal change occurred as a result of the Earth's axial tilt, they gave wrong answers to the question of why summer was warmer than winter. The most common view in these wrong answers was "The Earth is closer to the Sun in summer and it is farther in winter". Danaia and McKinnon (2007) administered the Astronomy Diagnostic Test in a study they conducted with 1920 7th, 8th and 9th graders from 30 schools in Australia. The test was modified for the South Hemisphere and a question was added that required the students to explain their ideas about why the seasonal change occurred. The subject of seasons is taught in 3rd, 4th and 7th grades in Australian educational system. Despite this, the most common statement coming from the students about the formation of seasons was "Seasons are formed as a result of the changing distance between the Earth and the Sun". The percentages of this alternative conception for the 7th, 8th and 9th graders were 85.4%-88.9%-91.7%, respectively.

In studies with teachers, similar alternative conceptions can be seen like the ones that elementary school, secondary school, high school and university students have (Parker & Heywood, 1998; Atwood & Atwood, 1996; Kikas, 2004; Mant, 1995; Mant & Summers, 1993; Ojala, 1992, 1997). According to these studies, a great number of teachers have the alternative conception that the Earth is warmer in summer months because it is closer to the Sun. In their study with 89 teachers in England, Parker and Heywood (1998) found that only 11 participants could explain the seasons scientifically. In a study with teachers, Kikas (2004) found that some of the teachers knew that the axial tilt of the Earth caused seasonal change while some of them thought that the axial tilt caused Estonia to get closer to the Equator and some of them thought that the orbit of the Earth (being closer to-farther from the Sun) caused the formation of seasons. These findings confirm the constructivist view that neither children nor adults are likely to fully understand a concept simply by being asked to memorize an explanation. Frede (2008) conducted a study in France with 20 teachers and found out three hypotheses as a result of the study:

- The Earth gets closer to the Sun in summer.
- Rotational axis changes its direction during the year.
- Rotational axis is oblique but it has a stable direction in the space.

The two most basic alternative conceptions of students, pre-service teachers and teachers are "*distance hypothesis*" and "*tilt oscillation hypothesis*". The underlying origin of the "*distance hypothesis*" mistake is the thought that the students have about the Earth being warm in summer because of being close to the Sun and being cold in winter because of being far from the Sun. In the second mistake (tilt oscillation hypothesis) the students do not think that the Earth's axis is not fixed and constant but they think that its axis goes towards and pulls away from the Sun. "Tilt oscillation hypothesis" alternative conception might also come from the fact that in some representations, the Earth is seen in two positions (summer and winter solstices) but with a different inclination of the rotation axis (Atwood & Atwood, 1996; Sebastia & Torregrosa, 2005).

1.2 Theoretical Framework: Model and Mental Models in Science Education

Model is the simplified presentation of a complicated object or process that helps to understand how a system works and equals real objects, phenomenon or the classification of phenomenon with a power to explain (NRC, 1996). Model is a structure that enables us to understand the formation and behavior of the object, the development of the process and to make predictions on these (Harrison, 2001). In a general sense, a model is a representation of a phenomenon, an object, or idea (Gilbert, 2004). In science, a model is the outcome of representing an object, phenomenon or idea (the target) with a more familiar one (the source) (Tregidgo & Ratcliffe, 2000). Model can be associated with only some features of a target or a thought. Some aspects of the target or thought should be excluded from the model. For example, the solar system model of the atom models the nucleus surrounded by electrons but excludes the delocalization of electrons, among other aspects (Van Driel & Verloop, 2002).

There are various kinds of models in science education. Before categorizing models, one should try to find out what makes them different. Thus, first it is necessary to understand the difference between conceptual and mental models. Conceptual models are designed as means to help understanding or teaching a system. In addition to this, conceptual models are external representations socially constructed and shared which are precise, complete and consistent with the shared scientific knowledge specially created to facilitate the comprehension or the teaching of the systems in the world (Greace & Moreira, 2000).

On the other hand, mental models guide people while they are using their thoughts (Norman, 1983). Mental models can be thought as the "mental simulation" of the real problem situation like probable ordinary models for the system or mechanism they represent. A mental model can never be completed, it can only continue to grow and develop when new knowledge is added (Greca & Moreira, 2000). Mental models are dynamic and produced representations that can be adjusted mentally to make assumptions about the conditions of the physical world and to make the casual explanation of a physical phenomenon (Vosniadou, 1994). Mental models are produced by individuals as a result of cognitive processes and used by students are not set; that is, they may change. According to Barquero (1995), mental model is implicit, incomplete, imprecise and disconnected with normal knowledge in many fields; but it is a powerful kind of knowledge since it is a powerful interpreter and predictive means for the interaction of the world and the individual and since it is a trustworthy source of knowledge because it comes from the individual's own perceptive and deductive experiences. Buckley et al. (2004) defined mental model as internal and cognitive representations. Mental models are the psychological representations of real or imaginary situations. They are formed with people perceiving and conceptualizing the events of the world in their minds. That is, mental models are the internal representations of the real situations in people's thoughts in order to understand and perceive the events of the world (Franco & Colinvaux, 2000). In other words, mental models are cognitive presentations that are used to reason, define, explain, estimate and sometimes control a phenomenon (Buckley & Boulter, 2000). Johnson-Laird (1983) stated that mental models are the structural simulations (analogies) of the world such as perception and conceptualization and that the basic source of these models is man's skills of perception. In parallel with this, Greca and Moreira (2000) states that people could not directly comprehend the world but they can form mental models with the inner representations of the world.

In order to understand mental models, their features should be taken into consideration. Mental models have a variety of features (Franco & Colinvaux, 2000). These are:

- Mental models are generative
- Mental models involve tacit knowledge
- Mental models are synthetic
- Mental models are restricted by world-view

People develop and use mental models according to their beliefs. In other words, a series of restrictions form the mental models used by people (Brewer, 2008; Vosniadou & Brewer, 1994). When a scientific knowledge is presented to them in class, they synthesize this knowledge with their previous assumptions and develop their new models. As the learning proceeds, the students modify this new model they synthesize gradually in a way that it can contain more scientific concepts. The teachers' mission is to lead the students' naive and initial models in such a manner that they will contain more scientific concepts. This situation requires presenting platforms for discussion to students and determining their present mental models instead of making them go through compulsory experiences that aim to teach only scientific knowledge. Determining students' present mental models will give teachers useful information in preparing a basis for them to structure knowledge as desired by knowing whether their present knowledge is correct or not.

It will be of use to compare the science education standards about the formation of seasons in various countries. The Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993) propose that students in the middle grades study observable phenomena that influence the seasons, followed by learning to explain these observations in high school: "because the Earth turns daily on an axis that is tilted relative to the plane of the Earth's yearly orbit around the Sun, sunlight falls more intensely on different parts of the Earth during the year". The Framework for K-12 Science Education (NRC, 2012) suggests a slightly different progression of instructional goals: seasonal patterns of the Sun rising and setting by the end of 2nd grade; explaining the changes in the Sun's apparent motion by the end of 5th grade; then explaining the seasons using the Earth's tilt relative to its orbit around the Sun by the end of 8th grade. Similarly according to the Next Generation Science Standards (NGSS, 2013), seasonal patterns of sunrise and sunset can be observed, described, and predicted by the end of 2nd grade; explaining the orbit of Earth around the sun, daily and seasonal changes in the length and direction of shadows and different positions of the Sun at different times of the day, month, and year by the end of 5th grade; explaining the Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the Sun and the seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year by the end of 8th grade. In Turkey, the formation of seasons is taught in primary (between 1st and 4th) and elementary schools (between 5th-8th grades) in the Science, Life Sciences and Social Studies education programs. Especially in 5th and 7th grades, the reason for the formation of seasons is not taught directly, but the students are told that during the daily and yearly motions of the Earth, day and night are formed with the Earth spinning on its own axis and seasons are formed with the Earth revolving around the Sun. Concepts such as axis tilt and orbit (elliptical) are not used in any way. In the 8th grade, the formation of seasons appears in science education program attainments as: "the student explains the reason for seasonal changes in temperature with the tilt in the revolving axis of the Earth" (T.M.E., 2010).

Studies done with students on the formation of seasons in general show the students' alternative conceptions on this subject and in part the experimental studies aimed to teach the concept of seasons to students. Based on the literature, it was found that there are only a few extensive studies that present the mental models of students on the formation of seasons. Thus, the purpose of our study was to determine the students' mental models. While doing this, we thought that it would be more appropriate to make a cross-sectional study design that was not used much for formation of seasons, unlike other studies. In addition, by comparing the changes in elementary school students based on their grades, the problems (if any) about this subject in the curriculum of elementary science teaching curriculum will be presented. For all these reasons, unlike other studies in literature, this study was planned not only to present the students' present situation but also to find out the changes in various levels (5th, 6th, 7th and 8th grades), to present the related problems and to propose solutions to these problems. Thus, this study has been planned for the gap in this area. Within this context, the following research questions were formed:

- What are the mental models of elementary school students about the formation of seasons?
- How do the mental models of elementary school students about the formation of seasons change based on their levels of grade?
- What are the alternative conceptions of elementary school students about the formation of seasons?
- How do the alternative conceptions of elementary school students about the formation of seasons change based on their levels of grade?

2. Research Model

This study is a descriptive research to determine the differences between the 5th, 6th, 7th and 8th graders' basic levels of knowledge and mental models on the formation of seasons based on their level of grade. Survey research designs are procedures in quantitative research in which investigators administer a survey to a sample or to the entire population of people to describe the attitudes, opinions, behaviors, or characteristics of the population (Creswell, 2012). In this research the data collected at just one point in time using cross sectional survey which is one of the survey designs. The cross sectional survey collects information from a sample that has been drawn from a predetermined population (Fraenkel, Wallen, & Hyun, 2012). Thus, the data were collected from the sample chosen from 5th, 6th, 7th and 8th grades.

2.1 Sample

The sample of the study consists of 5th, 6th, 7th and 8th graders chosen from an elementary school in the Black Sea Region of Turkey. The sample was chosen by simple random sampling method which is a random sampling

method (random sampling methods/ sample random sampling). With this purpose, a total of 294 students were included in the study by using simple sampling method (Table 1).

Table 1. The distribution of the research sample based on the levels of grade

Elementary School Students									
5th Grade		6th Grade		7th Grade		8th Grade		Total	
f	%	f	%	f	%	f	%	f	%
49	16.7	66	22.4	83	28.2	96	32.7	294	100.0

2.2 Data Collection Instrument and Data Analysis

The study included 4 multiple choice questions and 3 open ended questions to present the alternative conceptions and mental models of 5th, 6th, 7th and 8th graders on the formation of seasons. Multiple choice questions were prepared based on the findings of studies in the literature. KR-20 reliability coefficient of the test was found to be 0.86. The questions were analyzed in terms of their relevance for the level of the intended population and item analyses were conducted. For item analysis, total achievement test scores of each of the 294 students were calculated and the scores were arranged from the highest to the lowest. The first 27% of the score ranking (n=79) formed the upper group while the last 27% (n=79) of the score ranking formed the lower group. Item discrimination and difficulty were calculated. As a result of the item analysis that was conducted on the 4 items, the average discrimination of the questions was 0.38 (good discrimination) and the average difficulty of the items was 0.47 (intermediate difficulty). To ensure the content validity of the test, the views of three faculty members who specialized in science teaching program were obtained. When the views of these specialists were analyzed, the items that had consistency were left in the test. The questions were analyzed, discussed and assessed individually so that they could especially uncover the targeted alternative conceptions. In addition to multiple choice questions, 3 open ended questions were asked to collect more detailed information about the students' knowledge in the formation of seasons and to present their mental models and alternative conceptions. The question forms were finalized after the views of three experts in science education were taken.

In the science teaching curriculum in Turkey, astronomy subjects are generally taught at the end of the year as the last subjects of the academic term. Therefore, the data collection process was realized at the end of the term after the subjects were studied so that the levels of each grade were exactly reflected. In order not to affect the students' answers, open ended questions were asked first and two weeks later multiple choice questions were asked.

The answers of the students to 3 open ended questions were analyzed by the researchers through content analysis. The coding used for the analysis of the study was open coding which is one of the coding types suggested by Strauss and Corbin (1990). With this purpose, first of all the data were collected according to the code list formed by the conceptual structure and then rearrangements were made in the code list based on the new codes that came out during the analysis process. The resulting codes were grouped based on their similarities and differences and mental model categories were formed. The related literature was reviewed with the categories and each category was named based on their explanations.

The students' answers to the multiple choice questions were calculated as frequency (f) and percentage (%) values by using SPSS 20.0 program based on their level of grade. The answers of open ended questions were turned into tables as percentages within the related category/categories based on the answers given to the categories formed. Direct quotations were given in order to support the results and to present the perceptions of the students.

Table 2. Students' codes for the answer of open ended questions

Grade	Codes
5th Grade	S_1, S_2, S_3, …, S_{48}, S_{49}
6th Grade	S_{50}, S_{51}, S_{52}, …, S_{114}, S_{115}
7th Grade	S_{116}, S_{117}, S_{118}, …, S_{197}, S_{198}
8th Grade	S_{199}, S_{200}, …, S_{293}, S_{294}

In order to facilitate the content analysis and to present direct quotations, the participants were coded by being numbered from 1 to 294 as S_1, S_2, …, S_{294}. 1-49 represent 5th graders, 50-115 represent 6th graders, 116-198 represent 7th graders and 199-294 represent 8th graders (Table 2).

Table 3. Categories formed for the first and second open ended questions

Categories	Meaning of Categories
EarthSpin	- The spinning of the Earth on its own axis - The side of the Earth facing the sun is summer, the side that does not face the Sun is winter
EarthRotateSun	- The rotation of the Earth around the Sun (no mention of the Earth's spinning on its own axis and the Earth's axial tilt)
EarthSpinRotate	- The Earth's rotation around the Sun and spinning on its own axis based on both
Distance	- The Earth's getting closer to the Sun in summer and getting farther away from the Sun in winter and the change in seasons as the Sun gets away from the Earth
MoreEnergy	- Rays of the Sun giving off more energy in summer months - We see the Sun in summer and get warmer, we do not see the Sun in winter and we are less warm
Climate	- Explaining the general features of seasons (the general seasons of spring, summer, autumn and winter)
HeavyClouds	- Little or no clouds in summer, clouds preventing the rays coming from the Sun in winter
SunSpinRotate	- The Sun spinning on its own axis - The Sun rotating around the Earth
AxisTilt	- The tilt in the axis of the Earth and sun rays falling on the Earth with different angles
Irrelevant	- Irrelevant answers - Missing answers

During the content analysis, the same category list was formed for the first and second open ended questions (Table 3) while different categories (Table 4) were formed for the third open ended question since it is a drawing.

Table 4. Categories formed for the third open ended question

Categories	Meaning of Categories
EarthSpin	- Drawings that show only the Earth spinning on its own axis
EarthRotateSun	- Drawings that show the Earth rotating around the Sun (no drawings of the Earth's spinning on its own axis or its axial tilt)
EarthSpinRotate	- Drawings that show both the Earth's spinning on its own axis and its rotation around the Sun
Distance	- Drawings that show the Earth getting closer to and farther away from the Sun
Climate	- Drawings that show the general features of spring, summer, autumn and winter
SunSpinRotate	- Drawings that show the Sun spinning on its own axis and rotating around the Earth
EarthSun	- Drawings that show only the Earth and the Sun

FacingSun	- Drawings that divide the Earth with different seasons without showing the axial tilt
Irrelevant	- Irrelevant or missing drawings

3. Findings

The answers of the students to the 4 multiple choice questions and 3 open ended questions were analyzed as frequency (f) and percentage (%). While presenting the data, quantitative and qualitative data were presented under different subheadings.

3.1 The Analyses of Multiple Chose Questions

Table 5 presents the percentages of the correct answers given to multiple questions by the students.

Table 5. The distribution of the correct answers in the multiple chose questions based on the levels of grade

Item	Elementary School Students				
	5th Grade N=49 %	6th Grade N=66 %	7th Grade N=83 %	8th Grade N=96 %	Total N=294 %
1. What is the main reason that it is warmer in the summer than the winter?	34.7	36.4	43.4	65.6	**47.6**
2. What is the main reason for the formation of seasons?	22.4	18.2	18.1	17.7	**18.7**
3. Different seasons are lived in the two hemispheres of the Earth at the same time. What is the reason for this?	14.3	31.8	38.6	37.5	**32.7**
4. If the distance between the Earth and Sun would remain the same throughout the year, how would this affect the seasons?	10.2	12.1	8.4	11.5	**13.6**

The first three questions are intended for the same purpose but they are asked in different ways. The fourth question is a question that requires the students to put their knowledge in the first three questions into practice. It can be seen that there is no consistency between the students' correct answers. The most correctly answered question was the first question (47.6%), while the least correctly answered question was the fourth question (13.6%). When the answers were analyzed in terms of the change in the level of grade, 5th graders answered the third question "*whether different seasons were lived at the same time in different hemispheres*" correctly with a very low percentage (14.3%), while the percentages of the correct answer increased slightly in 6th, 7th and 8th grade. A significant difference was not observed in the percentages of correct answers given to the second and fourth questions while in the first question, which asked why summer was warmer than winter, the percentages of correct answers increased as the levels of grade increased.

Table 6 presents the distribution of the answers to the first question based on the choices and levels of grade.

Table 6. The distribution of the answers to the first multiple choice question based on the choices and levels of grade

1st Question	5th Grade N=49 %	6th Grade N=66 %	7th Grade N=83 %	8th Grade N=96 %	Total N=294 %
Earth closer to Sun in summer	28.6	53.0	48.2	26.0	**38.9**
Fewer clouds	10.2	1.5	1.2	3.1	**4.0**
*The Earth's axis points to the same direction relative to the stars, which is tilted relative to the plane of its orbit	34.7	36.4	43.4	65.6	**45.0**
The Sun gives off more energy in the summer	26.5	9.1	7.2	5.2	**12.0**

* The correct answer

The first question of the test asked the students the reason why summer was warmer than winter. 45.0% of the students answered this question correctly. The percentage of correct answers increased as the students' level of grade increased. The highest percentage of correct answers was given by the 8th graders. 38.9% of the students associated the seasonal differences of temperature with the concept of proximity-distance by giving the answer "*the Earth being closer to the Sun in summer*". In addition, the answers "*the Sun gives off more energy in the summer*" with a percentage of 26.5% and "*fewer clouds*" with a percentage of 10.2% given by 5th graders decreased as the level of grade increased.

Table 7 presents the distribution of the answers to the second question based on the choices and levels of grade.

Table 7. The distribution of the answers to the second multiple choice question based on the choices and levels of grade

2nd Question	5th Grade N=49 %	6th Grade N=66 %	7th Grade N=83 %	8th Grade N=96 %	Total N=294 %
The Earth spins on its axis	42.9	39.4	30.1	30.2	**35.6**
The varying distance between the Sun and The Earth	24.5	28.8	37.3	35.4	**31.5**
*The tilt of the Earth's axis as it rotates around Sun	18.3	18.2	18.1	28.1	**20.7**
Different amount of energy that the Sun releases in each season	14.3	13.6	14.5	6.3	**12.2**

* The correct answer

In the second question, the students answered the reason why seasons formed correctly with a percentage of 20.7%. An increase was found in the correct answers of the 8th graders when compared with the students of other grades. The percentage of correct answers to this question is way behind the percentage of the correct answers given to the first question. The most obvious alternative conception that the students have for this question is "*the Earth spins on its axis*" and the rate of this is 35.6%. Another alternative conception in this question is the concept of proximity-distance just like in the first question. The percentage of this alternative conception increased as the levels of the students increased.

Table 8 presents the distribution of the answers to the third question based on the choices and levels of grade.

Table 8. The distribution of the answers to the third multiple choice question based on the choices and levels of grade

3rd Question	5th Grade N=49 %	6th Grade N=66 %	7th Grade N=83 %	8th Grade N=96 %	Total N=294 %
The Sun spins on its axis	24.4	22.8	21.7	18.8	**21.9**
The Moon goes around the Earth	16.4	18.2	16.8	7.3	**14.7**
* Axial tilt of the Earth	14.3	24.2	26.6	37.5	**25.7**
The Earth spins on its axis	44.9	34.8	34.9	36.5	**37.8**

* The correct answer

While the rate of correct answers to the third question was higher than that of the second question, it was lower than that of the first question. The rate of correct answers to the question increased as the level of grade increased. Just like in the second question, a majority of the students (37.8%) had the thought "*the Earth spins on its axis*" for this question. In addition, unlike the other questions, 21.9% of the students were of the opinion that "*the Sun spins on its axis*". This alternative conception did not change much as the levels of grades increased and it was approved by the students of all grades.

Table 9 presents the distribution of the answers to the fourth question based on the choices and levels of grade.

Table 9. The distribution of the answers to the fourth multiple choice question based on the choices and levels of grade

4th Question	5th Grade N=49 %	6th Grade N=66 %	7th Grade N=83 %	8th Grade N=96 %	Total N=294 %
There would only be summer and winter	24.5	25.8	22.9	26.0	**24.8**
There would only be autumn and spring	18.4	16.7	9.6	11.5	**14.1**
The differences between the seasons would disappear and there would be no seasons	47.0	45.5	59.0	51.0	**50.1**
*The seasons would be as they are today	10.2	12.1	8.4	11.5	**10.6**

* The correct answer

In the fourth question that was a practice of the first three questions, the students were asked the question "*If the distance between the Earth and the Sun would remain the same throughout the year*, *how would this affect the seasons?*" 50.1% of the students gave the wrong answer that "*there would be no seasons*" if the distance between the Earth and the Sun remained the same throughout the year. This thought is in parallel with the thought that "*the Earth is closer to the Sun in summer*" which greatly caused the students to give the wrong answer in the first question. In this question, only 10.6% of the students gave the correct answer "*the seasons would be as they are today*". Eighth graders who were more successful than others in the first three questions could not show the same level of success in this question.

3.2 The Analyses of Open Ended Questions

The percentages of the answers that the students gave to the first open ended question based on the categories and levels of grade are presented in Table 10.

Table 10. The distribution of percentages the first open ended question answers based on the categories and levels of grade

1st Question: Why is summer warmer than winter? Please explain.					
Answers	**5th Grade**	**6th Grade**	**7th Grade**	**8th Grade**	**Total**
	%	**%**	**%**	**%**	**%**
EarthSpin	10.2	13.6	12.0	5.2	**10.3**
EarthRotateSun	16.3	12.1	12.0	6.2	**11.7**
EarthSpinRotate	4.1	-	2.4	1.0	**1.3**
Distance	20.4	27.3	31.3	31.2	**27.6**
MoreEnergy	26.5	18.1	19.3	19.8	**20.9**
Climate	8.2	12.1	12.0	10.4	**10.7**
HeavyClouds	4.1	3.0	2.4	1.0	**2.6**
SunSpinRotate	2.0	1.5	1.2	1.0	**1.4**
AxisTilt	-	1.5	-	14.6	**4.0**
Irrelevant	8.2	7.2	10.9	10.5	**9.2**

Table 10 analyzes the answers that the students gave to the question "*Why is summer warmer than winter*?" It was found that 27.6% of the students had the "***Distance***" model that associates the difference in temperature between seasons with the Earth's being close to or far from the Sun. As the level of grade increases, it can be seen that the students' explanations about seasonal temperature differences focus on this model. The followings are examples to the views of some students who have this model:

> *"Summers are warm because the Sun is closer to the Earth in summer. It gets further in winter"* (S_{115}).
>
> *"The Earth rotates around the Sun, follows an imaginary line. One side of this line is close to the Sun, while another side of it is far from the Sun. When it moves closer, it is summer and warm. When it moves further away, it is winter and cold"* (S_{67}).
>
> "*When the Earth rotates around the Sun for 365 days, it sometimes comes too close to the Sun and the season of summer is formed as a result of this"* (S_{126}).

20.9% of the students explained with "***MoreEnergy***" model that the Sun gives off more energy in summer or rays of the Sun has more energy and thus, summer months are warmer. It was found that the students preferred this model less as their level of grade increased. The followings are examples of the answers of students who have this model:

> *"It is warmer in summer since the Sun sends more energy than in winter"* (S_{100}).
>
> *"The Sun gives off more rays in summer and summer months are warmer"* (S_{159}).
>
> *"In summer, the temperatures are high everywhere since the Sun is more intense*" (S_{186}).

Without mentioning the Earth's spin around itself and the axial tilt, 11.7% of the students explained the temperature difference with "***EarthRotateSun***" which explains that as a result of the rotation of the Earth around the Sun, there is summer on the side of the Earth that faces the Sun and there is winter on the side that does not. The followings are some of the examples of the students who have this thought:

> *"The Earth rotates around the Sun and the side of the Earth that faces the Sun is warm, the side that does not is cold"* (S_{27}).

"While the Earth is rotating around the Sun, the temperature gets warmer in the side that faces the Sun. Summer comes with the months June, July and August and the weather gets warm" (S_{112}).

"While the Earth is rotating around the Sun, one side faces the Sun, the other does not. The side that faces the Sun is summer and the side that does not is winter" (S_{36}).

10.7% of the students explained the differences in temperature between summer and winter months with the "***Climate***" model by telling the general features of the seasons or climate. Some of the students explained this model as follows:

"It rains and snows in winter. It is cold then. It is sunny and warm in summer" (S_{22}).

"Summer months are more humid and arid" (S_{60}).

"Since it rains and snows in winter it is cold and it gets warmer if the Sun comes out in summer" (S_{101}).

In this question, 4.0% of the students explained the temperature difference between summer and winter by using "***AxisTilt***" model which is accepted as the scientific explanation. When the answers are analyzed in terms of level of grade, it can be seen that 8th graders gave the highest number of correct answer with a rate of 14.6%. The followings are the views of some students who gave the correct answer:

"When the Earth rotates around the Sun, rays of the Sun reach the Earth more directly in summer, because of this, summers are warmer" (S_{267}).

"Rays of the Sun reach the Earth more directly in summer" (S_{273}).

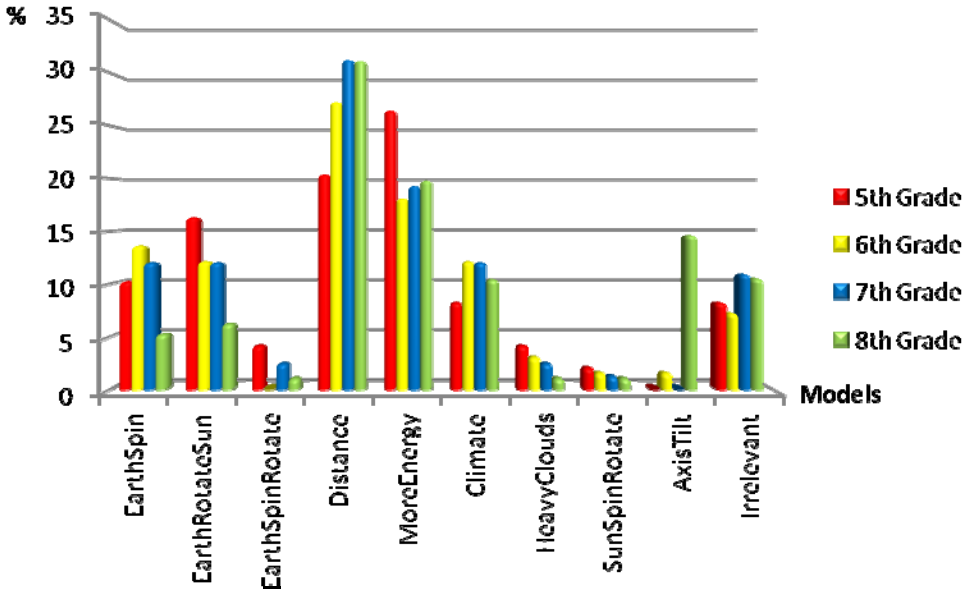


Figure 2. The bar graph of answers given to the first open ended question based on the categories and levels of grade

When the bar graph (Figure 2) that shows the distribution of answers given to the first open ended question based on the level of grade is analyzed, it can be seen that the students' answers centered on "*Distance*" and "*MoreEnergy*" categories in all levels of grade. The increase in the level of grade and the "*Distance*" model are parallel. On the contrary, there is a decrease in the rate of "*EarthRotateSun*" model as the level of grade increased. Although there is no obvious correlation between "*MoreEnergy*" model and the level of grade, this model can be seen in a great percentage in all levels of grade. When the category of "*AxisTilt*", which is the correct answer, is examined, it can be said that almost none of the 5th, 6th and 7th graders answered correctly while a great number of 8th graders answered correctly.

The percentages of the answers that the students gave to the second open ended question based on the categories and levels of grade are presented in Table 11.

Table 11. The distribution of percentages the second open ended question answers based on the categories and levels of grade

2nd Question: How the seasons are formed? Please explain.					
Answers	**5th Grade %**	**6th Grade %**	**7th Grade %**	**8th Grade %**	**Total %**
EarthSpin	10.2	10.6	12.0	10.4	**10.8**
EarthRotateSun	36.7	42.4	38.5	38.5	**39.0**
EarthSpinRotate	18.3	12.1	9.6	1.0	**10.3**
Distance	4.1	9.1	7.2	2.1	**5.6**
MoreEnergy	4.1	3.0	2.4	1.0	**2.6**
Climate	6.1	6.0	7.2	7.3	**6.7**
HeavyClouds	4.1	-	1.2	2.1	**1.9**
SunSpinRotate	10.2	9.1	8.4	5.2	**8.2**
AxisTilt	-	1.5	3.6	20.8	**6.5**
Irrelevant	8.2	7.6	13.3	14.5	**10.9**

Table 11 shows the percentages of the answers the students gave to the open ended question "*How the seasons are formed?*" It can be seen that 39.0% of the students had the ***"EarthRotateSun"*** model which expresses the formation of seasons as a result of the Earth rotating around the Sun regardless of the Earth's spin and axial tilt. They are of the opinion that changes in seasons occur based on the side of the Earth that faces the Sun and the side that does not along the orbit that the Earth follows around the Sun. This model was preferred in almost the same percentages even if the levels of grades changed. The followings are some of the examples of the answers given by the students who have this view:

> *"For instance, the Sun sends its rays to the Earth when the Earth rotates around the Sun. But there is a difference and it changes based on the months"* (S_{177}).
>
> *"They occur as the result of a cycle in 365days"* (S_{257}).
>
> *"Seasons are formed as a result of the rotation of the Earth around the Sun in 365 days and 6 hours"* (S_{50}).

The mental model that had the second highest percentage in this question is "***EarthSpin***" which supports the thought that "*Seasons are formed with the Earth spinning around itself*" with 10.8%. No numerical change is observed in the model based on the level of grades. Some of the students expressed this view as the following:

> *"The formation of seasons is associated with the spin of the Earth, the Earth's side facing the Sun is warm, the dark side is cold"* (S_{140}).
>
> *"When the Earth is spinning on its own axis, one side of it is turned to the Sun and the seasons are formed"* (S_{122}).
>
> *"As the Earth spins in its own axis, seasons change. Summer and spring are formed in half of the Earth that face the Sun, but since the other half is cold, winter and autumn are formed there*" (S_{182}).

10.3% of the students explained the question with "***EarthSpinRotate***" model which states that the seasons are formed as a result of Earth both spinning on its own axis and rotating around the Sun. When the answers are analyzed, it is seen that the students got away from this model as the level of grades increased. Some of the answers of students who have this view are as follows:

> *"Seasons are formed by the Earth spinning on its axis while rotating around the Sun at the same time"* (S_{84}).
>
> *"Seasons are formed by the Earth spinning on its axis and rotating around the Sun"* (S_{155}).

In this question, 6.5% of the students explained the formation of seasons by using "***AxisTilt***" model which is accepted as the scientific explanation. When the answers are analyzed in terms of the level of grade, it can be

seen that 8th graders gave the highest rate of correct answer with 20.8%. Some of the students who gave the correct answer stated their views as the following:

> *"The Earth forms the seasons by rotating around the Sun. Seasons are formed as a result of the 23° 27' tilt between the Earth's axis and its orbital plane"* (S_{270}).
>
> *"Seasons are formed as a result of the tilt between the Earth's axis and its orbital plane that forms while the Earth is rotating around the Sun"* (S_{276}).

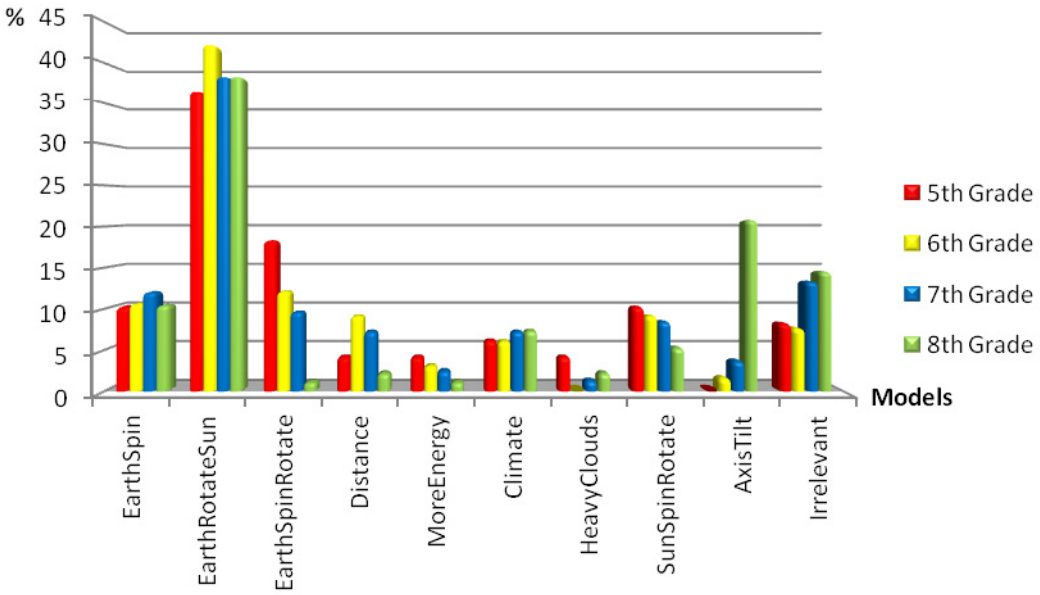
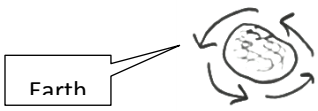
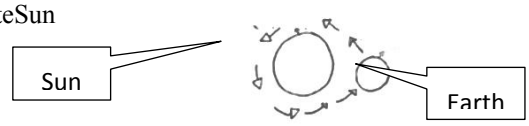
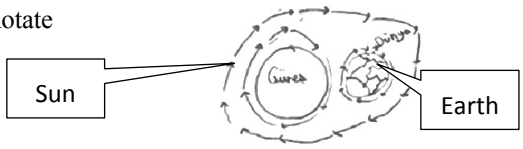
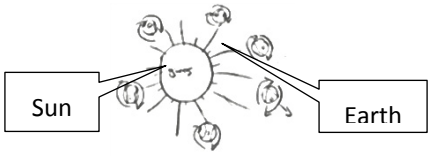
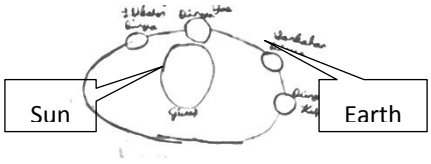
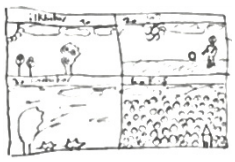
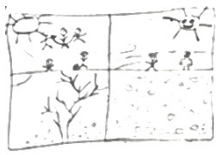
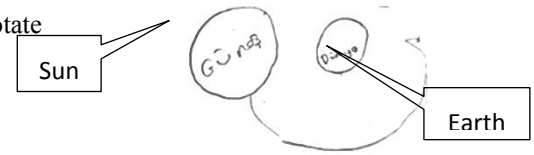
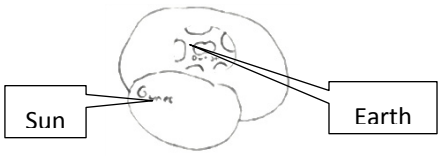
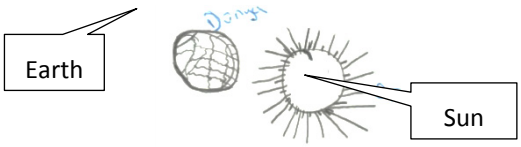
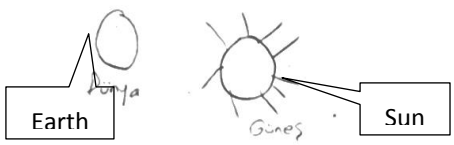
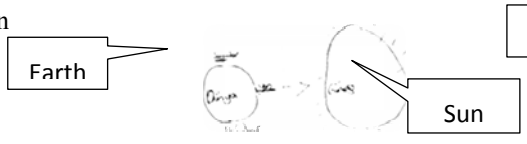
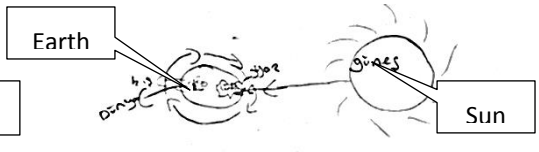


Figure 3. The bar graph of answers given to the second open ended question based on the categories and levels of grade

When the bar graph (Figure 3) that shows the distribution of answers given to the second open ended question based on the level of grade is analyzed, it can be seen that the students' answers centered on "***EarthRotateSun***" category. When the correct answer "***AxisTilt***" is considered, it is seen that a great number of 8th graders answered correctly just like in the first open ended question. "***EarthSpinRotate***" category decreased as the level of grade increased. The "***Climate***" category which explained the formation of seasons with the features of climates is used more in 7th and 8th grades when compared with 5th and 6th grades. Although there is no obvious correlation between "***EarthSpin***" model and the level of grade, this model can be seen in a specific rate in all levels of grades.

Table 12 shows the categories that were formed by the analysis of the drawings answering the open ended question *"Show by drawing how seasons are formed"* and sample student drawings for each category.

Table 12. Sample drawings based on the models

Categories	*Sample Drawing I*	*Sample Drawing II*
EarthSpin		
EarthRotateSun		
EarthSpinRotate		
Distance		
Climate		
SunSpinRotate		
EarthSun		
FacingSun		

The percentages of the answers that the students gave to the third open ended question based on the categories and levels of grade are presented in Table 13.

Table 13. The distribution of percentages the third open ended question answers based on the categories and levels of grade

3rd Question: Show by drawing how seasons are formed.					
Answers	**5th Grade**	**6th Grade**	**7th Grade**	**8th Grade**	**Total**
	%	**%**	**%**	**%**	**%**
EarthSpin	-	6.1	13,2	12.4	**7.9**
EarthRotateSun	42,9	45.4	43.2	49.1	**45.2**
EarthSpinRotate	20,4	3,0	3,6	3,1	**7.5**
Distance	4,1	3,0	3.6	2,1	**3.2**
Climate	2,0	1,5	7.3	6.2	**4.3**
SunSpinRotate	-	6,1	3,6	2,1	**2,9**
EarthSun	10,2	19,7	8,4	13,5	**13,0**
FacingSun	14,3	9,1	7.3	2.1	**8.2**
AxisTilt	-	-	-	-	**-**
Irrelevant	6,1	6,1	9.7	9.4	**7.8**

Table 13 shows the percentages of the answers to the open ended question "*Please show by drawing how seasons are formed*" based on the categories and levels of grades. 45.2% of the students tried to explain the formation of seasons by drawing "***EarthRotateSun***" model which states that seasons are formed as a result of the Earth rotating around the Sun without stating the Earth's spinning on its own axis and its axial tilt. 13.0% of the students explained the formation of seasons by the "***EarthSun***" model without making a drawing that could mean an orbit or rotation just by drawing the Earth and the Sun next to each other. When the other drawings by the students were analyzed, it was seen that 8.2% drew the "***FacingSun***" model which drew the Earth and the Sun next to each other meaning that the side facing the Sun was summer and the other side was winter; 7.5% drew the "***EarthSpinRotate***" model which stated that seasons were formed as a result of the Earth spinning on its own axis and rotating around the Sun; 7.9% drew the "***EarthSpin***" model which stated the spinning of the Earth on its own axis; 4.3% drew the "***Climate***" model that reflected the general features of the seasons; 2.9% drew the "***SunSpinRotate***" which stated the Sun rotating around the Earth; and 3.2% drew the "***Distance***" model which stated that summer was formed when the Earth was close to the Sun and winter was formed when the Earth was far from the Sun.

When the student answers to the third open ended question were analyzed, it was seen that almost half of students were centered on the drawing of "***EarthRotateSun***" model. When the percentages of the other models are analyzed, it can be seen that the rate of students who used "***EarthSpinRotate***" model was 20.4% in 5th grade while this rate was very low in 6th, 7th and 8th grades. The number of students who used "***FacingSun***" model in 8th grade is scarce while the rate of "***Climate***" model showed an increase in 7th and 8th grades when compared with 5th and 6th grades.

The diagrams of *AxisTilt*, *Distance*, *EarthRotateSun*, *EarthSpinRotate and EarthSpin* models taken from the answers of students are presented in Figure 4, Figure 5, Figure 6, Figure 7, Figure 8 and Figure 9.

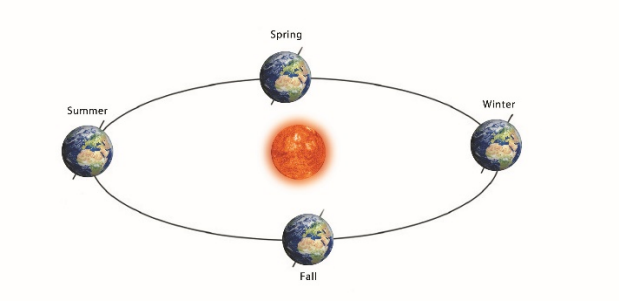


Figure 4. Axial Tilt model

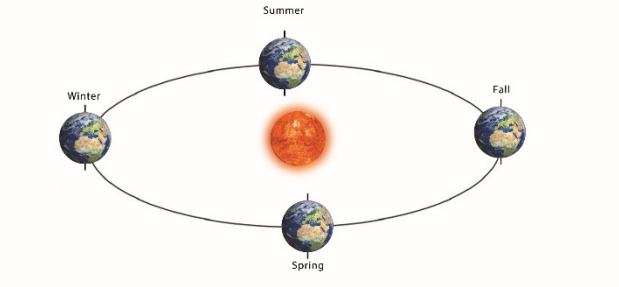


Figure 5. Distance model

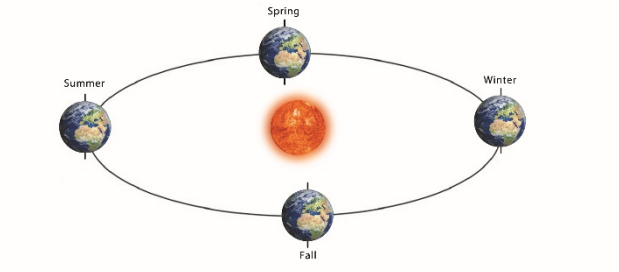


Figure 6. Earth Rotate Sun model

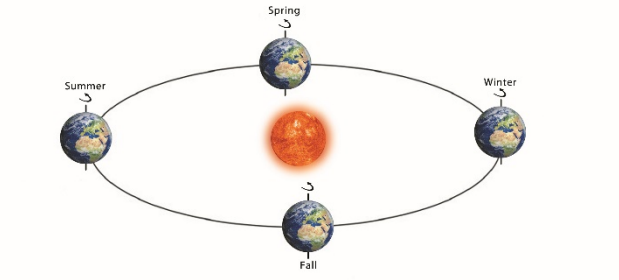


Figure 7. Earth Spin Rotate model

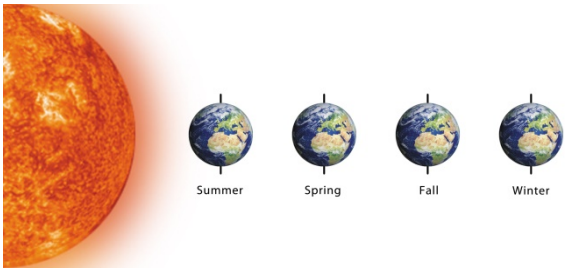


Figure 8. Distance model (no orbit)

Figure 9. EarthSpin model (no orbit)

4. Conclusions and Discussion

The most general result of this study which aimed to determine the mental models of elementary school students on the formation of season was that the students defined the formation of seasons in various ways and that they had mental models which were far from scientifically correct explanations. According to the data obtained as a result of the study, the students' alternative conceptions obtained from the multiple choice questions are in parallel with the mental models obtained from open ended questions.

It can be seen that there is no consistency between the results of multiple choice questions which were prepared to find out whether the concept of seasons was memorized or learned by the students. The reason for this is the fact that the rate of correct answers to the questions that were prepared to test the level of "*understand*" (making comparisons and associations between events) was comparatively higher than that of the questions prepared to test the level of "*apply*" (implementing the existing knowledge to a new situation) question according to Bloom's cognitive process dimension that aims to assess how the knowledge is transferred to another situation (Krathwohl, 2001). It was found that almost half of the students answered the reason "*why summer was warmer than winter*" and the percentage of correct answers increased as the level of grades increased. On the other hand, a great majority (38.9%) of the students gave the answer "*the Earth is closer to the Sun in summer*" to the question of why the Earth was warmer and thus associated the seasonal differences of temperature with the concept of proximity-distance. In the second multiple question which asked the reason why seasons were formed, a great majority of the students made their explanations by basing them on theories such as "*The Earth spinning on its own axis*" (35.6%) and "*proximity-distance*" (31.5%). This result shows that the students know have memorized the thought that the formation of seasons is caused by the Earth's axial tilt. This is because while almost half of the students gave the correct answer (*axial tilt*) to the first question that asked about the temperature differences between seasons, only a small number of students (20.7%) could give the correct answer *(axial tilt)* to the second question. In addition, an increase was found in the correct answers of the 8th graders when compared with the students of other grades. The question "*If the distance between the Earth and sun would remain the same throughout the year*, *how would this affect the seasons?*", which was prepared based on the choice "*the Earth being closer to the Sun in summer*" that made the students fall into alternative conception most was answered by almost half of the students (50.1%) as "*the differences among seasons would disappear and there would be only one season*". This thought supports the thought "*the Earth's being closer to the Sun in summer and being further from the Sun in winter*". When the multiple choice questions were analyzed in general, it was seen that the students gave correct answers to the questions which were aimed to test their knowledge in a higher rate than the questions that were aimed to test their practice (apply). Asked directly or indirectly about the

formation of seasons, the students tried to explain with alternative concepts such as "*proximity-distance*" which explained that the Earth's distance was not the same during its rotation around the Sun throughout the year and "*the spinning of the Earth on its own axis*". This situation obviously shows that the students learned the subject of seasons not by comprehending it but by heart.

In the qualitative part of the study, the students gave various answers to open ended questions about the formation of seasons. The students' mental model categories were formed from the students' answers and drawings. These are *EarthSpin*, *EarthRotateSun*, *EarthSpinRotate*, *Distance*, *MoreEnergy*, *Climate*, *HeavyClouds*, *SunSpinRotate* and *AxisTilt* models. Some of these models (Distance, MoreEnergy, Climate, HeavyClouds, AxisTilt) are already in literature and some of them (EarthSpin, EarthRotateSun, EarthSpinRotate, SunSpinRotate) are recommended to literature as new mental models encountered in students. When the students' mental models for the open ended question "*Why is summer warmer than winter*?" were examined, it was seen that the students' models centered on "*Distance*", "*MoreEnergy*" and "*EarthRotateSun*". In the question "*How seasons are formed?*", the students had the models of "*EarthRotateSun*", "*EarthSpin*" and "*EarthSpinRotate*" mostly. The presence of different mental models in the answers given to two questions that aim to test the same thing show that the students' thoughts on seasons are complicated just as in multiple-choice questions. Students who lack a sophisticated understanding of the relationship between the earth's rotation and our observations of the sun and the shape of the earth's orbit may find that the more sophisticated concepts which use tilt and the angle of the sun's rays to be incompatible with or incomprehensible to their mental model. Developing students' knowledge at the lower rungs of the learning progression should hypothetically be the function of elementary school astronomy instruction (Plummer & Maynard, 2014).

In young ages, children prefer the experiences they get from their daily lives to scientific explanations while perceiving the physical world. For the most part young students' ideas involved near and familiar objects. Older student gave explanations involving astral bodies changing their positions. Especially two results of our study support this view. The most observed mental model in all grade levels is the "*Distance*" model. In this model, the students have the thought "*The Earth gets closer to the Sun in summer and further away from the Sun in winter or seasons change as the Sun gets farther away from the Earth*". It is thought that students probably got this thought from their daily experiences that an object gets warmer when it approaches a warm object and cooler when it gets away from that warm object. This situation is commented by the students when the weather is warm in summer as "*The Earth should be closer to the Sun*" or "*As the Earth gets farther from the Sun the seasons of summer*, *spring*, *autumn and winter occur respectively*". In addition, it can be seen that the students' explanations of the seasonal differences of temperature center on this model as their levels of grade increases. Also another reason for this alternative conception that is seen frequently in literature is thought by researchers who have reached a similar alternative conception to be resulting from visuals about seasons in textbooks. The visuals in textbooks showing the Earth's rotation around the Sun in elliptical orbit cause the students to think that the Earth is warmer in summer since it is closer to the Sun and cold in winter since it is further from the Sun. Although children learn the seasons in early periods, they develop the theory of distance after they learn that the Earth rotates around the Sun (Kikas, 1998; Ojola, 1992, 1997; Schnepps & Sadler, 1989). As is known, the Earth's distance to the Sun is 146.4 million kilometers when it is closest to the Sun and 151.2 million kilometers when it is farthest to the Sun. January 3 when the Earth is closest to the Sun is the perihelion and July 4 when it is the farthest is the aphelion. However, drawings in various sources which are made to emphasize that the distance between the Earth and the Sun changes on the days of perihelion and aphelion and the shape of the orbit is elliptical, it can be seen that the distance between the Earth and the Sun is drawn regardless of real proportions (Simonelli, 2004). Thus, it increases the "*Distance*" alternative conception. Another popular model among students is the "*MoreEnergy*" mental model which was formed from the answers of students who thought that the Sun's rays gave off more energy in summer months. In this model, the students probably comment on temperature change by starting from the view that as the intensity of source of heat increases in daily life, the heat of the environment increases, too.

The students who have the "*EarthRotateSun*" mental model partially know the formation of seasons but they haven't fully comprehended it. These students state that seasons are formed as a result of Earth rotating around the Sun without mentioning "*Axial tilt*". This model was preferred by the students with approximately the same percentages even if their levels of grade changed. There are only a small number of students who made explanations based on the "*AxisTilt*" model that includes the scientific explanations about the formation of seasons. None of the students in 5^{th} grade explained through this model while scarcely any students in 6^{th} and 7^{th} grades explained through it. However, there was an increase in the use of this model in 8^{th} graders. This result shows that the subject of seasons is gradually comprehended in the level of 8^{th} grade.

In the question that required the students to draw the season formation models in their minds, almost half of the students explained the formation of seasons by drawing "*EarthRotateSun*" model in which the Earth rotates around the Sun without drawing the axial tilt. An interesting result was the absence of the correct answer in the students' drawings. The presence of "*EarthSun*" and "*FacingSun*" models were seen in the drawing question. The fact that the students drew the "*EarthSun*" model just by drawing the Earth and the Sun next to each other without drawing any orbit or rotation shows that they could not comprehend the dynamics of this concept. The students who drew the "*FacingSun*" model which shows the Earth and the Sun next to each other with the side facing the Sun as summer and the other side as winter preferred their daily observations and intuitive beliefs to scientific explanations. In general, the students were the most unsuccessful in the drawing question.

As is seen from the results of this study, students had various alternative conceptions and mental models that were not in line with scientific explanations. Therefore, a full comprehension of the concept of seasons requires some pre-learning. These are the concept of axial tilt, constructing the association between the Earth's tilt and the intensity of sunlight that falls on a unit cell of the Earth, movements of the Earth, day and night getting longer and shorter based on seasons, seasons being different from each other and the difference in the seasons in South and North hemispheres. Otherwise, students construct the concept of seasons in their minds with the experiences, beliefs and informal learning they get from their daily lives. Such learnings are different from scientific explanations and students attribute wrong meanings to the concepts.

In Turkish education system, the subject of seasons is taught within the courses of Science, Life Sciences and Social Sciences directly or indirectly from the first grade to the eighth grade. In textbooks, there are visuals and subjects about the seasons and the students are not fully explained scientifically how the seasons are formed until the 8th grade. The seasons are visualized in textbooks, they are introduced only by their general features and the reason why seasons are formed is explained as a result of the yearly movement of the Earth (with no mention of the axial tilt). The results of this study show that all the learnings that are formed about the subject of seasons in seven years until the 8th grade do not easily give way to new learnings in the 8th grade. Although the subject of seasons has a full place in the curriculum of 8th grade, it can be seen that the students' alternative conceptions and various mental models are not fully eliminated yet. In addition, it is thought that "*EarthRotateSun*" and "*Climate*" models, which are two of the models that explain the formation of seasons, are based on the visuals and knowledge about this subject in textbooks. Students cannot easily give up their incomplete learnings caused by textbooks until they became 8th graders. These results show that there are problems in Turkish education system in how the subject of seasons, the effects of which we always feel in our lives, is taught. Students will not have the chance to learn the subject of seasons again after they graduate from elementary school. Thus, the subjects that are misconception or learned incompletely will become much more rooted in the years ahead and it will be very difficult to change them.

It has been stated by a great number of studies that teachers and prospective teachers have problems with the basic concepts of astronomy including the formation of seasons (Bisard et al., 1994; Kalkan & Kıroğlu, 2007; Kalkan et al, 2014; Pasachoff & Percy, 2005; Trumper, 2003, 2006a, 2006b; Zeilik et al., 1998). Thus, this situation will cause teachers to form similar alternative conceptions in students while teaching astronomy concepts. As stated by Pasachoff and Percy (2005), astronomy concepts are in the teaching curriculum of many countries but either teachers do not know these concepts adequately or they experience problems while teaching these concepts to students. From this point of view, it has been thought that one of the reasons why students have various ideas about the formation of seasons is the fact that teachers transfer their alternative conceptions to students.

In this study, rather than making a recommendation about in which grade and at which age seasons should be taught, by emphasizing the diversity of students' mental models on this subject and the changes in these models based on levels of grade; we point to the complexity of the seasons as a set of observations combined with an explanatory model and prepare a groundwork on the formation and shaping of learning processes for science teachers and program development experts.

In general, considering the results of the study, the following recommendations have been made for researchers;

- Instead of telling the students how seasons are formed in short, it will be of more use to design basic activities based on hands-on and learning by doing which will enable the most effective learning and to put this in the textbooks in the most suitable way.
- It will be useful for students to include in science programs activities that will enable the students to comprehend the change of the Sun's path in the sky based on seasons with the help of their own observations.

- In order to be able to give students the necessary pre-learnings (the concept of axial tilt, constructing the association between the Earth's tilt and the intensity of sunlight that falls on a unit cell of the Earth, movements of the Earth, day and night getting longer and shorter based on seasons, seasons being different from each other and the difference in the seasons in South and North hemispheres) for the comprehension of seasons, it will be of use to teach the students abstract concepts perceptibly. Thus, it is thought that while teaching the seasons, it will be useful to use hands-on models in classrooms which show the Earth's axial tilt, the movements of the Earth in the elliptic orbit and which also show that the rays of the Sun reach the different parts of the Earth in different angles during these movements.

- It is thought that trying to teach the formation of seasons in classroom by making 2D drawings on the board will not be sufficient for a subject that requires too much 3D and spatial thinking. Thus, 3D simulation modeling and planetarium environment should be used in students' education. Students instructed in a planetarium environment are able to enhance their knowledge of seasons from a rote memorization level to a comprehension level. Thus, concept of season which is difficult to taught to the students in the concrete operational stage with two-dimensional figures can be instructed with alternative methods appropriate to constructivist approach.

5. Research Limitations and Future Directions

- The development process of students' mental processes about seasons can be examined by a longitudinal study that examines the mental development process of the same sample group in 5^{th}, 6^{th}, 7^{th} and 8^{th} grades.

- The subject of formation of seasons can be examined in detail by an experimental study that uses various teaching methods and techniques and researches can be made to eliminate the alternative conceptions found in students.

- This study has found that students have some models (EarthSpin, EarthRotateSun, EarthSpinRotate and SunSpinRotate) other than the mental models in literature. Future studies can test the presence of these models.

- Another limitation of the study is the fact that there are a great number of different socio-economic and cultural regions and schools in Turkey; it is difficult to make generalizations from the results of this study. This study can be implemented on schools of different socio-cultural structure, the results may be generalized and solutions may be recommended accordingly.

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