INVESTIGATION OF SECONDARY SCHOOL STUDENTS' CONCEPTUAL UNDERSTANDING LEVELS IN ASTRONOMY SUBJECTS ACCORDING TO GRADE LEVELS

***Önder Şensoy[1]**
Meltem Kocakuşak[2]
[1] Mathematics and Science Education Department, Gazi University, Türkiye
[2] Ministry of National Education, Yozgat, Türkiye
**sensoy@gazi.edu.tr*

ABSTRACT

This study aims to compare the alternative concept and achievement scores of secondary school students in the subjects of the structure of celestial bodies, celestial events and the motions of celestial bodies in terms of grade levels. The survey model, one of the quantitative research methods, was used in the study. To identify alternative concepts, the quantitative data collection tool of the research, the 20-item Alternative Concept Identification Test (ACIT), each consisting of three stages, was created. The test development stages were followed for ACIT, the necessary validity and reliability studies were conducted, the KR-20 value was found to be 0.82, and the Cronbach-Alpha value was found to be 0.83. The study group of the research consists of 332 students studying in the 5th, 6th, 7th and 8th grades in a province in Turkey. The sample in the study was determined by the monographic sampling method, one of the non-probability-based methods. The study created five score types to compare students' alternative concept and achievement scores according to grade levels. Reliability analyses were performed for these score types, and Cronbach-Alpha values for all were found. When secondary school student's achievements in the subjects of the structure of celestial bodies, celestial events, and the motions of celestial bodies were compared in terms of the grade level variable, the correct scores showed a significant difference. In contrast, the Alternative Concept Score mostly did not show a significant difference.

Keywords: *Alternative Concepts, Three-Tier Test, Structure of Celestial Bodies, Celestial Events, Astronomy Education*

INTRODUCTION

Astronomy is crucial in the human endeavor to understand the universe and nature. In addition, developments in astronomy accelerate the development of other branches of science. Astronomy education should be given the necessary importance for developing science. It is understood that there are different views on how this subject should be taught in the curriculum by looking at astronomy from an international perspective. These views focus on whether astronomy should be taught separately or as part of other subjects (Percy, 1998). The International Astronomical Union stated, 'Astronomy education should be included in all countries' primary and secondary education curricula, whether it is taught as a separate course or as part of another field' (Trumper, 2006).

Astronomy is one of the most important disciplines in science education to increase students' interest and curiosity in science. Astronomy education is growing rapidly beyond presenting existing information and activities (Bailey, 2006).

Misconceptions are the concepts that students develop erroneously in their minds, different from scientifically verified concepts. Students form their thoughts and opinions about events due to their experiences with the real world before receiving science education at school (Baxter, 1989). In recent years, the idea that the knowledge acquired by students before coming to the classroom environment affects students' learning processes has become more accepted (McDermott, 1991).

This erroneous information brought into the classroom environment negatively affects learning and causes erroneous learning, such as misunderstanding, misconception, alternative concepts, misconceptions, and common beliefs (Ayas, 2016). In the literature, these concepts that individuals develop other than scientifically valid and correct concepts are referred to by various names such as 'misconceptions' and 'alternative concepts' (Nakhleh & Krajcik, 1994). Although there are different nomenclatures, the most commonly used in the literature is 'misconceptions. Due to the negative meaning of this nomenclature, 'Alternative Concept' or 'Alternative View' has started to be used more commonly in recent years (Göncü, 2013; Karslı and Ayas, 2013a).

Alternative concepts must first be identified before being analyzed. Many different methods, such as interviews, open-ended tests, diagnostic branched tree, structured grid, concept maps, V-diagrams, word association tests, concept cartoons, multiple-choice tests and multi-stage tests are used to identify alternative conceptions (Al-Rubayea, 1996; Franklin, 1992; Canales et al., 2013; Sneider et al., 2011; Miller and James, 2011; Starakis et al., 2010; Fluke and Barnes, 2008; Bell and Trundle, 2008). Due to the disadvantages of methods such as interviews and open-ended tests, multiple-choice tests were needed. However, progressive tests were developed to eliminate the methods that negatively affect measurement, such as rote learning, chance factors, and the difficulties of writing quality questions in multiple-choice tests (Güneş, 2020). In the literature, progressive tests are seen as two-stage, three, and four-stage tests.

When the literature is examined, similar to the study, some studies identify alternative conceptions of astronomy using three-stage tests. Slaver et al. (2018), in their study titled 'Astronomy alternative conceptions in pre-adolescent students in Western Australia', examined the alternative conceptions of 546 students between 5th and 7th grades and revealed that students have various misconceptions about astronomy. The results show that some well-defined alternative conceptions, such as the 'eclipse model' explaining the phases of the Moon, existed before students entered high school and before any formal learning on the subject. In addition, he identified several alternative conceptions based on knowledge possessed by pre-adolescent students that should have been consolidated by students in grade 3, namely the relative motions of the Earth, Moon and Sun. Similarly, Cardinot and Fairfield (2021) 'Alternative Conceptions of Astronomy: How Irish Secondary Students Understand Gravity, Seasons, and the Big Bang' examined 498 secondary school students' alternative conceptions of gravity, seasons, and the Big Bang and found that students had various misconceptions about these topics. Similar to this study, some studies focus on primary school years and emphasize concepts related to astronomy. For example, Plummer (2009) states that children's early conceptions of day and night are centered on two alternatives: The Sun is blocked, causing darkness at night, and the Sun moves straight upwards and straight downwards. Stover and Saunders (2000) administered pre- and post-activity tests to students participating in astronomy camps. According to the study's results, it was observed that the students thought that the rotation of the Earth around the Sun causes day and night or that the Sun rotates around the Earth in a single day. Another alternative understanding of these students was that the movement of clouds causes day and night. Another study found that 'the Earth blocks the light from the Sun and causes a shadow across the Moon' as the most common alternative conception as an explanation for the phases of the Moon from primary school to university level (Naze & Fontaine, 2014; Trundle et al., 2002). The literature shows that many students have alternative conceptions about the cause of the seasons based on unscientific views of how the Earth moves through space. In the study by Starakis and Halkia (2014), about 23% of students think the Earth's orientation causes the seasons. Another common alternative conception is that the distance between the Earth and the Sun causes the seasons (Annenberger Foundation, 2014; Naze & Fontaine, 2014; Starakis & Halkia, 2014). In this direction, the study focused on the misconceptions that exist in students, and alternative concepts frequently encountered in the literature were considered. These concepts are presented in detail when creating data collection tools and discussion sections.

Due to the spiral structure of the science curriculum, students build the concepts they will learn in the future periods of their education life on the concepts they learn in the first stage of education (Bülbül, 2013). There should be no erroneous learning, such as alternative concepts in previous acquisitions, to comprehend the knowledge of the next grade correctly and completely. Comparison of students' alternative concepts according to grade levels is important in understanding conceptual change processes and developing effective teaching strategies (Ouch & Widiyatmoko, 2023). Since students may have different misconceptions depending on their age and grade level, grade-level-specific approaches should be developed to identify and eliminate them. In this study, the distribution of students' misconceptions about astronomy subjects according to grade levels was analyzed, and different misconceptions were found at each grade level. Such comparisons help to organize teaching programs and materials for students' cognitive development. Moreover, analyzing misconceptions according to grade levels allows teachers to determine which subjects they should focus more on. In this way, students' correct understanding of scientific concepts and permanent learning are supported. As a result, comparing alternative conceptions according to grade levels ensures that individual differences are considered in education and contributes to making teaching processes more effective.

When looking at the literature, it was noticed that there was a lack of a study in which alternative concepts were tested and compared at all grade levels while identifying alternative concepts. For this reason, in this study, it was seen that it was necessary to compare the alternative concepts identified in the subjects of the structure of celestial bodies, celestial events, and movements of celestial bodies of 5th, 6th,7th, 8th-grade students of secondary school.

METHODOLOGY

Research Design

This study aims to compare the alternative concept scores and achievement scores of secondary school students in the subjects of the structure of celestial bodies, celestial events and the motions of celestial bodies in terms of grade level. The "Alternative Concept Identification Test (ACIT)" was developed by the researchers to identify alternative concepts in secondary school students, and a survey model, one of the quantitative research methods, was used. In cross-sectional survey research, which is one of the types of survey research, the skills of large samples are measured at one time (Büyüköztürk et al., 2016).

Study Group of the Research

The research group consists of students studying in the 5th, 6th, 7th and 8th grades of secondary schools in a district that the researcher can reach within the universe of the study. The ACIT was applied to 332 students selected from the schools in the district, considering that equal numbers of students from each grade level were represented in the sample. Monographic sampling, one of the non-probability-based sampling methods, is based on available information. A sample is determined by selecting a subgroup or unit and accepting that it is representative of the researched population. The determined sample is examined in detail, and the results are interpreted by generalizing them to the whole population (Karagöz, 2017). Due to its suitability for the research, the researcher determined the sample using the Monographic Sampling type and criteria.

Table 1. *Demographic Information of the Students Participating in the Alternative Concept Identification Test*

		N	%
Gender	Female	170	51
	Male	162	49
	Total	332	100
Grade level	5th grade	61	18
	6th grade	79	24
	7th grade	91	27
	8th grade	101	31

	Total	332	100

Data Collection Tools of the Research

This study used a three-stage test due to the limitations of classical multiple-choice tests in identifying students' alternative concepts. Developing three-stage diagnostic tests to identify alternative conceptions was mainly inspired by the methods developed by Treagust (1988). While developing the test, the researchers utilized the stages of test development and were inspired by the work of Güneş (2020). After reviewing the literature for ACIT, a specification table was prepared, and 29 items were written in a way that made all items original and had three stages. While preparing the test items, the subjects that are commonly identified in the literature, the branches of astronomy, the results of the daily and annual movements of the Earth (the formation of day and night and the formation of seasons), the properties, movements and phases of the Moon, the distances and sizes of celestial bodies, the properties and movements of the Sun, other elements in the solar system (planets, asteroids, meteorites, comets), stars, constellations, black holes were discussed to reveal alternative concepts. In the first stage of each item, the question is asked; in the second stage, the reason for the answer is given to the first question; and in the third stage, whether the student is sure of their answer. After the expert opinions were given, necessary corrections were made, and a pilot study was conducted with 63 students from the 5th, 6th, 7th, and 8th grades. Based on the item difficulty indices and discrimination indices of the data obtained, nine items that were not suitable were removed from the test, and corrections were made to the items deemed necessary. The final version of ACIT consists of 20 items. The reliability analysis of the 20 items in the final version of the test was performed with the pilot study data, and the KR-20 value was found to be 0.82. Afterwards, the Cronbach-Alpha value was found to be 0,83. These values showed that the test was applicable.

Validity of the Data Collection Tool in the Study

The opinions of 1 language expert and five science experts were obtained to ensure the content validity of the data collection tool. The test draft was sent with the expert evaluation forms consisting of open-ended answers prepared by the researcher, and the experts' opinions were obtained. Construct validity shows to what extent the scores obtained in the test can measure the construct to be measured by the test (Erkuş, 2003). The criterion and construct validity of the Alternative Concept Identification Test were analyzed using different types of scores generated from the obtained data. Since confidence scores and reasoning questions can be examined separately in tests of more than one stage, it is recommended to calculate the correlation between confidence scores and reasoning questions (Kaltakçı, 2012). The relationship between the scores of the student responses at the initial reasoning and confidence stages can be examined separately and in combinations to determine the construct validity (Güneş, 2020). In this study, the construct validity of each item in the test was examined firstly by looking at the correlation between stage 1 and stage 2 questions and then between stage 1 and stage 3. In the 1st and 2nd stages of the test, the presence of knowledge about the subject is questioned in the 3rd stage and the state of certainty is questioned in the 3rd stage. In this study, the correlation between the confidence questions in the 3rd stage and the 1st and 2nd stages were analyzed separately. Pearson correlations (r), if $r = 0.10$ to $r = 0.29$, a small correlation can be mentioned; if $r = 0.30$ to $r = 0.49$, a medium correlation can be mentioned, and if $r = 0.50$ to $r = 1.0$, a large correlation can be mentioned (Pallant, 2011).

Table 2. *Correlations between the Correct Scores of the Stages of the Items in the Test*

1st Stages	STAGE2	
	Pearson Correlation	0,946
	Sig. (2-tailed)	0,000
	N	332
2nd Stages	STAGE3	
	Pearson Correlation	0,384
	Sig. (2-tailed)	0,000
	N	332

3rd Stages	STAGE1	
	Pearson Correlation	0,391
	Sig. (2-tailed)	0,000
	N	332

When Table 2 is analyzed, it is seen that the Pearson correlation between the correct scores of the 1st and 2nd stages is r = 0,946, indicating a very high level of positive relationship. The values of r = 0,384 between the correct scores of the 2nd and 3rd stages and r = 0,391 between the correct scores of the 1st and 3rd stages show a moderate positive relationship.

Reliability of the Quantitative Data Collection Tool

Since internal consistency reliability, one of the different types of reliability used to estimate it was found appropriate for this study, internal consistency was analyzed. The Cronbach's Alpha test can examine internal consistency reliability (Bacanlı, 2015). Cronbach's Alpha measures internal consistency in tests. As the alpha value approaches 1, reliability increases, while reliability decreases as it approaches 0 (Karagöz, 2017).

With the data obtained from the research, five different score types were formed: Achıevement-1, Achıevement-2, Achıevement-3, Achıevement-4 scores and Alternative Concept Score. This test can be used as an achievement test to determine alternative concepts. For this reason, reliability was analyzed separately for Correct Scores and Alternative Concept Scores.

Table 3. *Cronbach Alpha Reliabilities for Alternative Concept Score and Achievement Scores*

Score type	N	Cronbach's alpha
ACHIEVEMENT-1	20	0,785
ACHIEVEMENT-2	20	0,785
ACHIEVEMENT-3	20	0,832
ACHIEVEMENT-4	20	0,843
ALTERNATIVE CONCEPT SCORE	20	0,675
TOTAL (SCORE TYPES)	5	0,81

When Table 3 is analyzed since the Cronbach alpha values are α = 0,785 for the achievement-1 score type and α = 0,785 for the achievement-2 score type, it is seen that the achievement-1 and achievement-2 scores of the scale are highly reliable. The values of α = 0,832 for the achievement-3 score type and α = 0,843 for achievement-4 indicate that the achievement-3 and achievement-4 scores of the scale are highly reliable. When the Cronbach alpha value for the Alternative Concept Score is analyzed, α = 0.675 is observed. While this value indicates low reliability for achievement tests, since reliability coefficients are lower in alternative concept tests, unlike achievement tests, reliability coefficients of 0.60 and above indicate good reliability (Peşman & Eryılmaz, 2010). Therefore, the scale is reliable according to the types of scores obtained from the study.

Data Collection Process of the Research

The Alternative Concept Identification Test was applied to 332 secondary school students: 61 at the 5th grade level, 79 at the 6th grade level, 91 at the 7th grade level and 101 at the 8th grade level. The duration of the test is 40 minutes. The students' answers to the 20-item test, each consisting of three stages, were recorded using an MS Excel program.

Data Analysis of the Research

In the study, descriptive statistics of the score types were also examined for item analysis. For this purpose, minimum score, maximum score, arithmetic mean, standard deviation, median, mode values were calculated.

Table 4. *Table for the Formation of Score Types*

Score Types	Stage 1	Stage 2	Stage 3	Item For Points to be awarded		
				Max	Min	
Achievement-1	Correct=1 Wrong=0	-	-	1	0	Achievement Score
Achievement-2	-	Correct =1 Wrong =0	-	1	0	Achievement Score
Achievement-3	Correct =1	Correct =1	-	1	0	Achievement Score
Achievement-4	Correct =1	Correct =1	I'm sure=1	1	0	Achievement Score
Alt. Con. Scr	Wrong=0	Wrong =0	I'm sure=1	1	0	Alternative Concept Score

As can be seen in Table 4, achievement scores were created by taking into account only the scores obtained from the first stage of each item for each student while creating the achievement-1 score, only the scores obtained from the second stage of each item for each student while creating the achievement-2 score, the scores obtained from the first and second stages of each item for each student while creating the achievement-3 score, and the scores obtained by each student from the first, second and third stages of each item while creating the achievement-4 score. While creating the Alternative Concept score in the research, each student was given 0 points for the wrong answer, 1 point for the correct answer in the first and second stages for each item, and 1 point for 'I am sure' and 0 points for 'I am not sure' in the third stage. The student who answers the item 'wrong' (0), 'correct' (0), and 'I am sure' (1), respectively, receive 1 point for that item.

This method created five scores: achievement-1,2,3,4 and Alternative Concept score. While creating and explaining these scores, Güneş (2020), Peşman (2005) and Kaltakçı (2012) studies were taken as examples. When the ANOVA test was applied, the homogeneity of variances was first checked. After checking the homogeneity of variances, Tukey HSD and Tamhanes' T2 tests were applied according to their suitability.

For the other analyses to be made for the achievement scores and alternative concept scores, it was checked whether they showed normal distribution. As a result of this test, Skewness and Kurtosis values expressing the Skewness and Skewness coefficients were analyzed. The data show normal distribution since the Skewness and Kurtosis values between +1.0 and -1.0 meet the normality. (Büyüköztürk, 2011) Since the data showed normal distribution, parametric analysis methods were used for all score types.

Table 5. *Descriptive Statistics for Score Types*

Descriptive Statistics	Achievement-1	Achievement-2	Achievement-3	Achievement-4	Alternative Concept Score
Students	332	332	332	332	332
Arithmetic Mean	11,77	11,58	10,95	8,55	4,07
Median	12	12	11	9	4
Mod	11	13	10	9	3
Min. Score	1	1	0	0	0
Max. Score	20	20	20	19	15
Standard Deviation	4,03	4,13	4,69	4,76	2,93
Skewness	-0,20	-0,20	-0,35	0,006	0,90
Kurtosis	-0,61	-0,79	-0,63	-0,84	0,69

When the skewness and kurtosis values are examined, it can be said that the test shows the normal distribution and parametric tests can be used (Büyüköztürk, 2011). For this reason, parametric test analysis methods were applied in the analyses of all score types.

FINDINGS

In this part of the study, the relationship between the differences was examined by looking at whether the score types, created to determine the levels of the students in the analyses and findings, showed significant differences according to the grade levels.

Findings Regarding the Difference of Secondary School Students' Achievement and Alternative Concept Scores on the Structure of Celestial Bodies, Celestial Phenomena and Movements of Celestial Bodies According to Class Level

Table 6. *Descriptive Statistics of Score Types According to Grade Level*

Score Types	Class	N	$\bar{X}$	Std. Dev/s	Min.	Max.
Achievement-1	5th grade	61	9,57	3,116	1	17
	6th grade	79	10,36	3,749	1	18
	7th grade	91	12,95	4,340	4	20
	8th grade	101	13,12	3,537	3	19
	Total	332	11,77	4,035	1	20
Achievement-2	5th grade	61	9,52	3,263	3	18
	6th grade	79	9,94	3,957	1	18
	7th grade	91	12,86	4,415	3	20
	8th grade	101	12,95	3,530	4	19
	Total	332	11,58	4,139	1	20
Achievement-3	5th grade	61	8,61	3,963	0	17
	6th grade	79	9,00	4,574	0	18
	7th grade	91	12,44	4,794	2	20
	8th grade	101	12,54	3,957	0	19
	Total	332	10,95	4,695	0	20
Achievement-4	5th grade	61	6,47	3,645	0	15
	6th grade	79	7,10	4,595	0	18
	7th grade	91	9,92	5,086	0	19
	8th grade	101	9,71	4,490	0	18
	Total	332	8,55	4,768	0	19
Alternative Concept Score	5th grade	61	4,77	2,935	0	13
	6th grade	79	4,84	3,148	0	15
	7th grade	91	3,73	2,997	0	14
	8th grade	101	3,35	2,484	0	11
	Total	332	4,07	2,935	0	15

A one-way ANOVA test was performed to examine whether the achievement-1, achievement-2, achievement-3, achievement-4 and alternative concept scores had a significant difference in terms of the class level variable.

1. Findings for the comparison of students' achievement scores for class variable

In this section, the findings related to the comparison of the achievement levels of the students according to the class levels by using the ANOVA test using the achievement scores of the students are given.

Table 7. *Table for Homogeneity of Variance of Achievement Scores*

Score Types	Levene's statistic	sd	p
Achievement-1	5,007	3,328	0,002
Achievement-2	3,946	3,328	0,009
Achievement-3	2,690	3,328	0,046
Achievement-4	4,054	3,328	0,008

The variance homogeneity of the test (Levene's test) should be checked to look at the significance value from the ANOVA test. In cases where the variance homogeneity of the test is not provided, giving the findings of the ANOVA (F) test (Taysı & Çelik, 2018) is not entirely appropriate. If sig=p>0,05, the variances are homogenous, and the findings of the ANOVA test can be evaluated. However, if sig=p<0,05, the variances are not homogeneous and looking at the Welch test results instead of the ANOVA test will give more successful results. In case of detection of significant difference between the variables as a result of Welch test, Tamhane's T2 test, which is one of the different variance approaches (equal variances not assumed), is mainly used to look at the difference between each variable (Karagöz, 2017). As can be seen in Table 7, since the result of Levene's test for achievement-1, achievement-2, achievement-3, and achievement-4 scores was sig=p<0.05, Welch test results were analyzed, and Tamhane's T2 test, one of the different variance approach tests, was used.

Table 8. *Welch Test Results for Achievement Scores*

Score Types	Welch statistic (*)	sd	p
Achievement-1	20,523	3,328	0,000
Achievement-2	19,917	3,328	0,000
Achievement-3	20,149	3,328	0,000
Achievement-4	13,250	3,328	0,000

*Asymptotically F distributed

According to the Welch test given in Table 8, since sig=p<0,05 for the mean of the student's achievement scores, it is seen that there is a significant difference in the mean achievement scores in terms of class levels. For this reason, Tamhane's T2 test was used for achievement-1, achievement-2, achievement-3 and achievement-4 score types. When looking at the indicator (sig) values, if sig=p>0,05, the difference between group averages is insignificant; if sig=p<0,05, the difference between group averages is significant; if sig=p<0,001, the difference between group averages is highly significant (Karagöz, 2017).

Table 9. *Tamhanes' T2 Test Results for Achievement-1 Score*

CLASS		Mean Differences	p	Significant difference
5	6	-0,79332	0,683	-
	7	-3,38227	0,000	+
	8	-3,55494	0,000	+
6	5	0,79332	0,683	-
	7	-2,58896	0,000	+
	8	-2,76162	0,000	+
7	5	3,38227	0,000	+
	6	2,58896	0,000	+
	8	-0,17267	1,000	-
8	5	3,55494	0,000	+
	6	2,76162	0,000	+
	7	0,17267	1,000	-

When Table 9 is analyzed, sig(p=0,683) between the 5th and 6th grades and sig(p=1,000) between the 7th and 8th grades for achievement-1 scores are insignificant since sig=p>0,05. Therefore, there is no significant difference in group averages regarding achievement-1 scores between these grades. The sig(p=0,000) value between 5th and 7th grades, sig(p=0,000) between 5th and 8th grades, sig(p=0,000) between 6th and 7th grades, sig(p=0,000) between 6th and 8th grades is highly significant since sig=p<0,001. Therefore, there is a significant difference in group averages regarding achievement-1 scores between these grades.

Table 10. *Tamhanes' T2 Test Results for Achievement-2 Score*

CLASS		Mean Differences	p	Significant difference
5	6	-0,42478	0,982	-
	7	-3,34354	0,000	+
	8	-3,42590	0,000	+
6	5	0,42478	0,982	-
	7	-2,91876	0,000	+
	8	-3,00113	0,000	+
7	5	3,34354	0,000	+
	6	2,91876	0,000	+
	8	-0,08236	1,000	-
8	5	3,42590	0,000	+
	6	3,00113	0,000	+
	7	0,08236	1,000	-

When Table 10 is analyzed, for achievement-2 scores, the sig(p=0,982) value between the 5th and 6th grades and the sig(p=1,000) value between the 7th and 8th grades are insignificant since sig=p>0,05. Therefore, there is no significant difference in group averages regarding achievement-2 scores between these grades. The sig(p=0,000) value between 5th and 7th grades, sig(p=0,000) between 5th and 8th grades, sig(p=0,000) between 6th and 7th grades, sig(p=0,000) between 6th and 8th grades is highly significant since sig=p<0,001. Therefore, there is a significant difference in group averages regarding achievement-2 scores between these grades.

Table 11. *Tamhanes' T2 Test Results for Achievement-3 Score*

CLASS		Mean Differences	p	Significant difference
5	6	-0,62586	0,938	-
	7	-3,44767	0,000	+
	8	-3,24028	0,000	+
6	5	0,62586	0,938	-
	7	-2,82181	0,001	+
	8	-2,61442	0,001	+
7	5	3,44767	0,000	+
	6	2,82181	0,001	+
	8	0,20739	1,000	-
8	5	3,24028	0,000	+
	6	2,61442	0,001	+
	7	-0,20739	1,000	-

When Table 11 is analyzed, for achievement-3 scores, the sig(p=0,938) value between the 5th and 6th grades and the sig(p=1,000) value between the 7th and 8th grades are insignificant since sig=p>0,05. Therefore, there is no significant difference between these grades regarding achievement-3 scores. The sig(p=0,000) value between 5th and 7th grades, sig(p=0,000) between 5th and 8th grades, sig(p=0,000) between 6th and 7th grades, sig(p=0,001) between 6th and 8th grades is significant since sig=p<0,05. Therefore, there is a significant difference in group averages regarding achievement-3 scores between these classes.

Table 12. *Tamhanes' T2 Test Results for Achievement-4 Score*

CLASS		Mean Differences	p	Significant difference
5	6	-0,393	0,995	-
	7	-3,833	0,000	+
	8	-3,933	0,000	+
6	5	0,393	0,995	-
	7	-3,440	0,000	+
	8	-3,539	0,000	+
7	5	3,833	0,000	+
	6	3,440	0,000	+
	8	-0,100	1,000	-
8	5	3,933	0,000	+
	6	3,539	0,000	+
	7	0,100	1,000	-

When Table 12 is analyzed, for achievement-4 scores, the sig(p=0,995) value between 5th and 6th grades and the sig(p=1,000) value between 7th and 8th grades are insignificant since sig=p>0,05. Therefore, there is no significant difference in group averages regarding achievement-4 scores between these grades. The sig(p=0,000) between 5th and 7th grades, sig(p=0,000) between 5th and 8th grades, sig(p=0,000) between 6th and 7th grades, and sig(p=0,000) between 6th and 8th grades are highly significant since sig=p<0,001. Therefore, there is a significant difference in group averages regarding achievement-4 scores between these grades.

2. Findings on the comparison of students' alternative concept scores according to grade level

In this section, the findings related to comparing secondary school students' alternative concept scores in the subjects of the structure of celestial bodies, celestial events, and motions of celestial bodies according to their grade levels using one-way ANOVA are given.

Table 13. *Table of Variance Homogeneity of Alternative Concept Score*

Score Type	Levene's statistic	Sd	p
Alternative Concept Score	2,356	3,329	0,072

The variance homogeneity of the test given in Table 13 should be checked to look at the significance value from the one-way ANOVA test. If Sig= p>0.05, the variances are homogenous, and the significance value in the ANOVA test is considered (Karagöz, 2017).

Table 14. *One-Way Anova Test Results of Alternative Concept Score*

Score Type	Source of variance	Sum of squares	sd	Mean squares	F	p	Significant difference
Alternative Concept Score	Intergroup	139,473	3	46,491	5,621	,001	+
	Intragroup	2721,074	329	8,271			
	Total	2860,547	332				

According to the ANOVA test given in Table 14, since sig(p=0,01) value sig=p<0,05, the difference is significant, and there is a significant difference between the group averages of Alternative Concept scores according to the grade levels. In variance analysis, Tukey and Sheffe tests are frequently used to compare groups in cases where variance homogeneity is provided. While the Scheffe test gives stronger results than the Tukey test in multiple comparisons, the Tukey test gives better results for pairwise comparisons (Karagöz, 2017). Since the variance distribution of alternative concept scores is homogeneous and gives a stronger result in pairwise comparisons, the Tukey HSD test was preferred in this study.

Table 15*. Tukey HSD Test Results of Alternative Concept Score According to Class Levels*

CLASS		Mean Differences	p	Significant difference
5	6	-0,065	0,999	-
	7	1,045	0,126	-
	8	1,418	0,013	+
6	5	0,065	0,999	-
	7	1,110	0,060	-
	8	1,483	0,004	+
7	5	-1,045	0,126	-
	6	-1,110	0,060	-
	8	0,372	0,806	-
8	5	-1,418	0,013	+
	6	-1,483	0,004	+
	7	-0,372	0,806	-

When Table 15 is analyzed, there is no significant difference between the classes in terms of alternative concept score since sig(p=0,999) between 5th and 6th grade, sig(p=0,126) between 5th and 7th grades, sig(p=0,060) between 6th and 7th grades, sig(p=0,806) between 7th and 8th grades sig=p>0,05. For the alternative concept score, there is a significant difference between the 5th and 8th grades since the sig(p=0,013) value between the 5th and 8th grades and the sig(p=0,004) value between the 6th and 8th grades is sig=p<0,05.

DISCUSSION

As a result of the evaluation of the Achievement Scores generated by the ACIT to determine the achievement levels of secondary school students in the subjects of the structure of celestial bodies, celestial events, and the motions of celestial bodies, it was observed that the achievement increased as the grade level increased. A significant difference was observed between the 5th and 7th, 5th and 8th, 6th and 7th, and 6th and 8th grades in favor of the older grades in all academic achievement score types. According to Arslan and Babadoğan (2005), the age variable reveals a significant difference in information processing processes. Per the results obtained, as the age and class level increase, the students' information processing skills will increase, and therefore, academic success will increase. In support of the study, Harman (2016) examined the mental models of secondary school students about astronomy. The study revealed that students have different mental models depending on their age and that these models affect their level of understanding. Kurnaz and Değirmenci (2012) investigated pre-service science teachers' level of understanding of astronomy concepts and their misconceptions. The results showed that age and education level affected the level of understanding. Plummer and Krajcik (2010) investigated elementary school students' understanding of the motions of celestial bodies. It was found that students' conceptual understanding improved with increasing age, and they better understood more complex astronomy concepts. Barnett and Morran (2002) examined children's alternative conceptual frameworks about the phases of the Moon and eclipses. They found that age and educational level play an important role in understanding these concepts. Kavanagh et al. (2005) guide teachers and curriculum developers on the phases of the Moon and eclipses. Accordingly, it is emphasized that students' understanding of these concepts varies according to their age and grade level. However, according to Jean Piaget's theory of cognitive development, the formal operational stage usually begins around 11 and develops during adolescence. In this period, individuals develop abstract thinking, hypothesizing and systematic problem-solving skills (Ahmad et al., 2016). For example, Uludağ et al. (2014), who worked with young age groups in the context of astronomy education, published 'Small Astronomers: Science Education in Early Childhood', examined the level of understanding of basic astronomy concepts of children aged 4-6 years, and found that age and gender were not factors affecting basic astronomy achievement.

As another study result, no significant difference was found in the ANOVA test between the Achievement Scores of the 5th to 6th and 7th to 8th grades. This can be explained by the fact that the ages of the students are close in these groups or that there are the same age groups in these classes. In contrast to the results obtained in this study, according to Eren's (2011) study, no significant difference was found in the academic achievement of 6th to 7th-grade students in science courses, while there was a significant difference between 6th to 8th grades and 7th to 8th grades. Per the averages of the student's achievement scores in the study, achievement increases as the grade level increases.

Since there was no significant difference in the mean scores of Alternative Concept Scores in the other grade types except 5th to 8th grades and 6th to 8th grades, it can be concluded that there is no difference in Alternative Concepts between the grade levels close to each other. It can be said that students have similar misconceptions about basic astronomy concepts and properties at all grade levels (Kurnaz & Değermenci, 2011). The difference between 5th to 8th grades and 6th to 8th grades may be due to the increase in their information processing abilities due to the higher grade levels and the age difference between them compared to other grades or the resolution of existing alternative concepts by science teachers after they started secondary school. Kurnaz and Değermenci (2011) found that although the failures at all grade levels were similar, the rate of correct answers increased at higher grade levels. In this respect, it supports this study by comparing achievement scores that determine academic achievement according to grade level and comparing alternative concept scores that indicate failure according to grade level. The alternative concepts questioned in the alternative concept identification test were encountered intensively at all grade levels. For example, it is noteworthy that students preferred statements such as 'Solar eclipse occurs once every year' and 'Solar eclipse occurs only once a year because the Earth revolves around the Sun in 1 year'. When the literature was examined, it was seen that there were alternative concepts identified in the studies on topics such as the positions and order of the Moon, the Earth and the Sun during solar and lunar eclipses (Brown & Taylor, 2022; Smith & Johnson, 2024; Yılmaz & Kaya, 2020). 'The Earth rotates around its axis in 365 days and 6 hours.' and' The Earth completes its rotation around its axis in 365 days and 6 hours. This period is called a year.' It was observed that these statements were repeated quite frequently. In support of this study, Ertuğrul and Karamustafaoğlu (2020) examined the misconceptions of elementary school students about the motions of the Sun, Earth and Moon. The study found that students misunderstood the Earth's rotational period around its axis as 365 days and 6 hours. It was stated that this misconception was caused by the students' confusion between the Earth's rotation around its axis and the rotation around the Sun. The study observed that statements such as 'Day and night occur when the Earth goes round the Sun.' and 'When the Earth goes round the Sun, one side of the Earth is illuminated, and the other side remains in darkness.' were repeated. When the literature was examined, studies supported the alternative concepts identified. For example, Bolat (2019) examined the misconceptions of 5th-grade elementary school students about the concepts of the Sun, Earth and Moon. It is discussed that students think that day and night are caused by the motion of the Earth around the Sun and how these misconceptions should be addressed in education. Apart from these alternative concepts, 'When we observe the Sun during the day, the reason why we observe it in different positions from sunrise to sunset is that the Earth moves around the Sun', 'When the Earth moves around the Sun, the Sun is seen in different places in the sky.', 'When the Earth rotates on its axis, the Moon is observed differently.' 'When the Earth's shadow falls on the Moon, the Moon is observed in different ways.' 'When the Earth rotates around its axis, the Moon is observed differently because it leaves the Earth's field of view.' 'When the Earth is between the Moon and the Sun, different shapes are seen when the Earth's shadow falls on the Moon.' 'The celestial event called shooting star is the movement of comets.' 'The phases of the Moon occur due to the Earth's shadow.' 'Stars are small celestial bodies.', 'Constellations consist of stars that are close to each other.' It was observed that the alternative concepts were repeated at each grade level. When the literature is analyzed, many studies supporting the study stand out (Bostan, 2008; Emrahoğlu & Öztürk, 2009; Ercan et al., 2010; Frede, 2006; Göncü, 2013; Harman, 2016; İyibil et al., 2010; Küçüközer et al., 2010; Kurnaz, 2012; Öztürk, 2011; Trumper, 2001; Trumper, 2003; Ünsal et al., 2001).

CONCLUSION

Educators can determine the alternative conceptions in the subjects of the structure of celestial bodies, celestial events, and motions of celestial bodies by applying the developed ACIT to all 5th, 6th, 7th and

8th-grade students. In the research, it was observed that students could easily access publications containing erroneous or incomplete concepts in their research to satisfy their curiosity about astronomy. For this reason, alternative conceptions of students can be prevented by educators by suggesting resources so that students can healthily do their research in the lesson and by ensuring that the authorized institutions increase the accessibility and number of these resources.

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