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# From Elementary to University Students' Ideas About Causes of the Seasons

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## ABSTRACT

This research was a cross-age study that sought to determine and compare students' ideas about the causes of the seasons. Toward this aim, the research was carried out with 974 students at different educational levels and across the various age groups. First, the data obtained from the responses to the open-ended question was categorized according to a rubric formulated in line with the goal of the study. The methodology used in analyzing the data derived from the interviews was a grouped categorization of those responses that were construed as having similar intended meanings. Statistically, a significant difference was found between the groups of university students aged 20-22 and the other groups of students who were between the ages of 10-19. In addition, whereas the frequency of encountering some misconceptions decreased with age, on the other hand, the frequency of other misconceptions showed an increase in older students. At the same time, there were some misconceptions which did not vary significantly in frequency across the age groups and still others that did show changes.

**Keywords:** Cross-Age Study; Causes of the Seasons; Research into Learning.

## INTRODUCTION

In recent years, there have been many studies conducted in the field of science education to discover what ideas students have about different concepts (Duit, 2009). These studies have shown that students come to the classroom with different ideas about the concepts about which they will be learning. Since the preliminary knowledge students have when they enter the classroom is based on different sources, such as their daily experiences and what they have learned in the family and in the community, and because their educational backgrounds might be different as well, there will also be differences in their preliminary knowledge. When students' advance information diverges from scientific concepts, the literature refers to this information as misconception (Eaton, Anderson & Smith, 1984, Gilbert, Osborne & Fensham, 1982; Hewson & Hewson, 1984). Although there can be many

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different sources of misconception, some that can be mentioned here are daily experience (Klammer, 1998), language (Klammer, 1998), textbooks (Bryce & MacMillan, 2009; Helm 1980; Ivowi, 1984) and mistakes teachers make in teaching particular topics (Helm, 1980; Ivowi, 1984). The misconceptions students have may prevent the learning of new knowledge (Helm & Novak, 1983). For this reason, there is a need to determine what students' misconceptions are so that activities can be designed to encourage a change toward the adoption of scientific concepts. To effect this change, however, is not an easy process because many misconceptions are hard to comprehend, inconsistent, and in some instances, extremely resistant to change (Windschitl & Andrew, 1998, in cited by Hsu 2008). Studies have shown that misconceptions can continue to exist despite formal instruction (Hewson & Hewson, 1983; Hsu, 2008; Strike & Posner, 1992; Wild, 2010).

A look into the literature on astronomy education reveals that the most frequently encountered concepts studied are the seasons, the phases of the moon, eclipses, distance and size. The causes of the seasons, the topic on which the present cross-age study has focused, has been examined among kindergarten children (Küçüközer & Bostan, 2010), elementary school pupils (Baxter, 1989; Dunlop, 2000; Sharp, 1996), high school students (Hsu, 2008; Sadler, 1992; Tsai & Chang 2005), and university students (Atwood & Atwood, 1997; Küçüközer, 2007). The studies report many misconceptions about the causes of the seasons among different age groups. In these studies a single education level of the sample' ideas are revealed. Unlike this study revealed students' ideas in different education levels from elementary school to university level about the concept of seasons and compared with each other.

The misconceptions cited in the literature about the causes of the seasons as "the seasons are caused by the change in the distance of the Earth to the Sun" and "the seasons occur as a result of the Sun's orbit around the Earth" have been found to exist in studies carried out with all age groups (Atwood & Atwood, 1997; Trumper, 2000; Trumper, 2001; Küçüközer, 2007, Küçüközer & Bostan, 2010; Dove, 2002; Dunlop, 2000; Sadler, 1992; Sharp, 1996; Tsai & Chang, 2005). The misconception, "the seasons are caused by the Earth's rotation around its own axis" appears before us across groups of kindergarten, elementary school and university students (Atwood & Atwood, 1997; Küçüközer, 2007; Küçüközer & Bostan, 2010). The misconception, "the seasons are caused by the change in the distance between the Earth's hemispheres and the Sun as a result of the tilt in the Earth's axis" has been encountered among elementary school, high school and university students (Baxter, 1989; Sadler, 1992; Tsai & Chang, 2005). The erroneous idea that "clouds cause the seasons" has been a misconception found among kindergarten and elementary school students (Küçüközer & Bostan, 2010; Baxter, 1989; Sharp, 1996). Some other misconceptions encountered only in certain age groups were: "changes in plants cause the seasons" (Baxter, 1989; Sharp, 1996) and "the sun warms up in the summer and cools off in the winter" (Dunlop, 2000; Sharp, 1996), encountered among elementary school students; "the gases causing the ocean currents and global warming are what cause the seasons" an idea seen among high school students (Sadler, 1992); and "the seasons occur because the world is orbiting around the Sun and at the same time rotating around its own axis" among university students (Küçüközer, 2007).

It can be said in general that while these studies have exhibited that there are certain misconceptions among students of certain ages, misconceptions that are more frequently encountered are those which usually exist across the age groups. In this context, it can further be said that students graduate with the same misconceptions and non-scientific ideas that they had when they first entered the classroom (Wild, 2010). It is for this reason that most misconceptions show similarity across the different age groups.

**Cross-age Studies**

Longitudinal and cross-age studies are used to discover what ideas students have at different age levels (Abraham, Williamson & Westbrook, 1994). Compared to longitudinal studies which spend a long period of time on the same group, cross-age studies have a shorter schedule and thus allow the researcher to study different age groups within the same period of time (Abraham et al. 1994; Gay & Airasion, 2000; Thomas, Nelson & Silverman, 2005). Abraham et al. (1994) report that cross-age studies are more useful than longitudinal studies when considering a particular period of time, and Blanco and Prieto (1997), Krnel, Glazar and Watson (2003), and Westbrook and Marek (1991) have obtained successful results in their cross-age research.

Many researchers have used cross-age studies for various concepts in science education. For example, Abraham et al. (1994) have conducted studies with 100 second-tier elementary school, high school and university prep students, Coll and Treagust (2003) with 15 students between the ages 16-24, Çakmakçı, Leach and Donnelly (2007) with 191 students between the ages of 15-19, Çalık and Ayas (2005) with 441 students between the ages of 13-17, Çepni and Keleş (2006) with 250 students between the ages 11-22, Krnel, Glazer and Watson (2003) with 84 students between the ages of 3-13, Özdemir and Clark (2009) with 32 students between the ages of 5-16, and Ültay and Ültay (2009) with 191 students between the ages of 13-17. The basic outcome of all of these studies has been that the frequency of misconceptions decreases with age but those misconceptions still continue to be seen across the age groups, albeit in different proportions. There are few cross-age studies about various astronomy concepts which is one of the science topic. Only Baxter (1989), Dunlop (2000), Agan (2004), and Plummer (2009) did studies that investigate what ideas students of different age groups have about various concepts in astronomy.

One of these is the research carried out by Baxter (1989) in a study of 100 students, ages 9-16, in which the students' notions about the phases of the moon and the seasons were treated. The most commonly encountered misconception about the phases of the moon across all of the age groups was that the Earth's shadow was falling on the moon. It was also reported in the study that students confused the phases of the moon with the concept of an eclipse. As regards the causes of the seasons, younger children were seen to believe that "cold planets take away the heat of the Sun and the heavy winter clouds prevent the Sun's rays from coming to Earth". On the other hand, older pupils thought that "the sun travels to the other side of the Earth in summer". The misconception "the Earth is farther from the Sun in winter and closer in summer" was the most frequently encountered misconception across all the age groups. The results of this study indicated that as age increases, the frequency of encountering misconceptions decreases, but at the same time, misconceptions continue to be encountered in older age groups. Dunlop (2000) carried out a study of 67 students, ages 7-14, in which the objective was to reveal students' ideas about day/night, the phases of the moon, the seasons, and the concept of orbiting, both before and after instruction was given about these topics in school. A misconception that was encountered on the subject of day and night was that "just as the Sun causes the day, the moon causes the night". While students of younger ages explained the reason for the phases of the moon as their belief that the clouds were getting in the way of the moon, the frequency of encountering this particular misconception diminished at older ages. The idea, however, that the moon is somehow being covered up by something and that it is this that causes the phases of the moon to occur was a misconception that continued, even after the subject was taught in school. The frequency of the misconception of believing that the distance of the Earth to the Moon is the reason for the seasons was 9% before the topic was taught and 6% afterwards. This study indicated that younger children had more misconceptions but that misconceptions continued to be seen in older students. It can be seen furthermore that teaching a topic is not completely effective in dispelling

misconceptions. Agan (2004) conducted a study with 17 students, ages 14-19, in which the students' ideas were examined about which star is closest to the Earth and the differences between stars and planets. None of the high school first-year students could provide the correct answer that the Sun was the closest star to Earth; students instead claimed that the North Star was the brightest star in the sky. The misconception that stars are smaller than the Sun diminished with age and disappeared among university first-year students. The misconception about how stars change with time to the effect that stars turn into falling stars over time was an idea seen among high school first-year students but not seen in the higher age groups. The misconception that stars are closer than the Sun diminishes too with age and is not seen among university students. Although the conclusion drawn in this study was that misconceptions decrease as children get older, it was also seen that 3rd and 4th-year high school students who had taken astronomy had less misconceptions in their minds than university first-year students. Plummer (2009) studied 60 students ranging between the ages of 6-14 to find out what their ideas were about the movement and orbit of the Sun in winter and summer, the changes in the appearance of the moon, and the changes in the movement of the stars. While it was seen that elementary school children could not draw a picture of more than one shape of the moon, it was noted that students in older age groups were able to explain the phases of the moon more accurately. Fourteen-year-olds understood the movement of the Sun but students in younger groups had many different ideas about this concept. A large part of these ideas are of the nature of misconception. For example, the most frequently encountered misconceptions were "the sun goes to its highest point more than once during the day" and "the sun rises and sets all within 45 degrees". The most accurate response about the changes in the appearance of the moon was mostly received from older students. The misconceptions that the moon changes in appearance in less than one night and that the moon does not come up in the daytime were more prevalent among young pupils. In this study, all of the misconceptions encountered across the age groups were similar but younger students displayed a higher percentage of misconceptions.

In short, similar to the results obtained from the studies in science described above, cross-age research on topics in astronomy also showed that all age groups had misconceptions and that as students got older, the frequency of encountering misconceptions decreased.

The objectives of the present study were to discover what ideas students of different age groups had about the causes of the seasons and to compare the different groups in this context. Another objective was to discover what misconceptions students had about the causes of the seasons and how their misconceptions changed with age. Our two research questions according to study aim were the following:

1- What ideas did students have about the causes of the seasons and how did these ideas change with age?

2- What were the misconceptions students had about the causes of the seasons and how did these misconceptions change with age?

## METHODOLOGY

The research was carried out with a cross-age or, as it is generally referred to, a cross-sectional design technique, a type of development research that focuses on making comparisons of ages as one of the methods used in descriptive research. Cross-age studies are effective in uncovering and assessing the ideas students have at different age levels. Mixed method has been determined as a research method. At the research the qualitative data were embedded into the quantitative one. The main data collection technique was an open-ended survey and the responses were quantitatively scored using a rubric and the secondary data tool was interview that served as a support element for the main data.

### a) Sample

The sample of the study was a total of 974 students between the ages 10-22. The students comprising the sample were selected by simple random sampling from five elementary schools, five middle schools, four high schools and one university education department located in a midsize city in the north-western part of Turkey. Simple random sampling is subset of a statistical population in which each number of the schools has an equal probability of being chosen. All of schools in the sample are public schools. Deciding the age groups starting from the $4^{th}$ grade class began taking science lessons with the three class range of students were selected. At the university level all students were included in the science education department from the faculty of education. At university level the sampling divided two groups because third and fourth class students have been take formal astronomy instruction before the research. Table 1 displays the class levels of the groups, the number of students and the range of ages involved.

**Table 1.** *Characteristics of Sample Groups*

| Group | Class Level | Number of Students | Range of Ages |
|---|---|---|---|
| Group 1 | Elementary 4th and 5th grades | 260 | 10-11 |
| Group 2 | Middle 7th grade | 250 | 13 |
| Group 3 | 2nd year high school | 223 | 16 |
| Group 4 | 1st and 2nd year university | 110 | 18-19 |
| Group 5 | 3rd and 4th year university | 131 | 20-22 |

All of the students in the sampling had received formal education about the causes of the seasons. In this study, the researchers did not give the student groups any special instruction about the study subject. The aim was to have the students answer the question on the basis of what they had already learned in school. The sampling was divided into five groups of different ages and educational levels. In determining the age groups, the researchers considered which class the students were in at the time of the study and in which class they had last received instruction on the causes of the seasons. The classes in which the students in the different age groups had received formal instruction on the seasons were in 4th grade elementary school for Group 1, 6th grade middle school for Group 2, and 1st year high school for Groups 3 and 4. Because Group 3 was made up of high school and Group 4 comprised university students, these students were divided in two separate groups. The students in Group 5 had additionally received formal instruction in their 4th semester astronomy class and for this reason were separated from the students in Group 4.

### b) Collection of Data

To explore the ideas students of different age groups had about why the seasons occur, the students in the sampling were asked a written question: “What causes the seasons?”. The scientifically acceptable answer expected as a response to this question was the tilt of the Earth’s axis while orbiting around the sun. They were asked to explain to their responses in writing. Determining misconceptions between the responses of the students were utilized the misconceptions related to causes of the seasons in the literature. Two researchers have analysed the 50 open-ended questions independently and researchers’ consistency was calculated as .89 percent. In addition, a semi-structured interview was conducted with a randomly selected volunteer from each age group. Interview form has been prepared by the two researchers together and was examined by two science educators to get an expert opinion.

Semi-structured interviews were held with 18 students from Group 1, with 12 students from Group 2, with 8 students from Group 3, with 8 students from Groups 4 and 5 taking average 10 minutes. The interviewer (the first researcher) talked to the students on a one-to-one basis. The interviews were conducted in order to support the data obtained from the open-ended question and to elicit more in-depth information.

### c) Data Analysis

The explanations students offered about the causes of the seasons were fitted into a five-category rubric (Table 2) that was created based on the studies of Atwood and Atwood (1997), Barnett and Morran (2002) and Tsai and Chang (2005). Each category was scored and analysed. Thus, the data arranged in this way facilitated the comparison of the responses of students across the different age groups. The content of the rubric is briefly explained in Table 2.

**Table 2.** *Code and Score Legend for Calculating Questionnaire Scores*

| Score | Categories | Explanation of Categories |
|---|---|---|
| 4 | Correct answer | In this category, students gave an answer that may be considered scientifically accurate and were able to correctly explain the reason for their response. Example: *The seasons occur because of the tilt of the Earth's axis while orbiting around the Sun.* |
| 3 | Correct answer + misconception | In this category, the answer given to the question is correct but the explanation contains a misconception. Example: *Because the Earth's axis is tilted, the distance between the hemispheres and the Sun changes and this causes the seasons.* |
| 2 | Misconception | Only explanations containing misconceptions were included in this category. Example: *In summer, the Earth is closer to the Sun and that's why the weather is warmer. In winter, the Earth is at a further distance from the sun and therefore benefits from it less and the weather becomes cold.* |
| 1 | Couldn't be encoded | In this category, students' answers are either unrelated to the topic or there are statements that were incomprehensible to the researcher. |
| 0 | No response | In this category, students did not offer any comment on the question. |

After the written responses of the students were reviewed by both researchers, a decision was made regarding into which category each of the students' responses would fit. Each student's response was placed in only one of the five categories. The percentage of students responding to each category of the rubric from the various age groups was calculated. Thus, the researchers were able to find the frequency of each response of the students in the different age groups in each category and also make a cross-age comparison. Each category in the study was given a score and a qualitative analysis was carried out. The

SPSS 12.0 package program was used for the qualitative analysis of the data. In order to be able to make a quantitative comparison between groups, each category of the rubric was assigned a score in descending order (4-0) and the total score of the various age groups was calculated to find out whether there was a difference between groups. The score corresponding to the category in the rubric into which the student's response fit was entered into the SPSS program and the same program was used to calculate the total score of students in each group. Before ANOVA test applied, it was determined that data showed a normal distribution. The ANOVA test was used in the comparison of group scores to determine whether there were significant differences between groups. If the results of the ANOVA displayed a significant difference across the age groups, the "Tukey Post Hoc" test was used to determine between which groups the difference lay.

The misconceptions encountered in the study were fitted into the misconception category of the rubric and the frequency of these misconceptions was calculated. In this way, not only were the misconceptions revealed but the frequency of encountering these misconceptions in the various age groups was also determined. The results of the frequency calculations made it possible to compare how misconceptions changed in the various age groups. The Results section uses the data obtained from the semi-structured interviews set forth in the section following the categories of misconceptions. The interviews were recorded and transcribed after the completion of the sessions. The methodology used in analysing interview data was a grouped categorization of those responses that were construed as having similar intended meanings. The categorizations were mostly based on misconceptions that had been reported in previous studies. (Each student interviewed was given a group number to indicate which group he/she belonged to and then each student in the group was given a code number. For example, the 5th student in Group 2 was given the code number S2-5).

To increase reliability of the data analysis, randomly selected sample of students' answers to the questions were analyzed by a science educator and response categories are placed. Reliability between scores from the researches and outside researcher involved in the study was calculated as 0.92.

## FINDINGS

### a) Results of Responses to Research Question 1

This section deals with the responses to the question about the causes of the seasons offered by students who were divided into 5 groups on the basis of their ages and educational levels. First of all, the students' responses were imposed in the appropriate category in the rubric and then a total frequency was calculated for each age group represented in the various categories. Table 3 below shows the categories representing the responses of the different age groups and the frequencies recorded in these categories.

**Table 3.** *Categories of Responses by Group and Frequency*

| Response Categories | Group 1 | Group 2 | Group 3 | Group 4 | Group 5 |
|---|---|---|---|---|---|
| | n (%) | | | | |
| Correct answer | 4 (1.5) | 1 (0.4) | 9 (4.0) | 3 (2.7) | 65 (49.6) |
| Correct answer + misconception | 15 (5.8) | 2 (0.8) | 24 (10.8) | 5 (4.5) | 30 (22.9) |
| Misconception | 225 (86.5) | 214 (85.6) | 187 (83.9) | 94 (85.5) | 31 (23.7) |
| Couldn't be encoded | 15 (5.8) | 31 (12.4) | 3 (1.3) | 7 (6.4) | 5 (3.8) |
| No response | 1 (0.4) | 2 (0.8) | 0 (0) | 1 (0.9) | 0 (0) |
| Total | 260 | 250 | 223 | 110 | 131 |

As can be seen in Table 3, the percentages of the correct answer that the cause of the seasons is the tilt of the Earth's axis while orbiting around the sun, with the exception of Group 5, very low and very close to each other across the ages. However, almost half of Group 5, made up of students who had taken a class in astronomy at the university, gave the correct answer. The high rate of correct responses in the students in Group 5 may be explained by the impact of the university-level course on the students. Below are presented excerpts from the interviews held with one of Group 5 students who gave correct explanation.

*I: Can you say something about what you were taught in your astronomy class?*
*S5-4: We had the support of computers in most of the lessons. The instructor used animations. Also, we discussed our ideas with each other in class.*
*I: Did the teaching have an impact on your ideas?*
*S5-4: Of course. First of all, I learned a lot that I didn't know and I saw that some of what I thought I knew was incorrect.*
*I: What were your thoughts on the causes of the seasons before the instruction?*
*S5-4: Before the instruction, I used to think that summer occurred as the Earth neared the Sun and winter happened when the Earth drew away from the Sun.*

The students in Group 5 stated in the interviews that the class had been taught with the help of various computer programs and that animations were also used. Teaching was further supported with class discussions. The students said that computer-supported teaching had an impact on their ideas. However, as seen in Table 3, the students in Group 5 were still unable to dispel all of their misconceptions and as a result, after the formal teaching, close to half of the students continued to have their previous misconceptions.

In the 'correct answer + misconception' category, different percentages were encountered in the different age groups. The most frequent response in this category was "because the Earth's axis is tilted, the distance between the hemispheres and the Sun changes and this causes the seasons". While the simple answer was the tilt of the Earth's axis, the misconception was formulated around the idea that the tilt of the axis caused a change in the distance of the hemispheres to the Sun. The percentages of this category among Groups 1, 3 and 5 are higher compared to Groups 2 and 4. This type of response was mostly seen in students in Group 5. The students in Group 5 knew the concept of the tilted axis because they

had received formal instruction in this a short while ago but they were still unable to abandon the misconception about the Earth's distance to the Sun. It was found that students offering this response had been affected by the teaching but also had difficulty giving up their misconceptions. A student in Group 5 whose answer fell in this category expressed his ideas as follows.

*I: You've explained that the seasons are caused by the change in the distance of the hemispheres to the Sun as a result of the tilt in the Earth's axis. Could you clarify this?*
*S5-2: The seasons occur because the Earth's axis is tilted. And because of this, the distance of the hemispheres to the Sun changes. For example, in summertime, the northern hemisphere is closer to the sun whereas it's farther away in wintertime.*

In the 'misconception' category, the percentage corresponding to Group 5 students was 23% while that corresponding to the other age groups was approximately 85%. Although however, there was an increase in the percentage of correct answers in Group 5, the students who had received university instruction, the frequency of their misconceptions diminished. In the other groups, it can be said that their formal teaching did not have much of an impact on their producing the correct answer. In Group 5, the computer-supported program of teaching gave rise to an increase in the percentage of correct responses and also caused a reduction in misconceptions.

The ANOVA results showing the relationship between the different age groups in terms of their responses to the question about causes of seasons are shown in Table 4.

**Table 4.** *ANOVA Results across the Groups*

| Source | Sum of Squares | df | Mean Square | F | p |
|---|---|---|---|---|---|
| Between Groups | 142,011 | 4 | 35,503 | | |
| Within Groups | 302,375 | 969 | ,312 | 113,773 | 0,001 |
| Total | 444,386 | 973 | | | |

* p<0.001

As seen in Table 4, there are significant differences between age groups in students' responses to the question about the causes of the seasons at the p<.05 level for the five groups [F(4, 969) = 113,773, p= .001)]. The results of the "Tukey Post Hoc" test carried out to determine between which age groups there were significant differences is given in Table 5.

A look into Table 5 shows that the "Tukey Post Hoc" test results indicate that there was a significant difference between the scores of Group 5 students who had taken a course in astronomy and the scores of students in all the other age groups; the difference favored the scores of students in Group 5. There was also a significant difference in favor of Group 3 students between the scores of Group 2 and Group 3 students. There was no other significant difference between the other groups.

**Table 5.** *Tukey Post Hoc" Test Results*

| | | Mean Difference | Std. Error | p |
|---|---|---|---|---|
| Group 1 | Group 2 | 0,155 | 0,050 | 0,017 |
| | Group 3 | 0,143 | 0,051 | 0,042 |
| | Group 4 | 0,014 | 0,064 | 0,999 |
| | Group 5 | 1,053* | 0,060 | 0,000 |
| Group 2 | Group 1 | 0,155 | 0,050 | 0,017 |
| | Group 3 | 0,298* | 0,052 | 0,000 |
| | Group 4 | 0,169 | 0,064 | 0,066 |
| | Group 5 | 1,208* | 0,061 | 0,000 |
| Group 3 | Group 1 | 0,143 | 0,051 | 0,042 |
| | Group 2 | 0,298* | 0,052 | 0,000 |
| | Group 4 | 0,129 | 0,065 | 0,279 |
| | Group 5 | 0,910* | 0,062 | 0,000 |
| Group 4 | Group 1 | 0,014 | 0,064 | 0,999 |
| | Group 2 | 0,169 | 0,064 | 0,066 |
| | Group 3 | 0,129 | 0,065 | 0,279 |
| | Group 5 | 1,039* | 0,073 | 0,000 |
| Group 5 | Group 1 | 1,053* | 0,060 | 0,000 |
| | Group 2 | 1,208* | 0,061 | 0,000 |
| | Group 3 | 0,910* | 0,062 | 0,000 |
| | Group 4 | 1,039* | 0,073 | 0,000 |

* $p<0.001$

**b) Results of Responses to Research Question 2**

Table 6 displays the misconceptions about the causes of the seasons and the frequency of these misconceptions among the various age groups. The 'correct answer + misconception' category was included in the misconceptions listed in Table 6 because, as mentioned before, this category encompassed misconceptions in addition to the right answers. The calculation of the frequencies in Table 6 considered the total of the 'correct answer + misconception' and 'misconception' categories.

Although the misconceptions about the causes of the seasons which were encountered within the various age groups were similar, the frequency of encountering these misconceptions displayed differences across the age groups. The frequency of some of the misconceptions dropped with the increase in age; that of others increased, while still others showed almost no difference or differences within the particular age group.

**Table 6.** *Misconceptions about the Causes of the Seasons*

| Misconception | G. 1 (n=240) | G. 2 (n=216) | G. 3 (n=211) | G. 4 (n=99) | G. 5 (n=61) |
|---|---|---|---|---|---|
| | % (n) | | | | |
| -The Earth orbits around the Sun | 67.1 (161) | 60.2 (130) | 71.6 (151) | 55.5 (55) | 36.1 (22) |
| -The change in the distance to the Sun of the Earth's hemispheres | 6.3 (15) | 5.6 (12) | 16.1 (34) | 5.1 (5) | 11.5 (7) |
| -Earth's distance from the Sun changes as it orbits around the Sun | 4.2 (10) | 6.9 (15) | 7.1 (15) | 27.2 (27) | 49.2 (30) |
| -The rotation of the Earth around its own axis | 10.4 (25) | 9.3 (20) | 1.9 (4) | 2 (2) | 1.6 (1) |
| -The Earth's orbiting both around the Sun and around itself | 4,6 (11) | 7.9 (17) | 2.4 (5) | 8.2 (8) | 1.6 (1) |
| -The Sun's orbiting around the Earth | 6.6 (16) | 8.8 (19) | 0.9 (2) | 2 (2) | - |
| -Clouds cause the seasons by blocking the Sun | 0.8 (2) | 1.3 (3) | - | - | - |

Two examples of the misconceptions that were less encountered as age increased were "the rotation of the Earth around its own axis" and "the clouds obstruction of the light rays of the Sun". Figure 1 shows the frequency percentages across the age groups of the misconception "the seasons are caused by the Earth's rotation around its own axis" which decreased as age increased.

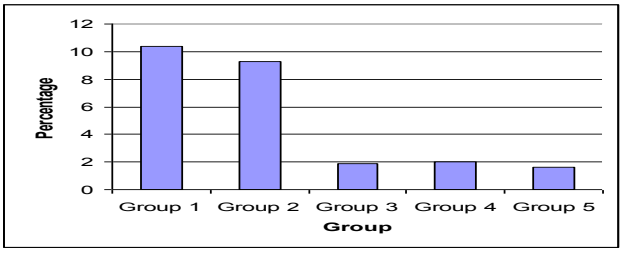


**Figure 1.** *Frequency Percentages across the Age Groups of a Misconception That Was More Encountered at Small Age Groups and Less Encountered at Old Age Groups*

The frequency of the misconception "the seasons are caused by the Earth's rotation around its own axis" was seen to drop as age increases. This misconception was most encountered among the students of Group 1 and 2 and the decreasing frequency seen in the students of Groups 3, 4 and 5 was observed to ultimately approach each other. Similarly, the misconception that seasons are caused by the obstruction of the light rays of the sun by clouds appeared before us only in the students in Groups 1 and 2, being nonexistent among students of older ages. The students in Group 1 with this misconception expressed their ideas as follows.

*I: Why do the seasons occur?*
*S1-8: The seasons occur because of the clouds.*
*I: How do the clouds affect the seasons?*
*S1-8: In wintertime, you can see that the clouds are darker and that's why there are less light rays coming from the sun. In summertime, clouds are white and the sun can reach Earth more easily.*

An example of the type of misconception that was seen more as age increased was "the seasons occur because the Earth's distance from the Sun changes as it orbits around the Sun". The percentages seen of this misconception across the age groups are seen in Figure 2.

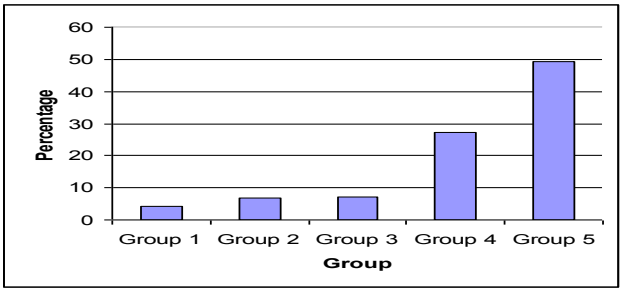


**Figure 2.** *Frequency Percentages across the Age Groups of a Misconception That Was More Encountered as Age Increased*

As can be seen in Figure 2, the frequency of this misconception rises as age increases. While the percentage of encountering this misconception among Group 1, 2, and 3 students was low, the percentage suddenly rose in Group 4 students. The percentage of encountering this misconception rose even more among Group 5 students, making this the most frequently encountered misconception in this age group. Excerpts from the interview with a student in Group 1 with this misconception and with another student in Group 5 are given below.

*I: What causes the seasons?*
*S1-14: The Earth is closer to the sun in summer and this is why the weather is warmer in summertime. In winter, the Earth moves away from the sun and so it benefits from the sun less and the weather is cold.*
*I: All right and where did you learn this?*
*S1-14: This should be right because when we're close to the sun, we're warmer.*

*I: What causes the seasons?*
*S5-6: The Earth rotates around the sun in an elliptic orbit. In that orbit, when the Earth gets closer to the sun, it becomes summer and when it gets farther away, we experience winter.*

It was observed that students of different ages who had the misconception that seasons are caused by the change in the distance of the Earth to the Sun had different explanations to support this idea. Younger students (Groups 1 and 2) explained the causes of the seasons in terms of their daily experiences, offering the example that we feel warmer the more we approach a source of heat. The students in the older age groups (Groups 3, 4 and 5) tried to explain the causes of the seasons by using the concept of the elliptic orbit to base their idea on the change in distance. Although the concept of the elliptic orbit increased with age, it was mostly observed in Group 5 students, the group who had received instruction in astronomy. Their explanation was that because the Earth rotated around the Sun in an elliptical orbit, it

would be closer to the Sun in summer and farther away in winter. While younger students who had the same misconception said that distances had to change for the seasons to come about, they did not specify what occurrences would change these distances. The older students, however, stated that it was because of the elliptical orbit that distances changed and the seasons came about.

An example of a misconception whose frequency did not display a change as age increased was the misconception that "the Earth orbits around the Sun". The percentages in which this misconception was encountered across the age groups are given below in Figure 3.

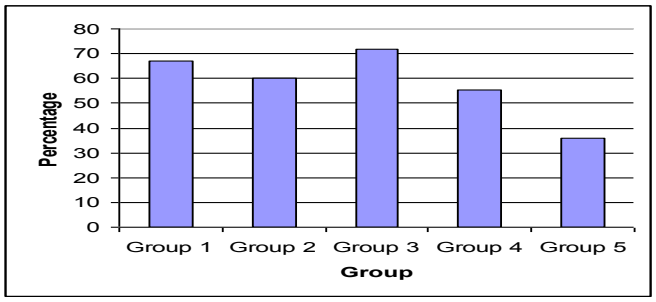


**Figure 3.** *Frequency Percentages across the Age Groups of a Misconception Whose Frequency did not Change as Age Increased*

The misconception of "The Earth orbits around the Sun" was an idea that was mostly encountered among the students in Groups 1, 2, 3 and 4. The frequency that this misconception was encountered was more or less the same in all the groups and it was also seen that the education received on this topic had not been effective in dispelling the incorrect notion the students in these age groups had. Although the frequency of this misconception among the students in Group 5 had decreased compared to the other groups, the frequency of encountering this misconception in this group was still 36%. The university instruction the students in Group 5 had received had been enough to reduce the frequency but the misconception still lingered. Excerpts from the interview with a student from Group 2 regarding this particular misconception are as follows.

*I: Why do the seasons occur?*
*S2- 10: The seasons occur because the Earth orbits around the Sun.*
*I: Would you clarify this, please?*
*S2-10: I don't remember what was said in class but I think our elementary school teacher explained it to us. It seems the Earth orbits around the Sun. I think that's why the seasons occur.*

In the interview, this Group 2 student refers as the source of his answer to the instruction he had received. All of the students across the age groups with this misconception similarly pointed to what they had learned in school as the reason behind their ideas. To follow is an excerpt from the interview with a student from Group 5 with the same misconception.

*I: What cause the seasons?*
*S5-30: They occur because of the Earth orbiting around the Sun.*
*I: I see. How do you know this?*
*S5-30: It wasn't taught in high school, I may have learned it in elementary school. We learned about the Sun, the solar system, the Earth and its movements in elementary school.*

This Group 5 student indicated that it was the instruction he received in elementary school that caused him to have this misconception. It was thus seen that the instruction he had received in the university had not been effective in dispelling the misconception.

Examples of misconceptions whose frequency of encounter changed across the age groups were “the change in the distance to the Sun of the Earth’s hemispheres”, “the Earth’s orbiting both around the Sun and around itself” and “the Sun’s orbiting around the Earth”. The graph of frequency percentages for the misconception “the change in the distance of the Earth’s hemispheres to the Sun” an idea on the basis of which frequency changed as age increased can be seen across the various age groups below in Figure 4.

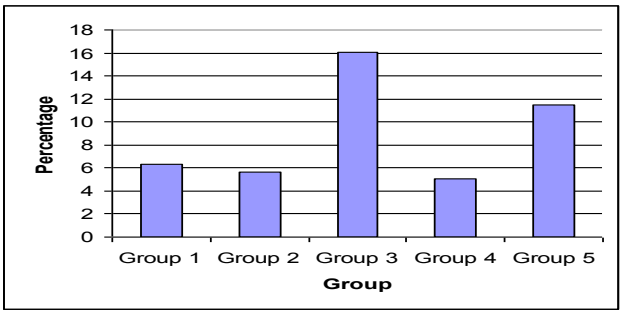


**Figure 4.** *Frequency Percentages across the Age Groups of a Misconception Whose Frequency Changed as Age Increased*

As can be seen in the figure, the frequency of encountering the misconception “the seasons occur because of the change in the distance of the Earth’s hemispheres to the Sun” varies across the age groups. This misconception is most encountered in Group 3, and then in the students in Group 5. The frequency of encountering this misconception is least in Groups 2 and 4. The students having this misconception stated that as a result of the earth’s tilted axis, the hemisphere closer to the sun would experience summer and the hemisphere farther away from the sun would experience winter.

The misconception of “the seasons are caused by the Sun’s orbiting around the Earth” was mostly seen among the students in Group 2. While percentages of encountering this misconception dropped in Group 3, Group 4 students exhibited an increased percentage when compared with Group 3 students. This misconception was not encountered among Group 5 students, who had received instruction on the topic.

The frequency of encountering the misconception of “as the Earth orbits around the Sun, it also rotates around its own axis and that is why the seasons occur” changed across the age groups. While this misconception was seen more in Group 2 students compared to Group 1, the frequency exhibited a drop in Group 3 students. This misconception however was seen more in Group 4 students as compared to Group 3 students. In Group 5, the frequency of the misconception dropped once more, exhibiting the lowest percentage of the groups.

## DISCUSSION and CONCLUSION

It was established in this study that students in different age groups had a variety of ideas about the causes of the seasons. While it was only among the students in Group 5, who had been supported by classroom discussions and computer-based instruction, that the percentage of correct answers was high, in all of the other age groups, the percentage of correct answers was so low as to be considered negligible. The results of the ANOVA test showed that there was a significant difference between the students in Group 5 and all the other groups of students in that students in Group 5 were more successful in results the right

answer. At the same time, the frequency of encountering misconceptions in Groups 1, 2, 3, and 4 was considerably high but similar while the percentage was low in Group 5 when compared to these groups. One of the conclusions of the study was that there were no changes in the frequency of encountering misconceptions in Groups 1-4, signifying the age range of 10-19 but that there was a significant drop in frequency in Group 5 compared to the other groups. The reason for the drop in the frequency of encountering misconceptions among the students in Group 5 may be said to have stemmed from the organized instruction that had been geared to make a change in students' conceptual notions at the university level. This instruction, however, was not effective enough to make a complete change in Group 5 students' misconceptions. For example, in the cross-age study conducted by Dunlop (2000) on the concept of the seasons, the frequency of encountering the misconception of "the change in the distance of the Earth to the Sun" was 9% before instruction and 6% after instruction. This result is consistent with the present study, which indicated that instruction geared to bring about conceptual change did in fact reduce the frequency of encountering misconceptions among students but failed to eliminate them altogether, even after instruction.

Most students have various misconceptions about the causes of the seasons. These misconceptions are similar to the examples of misconceptions taken from the literature and presented in the introduction of this work. Cross-age studies of students have shown that the frequency of misconceptions decreases as students get older (Baxter, 1989; Dunlop, 2000; Plummer, 2009). In line with this general belief, in this study too, it was found that certain misconceptions about the causes of the seasons were less encountered as students got older. The misconception of "the seasons are caused by the Earth's rotating around its own axis" can be shown as an example of a misconception that is less frequently seen as age increases. On the other hand, there were certain misconceptions in the study which were more frequently encountered as students' ages increased. An example of this is the misconception that "seasons occur because of the change in the distance of the Earth to the Sun as it orbits on its elliptic path". This is consistent with reports that in certain cases, misconceptions may appear after a program of instruction (Strike & Posner, 1992). In the interviews held with students, it was found that students in Group 4 and especially in Group 5 used the scientific facts that they had learned to support their misconceptions and continued to keep these misconceptions despite their knowledge of the facts. In addition, besides the misconceptions which were more or less frequently encountered as students got older, there were also some misconceptions that were discovered that changed very little and showed different frequencies across the age groups. An example of a misconception that did not change in frequency across the age groups is the answer "the Earth's orbit around the Sun". This misconception was resistant to change, to the point that it was unchanged and difficult to dispel even after formal instruction. In fact, the same misconception is frequently encountered even after a program of instruction geared to instil conceptual change. This result was reported in previous studies that have indicated that some misconceptions continue to exist despite formal instruction (Hewson & Hewson, 1983; Hsu, 2008; Wild, 2010). An example of a misconception where the frequency of encounter changes with age is "the change in the distance of the Earth's hemispheres from the Sun". This type of misconception appears before us in different percentages in each age group, exhibiting no methodical change as age increases. The fact that the frequency of misconceptions changes across the age groups may stem from various reasons.

## RECOMMEDATIONS

The conclusions of this study showed that most students across various age groups had misconceptions in their minds. The frequency of some of these misconceptions dropped as age increased while the frequency of others increased. There were also some misconceptions that showed very little or no change across the age groups. Teachers in the classroom have neither the time nor the opportunity to uncover and remedy all misconceptions. For this reason, it is believed that there is no need to devise a special activity to eliminate misconceptions that are less frequently encountered with increasing age; such misconceptions will diminish with time without an activity designed to encourage conceptual change. Misconceptions that are resistant to change and do not disappear as students get older continue to be encountered even though students have been given formal instruction. Misconceptions that are more often seen as age increases are seen to be supported by instruction and become even more frequently encountered after a program of instruction. Cross-age studies conducted at different times and in different countries about the causes of the seasons may be useful in determining which misconceptions increase or remain the same with age. Common misconceptions encountered on the causes of the seasons may be fitted into science and physics course programs so that attention is called to these mistaken notions. In this way, activities to instigate conceptual change may be included in textbooks and teachers may use these activities in the classroom to ensure the eradication of misconceptions that increase or remain the same with age.

Misconceptions that increase, remain the same, or change with age may be encountered in many other science subjects other than the causes of the seasons. Conducting cross-age studies in various topics of science may be beneficial in establishing which misconceptions are more frequently encountered with age, which stays the same, and which exhibit change. Steps should be taken to eradicate these misconceptions.

The present study's results differ from previous cross-age research in the literature in that some misconceptions were found to be more frequently encountered or to exhibit changes as age increased. Since this was the first time the outcome of higher frequencies at later ages and changes of frequency across the age groups was seen, a comprehensive inquiry into the reasons for this could not be carried out. A topic for subsequent studies might indeed be a more comprehensive exploration into why some misconceptions encountered in younger students increase or exhibit a change as student groups get older.

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