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The Effect of Conceptual Change Texts on Pre-Service Science Teachers' Achievement Levels Towards Astronomy

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This study aims to develop conceptual change texts to change the misconceptions in astronomy courses and to compare the effect of conceptual change texts on the achievement levels of pre-service science teachers towards astronomy with classical text and traditional learning methods. The study employed a quasi-experimental design with a pre-test post-test control group. The study sample consisted of 4th-grade pre-service teachers studying in the Department of Science Teaching at a state university in Türkiye and taking the astronomy course. The first experimental group, consisting of 27 pre-service teachers, used conceptual change texts, and the second experimental group, consisting of 24 pre-service teachers, used classical texts in the experimental process. The control group of 26 pre-service teachers continued the lessons using the traditional learning method. In this respect, the study's sampling method was determined to be purposive sampling. The astronomy achievement test, developed by the researchers and used to measure the success of pre-service teachers in astronomy subjects, consists of 34 multiple-choice questions. Based on the pilot studies and expert opinions, researchers conducted validity and reliability studies of the test and calculated item difficulty and discrimination indices. In the study, t-tests for dependent groups, t-tests for independent groups and one-factor variance (one-way ANOVA) for unrelated samples were performed, and the results were evaluated. At the end of the intervention, the achievement score of the group to which conceptual change texts were utilized was significantly higher than the group using traditional teaching method.

Introduction

Human beings have been curious about the sky since they became aware of its existence and have tried to answer many questions about the universe. Firstly, while answers were sought regarding events such as how the seasons were formed and how the sun and the moon were eclipsed, in today's age, we are looking for answers to the questions of whether there is life on Mars and whether it is possible to travel to the stars. This interest shows that astronomy is not only the oldest branch of science but also a branch of science that will always remain up to date

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with this interest in the development of technology (Trumper, 2006). This curiosity paved the way for the formation of many branches of science thanks to astronomy (Türk et al., 2012), played a pioneering role in the development of these branches (Yılmaz, 2014) and enabled interdisciplinary working environment (Kanlı, 2015; Kurnaz, 2016; Türk et. al., 2012). Physics and mathematics are used to explain and interpret the data obtained from astronomy. Chemistry is used to analyze the elements that make up the structure of celestial bodies, biology is used to investigate whether there is life on other planets, and geology is used in the formation of the earth (Board of Education, 2017). As can be seen, astronomy, which is directly intertwined with the disciplinary branches that make up science (physics, chemistry, biology, geology, geology, mathematics, geometry, and alike), has an important place among natural sciences (Kanlı, 2014; Saraç, 2017). For this reason, a branch of science that is intertwined with science is inevitably included in the science curricula of countries. Astronomy is an effective tool for learning science with mind-opening and horizon-expanding qualities (Trumper, 2006). Thence, astronomy is very important in raising science-literate individuals interested in science, gaining scientific thinking skills, and learning to investigate and discover. The basic topics in astronomy are mostly encountered in the Science Curriculum in primary education (Board of Education of Türkiye?, 2018). In the science course, which basically consists of unified disciplines, these units, which include basic astronomy topics and other units in the Science Curriculum, are rich in terms of both concrete and abstract concepts. This causes many similar concepts to be confused. These concepts, which are the building blocks of knowledge, reveal scientific knowledge by establishing connections with each other and enable this knowledge to be classified and organised as schemes in the mind (İzgi, 2012; Sert-Çıbık, 2011). Concept teaching is of great importance in achieving the aim of the science course, which includes many concepts (Aydın & Balım, 2007; Wood, 2012).

It is known that misconceptions occur due to the perception of concepts different from their scientifically accepted definitions (Treagust et.al., 2017). Misconceptions negatively affect other learning related to the subject, and therefore, it is of great importance to identify and eliminate misconceptions in students (Birinci-Konur, 2010; Kılıçoğlu, 2011; Öztürk & Doğanay, 2013; Posner et.al., 1982).

Misconceptions in science education are among the most important factors affecting student achievement (Eryılmaz, 2002; Sudarmaji & Abdullah,2021). It is extremely important that students learn the concepts correctly at the beginning of their education life. A student who correctly comprehends the science concepts that he/she learnt for the first time will not have difficulty learning similar concepts that he/she will encounter in his/her subsequent education life (Uyanık & Dindar, 2016). Although astronomy, which is an important part of the science course, is rich in terms of concepts because it is an old branch of science, with the rapid development in recent years, new scientific knowledge every day causes an increase in the amount of these concepts (Bolat et.al., 2014). Misconceptions are inevitable in the field of astronomy, which has such a large number of concepts. Many studies show that these misconceptions are present among the public, students, prospective teachers and even teachers (Bektaşlı, 2013; İyibil & Sağlam-Arslan, 2010; Kalkan & Kıroğlu, 2007; Kanlı, 2014; Kurnaz & Değermenci, 2011; Percy, 1998; Şenel- Çoruhlu & Çepni, 2015; Şensoy & Yıldırım, 2018; Trumper, 2001; Trundle et.al., 2002; Zeilik et al., 1997; Zeilik et.al.,1998). These misconceptions about astronomy subjects also affect the success of astronomy teaching

(Gündoğdu, 2014).

Traditional learning methods are insufficient to achieve the desired success in astronomy education. For this reason, utilize many different learning methods and techniques is of great importance (Yılmaz, 2014). Conceptual Change Texts (CCT), which is an effective teaching method, is one of them.

In Turkey, astronomy education starts in the first grade of primary school and continues until the last high school grade. However, the literature review and the results of both the pilot study and the pre-test of the astronomy achievement test utilized to pre-service science teachers show many misconceptions about basic astronomy topics. For this reason, conceptual change texts written about the basic topics in astronomy are important in eliminating the misconceptions of pre-service science teachers in this subject and their conceptual understanding. These misconceptions in pre-service teachers and teachers can be transferred directly or indirectly to their students. For this reason, another important point of the research is to reduce the misconceptions of pre-service teachers in astronomy to the lowest possible level and even to start their profession with their misconceptions eliminated.

Method

Research design

This study aims to develop conceptual change texts to overcome the misconceptions in astronomy courses and to compare the effect of conceptual change texts on the achievement levels of pre-service science teachers towards astronomy with classical text and traditional learning methods. The study is a quasi-experimental design with the pre-test post-test control group. In this design, experimental and control groups are matched on certain variables (Büyüköztürk et.al., 2017). The design is related since the matched groups are measured with dependent variables before and after the intervention. However, this design is also unrelated since the group participants are different. Care was taken to ensure the participants had similar qualities, but no special effort was made.

Table 1. Pre-test Post-test Paired Control Group Design of the Study

Group	**Pre-Test**	**Method**	**Post-Test**
1st Experiment Group	AAT	CCT	AAT
2nd Experiment Group	AAT	CT	AAT
Control Group	AAT	TL	AAT

*Astronomy Achievement Test (AAT), Conceptual Change Text (CCT), Classical text (CT), Traditional learning (TL)

Study group of the research

The study group of the research consists of 77 pre-service teachers studying in the 4th grade of the Department of Science Education of the Faculty of Education of a state university in Turkey. A purposive sampling method was used to select the participants, and the study group was composed of individuals with a science education background. While forming the experimental and control groups, two existing classes were assigned as experimental and one as control groups. The researchers carried out the implementation process.

Table 2. Frequency and Percentage Distributions of Preservice Teachers Participating in the Study

Group	**Frequency**	**(%)**
1st Experiment Group (CCT)	27	35
2nd Experiment Group (CT)	24	31
Control Group (TL)	26	34
Total	77	100

Data collection tool of the research

The achievement test prepared for the research was started to be prepared by creating a specification table including the subjects in the content of the Science Teaching undergraduate Astronomy course and the acquisitions determined by the Ministry of National Education within the scope of 3rd, 4th, 5th, 6th, 7th and 8th-grade astronomy units and starting from this table. The AAT, which was developed by researchers and used to measure the success of pre-service teachers in astronomy subjects, consisted of 34 multiple-choice questions in total and the highest score that can be obtained from this test is 34, and the lowest score is 0. This test was utilized to both experimental and control groups as a pre-test and post-test. While preparing the questions for the AAT, a literature review on the misconceptions of students, preservice teachers and teachers in astronomy subjects was conducted, and the results obtained shaped the questions. In this way, words or sentences containing misconceptions were placed in the distractors. KR-20 and KR-21 are two statistical methods used to measure the reliability of tests. The KR-21 formula assumes that the difficulty levels of the test items are equal and is suitable for tests without item analysis (Setyaedhi, 2024). The difficulty levels of the test were examined in the research, and it was decided that the KR-20 Reliability Calculation Method was appropriate. The achievement test was utilized to 110 preservice science teachers and the KR -20 reliability coefficient was calculated as 0.678. Kehoe (1995) stated that the KR -20 reliability coefficient should be above 0,500 for achievement tests to be implementable. In addition, the test's item analysis and discrimination index were examined from the data obtained, and the opinions of three academicians and two teachers were also taken. As a result of the arrangements made, the Astronomy Achievement Test got ready by ensuring content validity. In addition, this result is compatible with many scales developed in astronomy (Trumper, 2006; Güneş, 2010). The astronomy achievement test obtained from the pilot study was accepted as reliable for the research.

Text development process and its intervention

Determination of teaching outcomes/goals

Before intervention, to determine the objectives gained during the whole learning period, the acquisitions that were tried to be given to students from primary school to university and pre-service teachers studying astronomy subjects in the relevant department at university were investigated in detail. These acquisitions were only taken into consideration in the process of creating the texts.

Determination of misconceptions

Since the preliminary information of the pre-service teachers before the intervention is critical in the development process of the texts, the misconceptions in astronomy subjects were determined because of the descriptive analysis of the answers they gave in the pre-test of the AAT and the examination of the relevant literature. Based on the results obtained, it was tried to include the misconceptions of students and pre-service teachers on astronomy in the texts.

Creating the conceptual change texts

The Conceptual Change Texts in this study were developed based on the conceptual change approach developed by Posner et.al., (1982). After the preparation process of the conceptual change texts (examining the curricula and identifying misconceptions) was completed, the creation of the texts started. The concepts, questions, explanations and examples in the conceptual change texts were formed by blending the information in the relevant literature and in line with the opinions of 3 faculty members who have studies on astronomy education. After the initial format of the texts was created, they were evaluated by three faculty members who are experts in the field, two science teachers working in Ministry of National Education and three pre-service teachers. Within the feedback framework received, the Conceptual change texts were modified and re-read by three expert lecturers for re-evaluation. Thus, all the revised conceptual change texts were finalized, and 18 conceptual change texts were developed to teach astronomy concepts.

Identification of initial questions. The initial questions were formulated after determining the misconceptions to be included in the conceptual change texts. Conceptual change texts start with one or more conceptual questions that contain misconceptions. In line with the results obtained from the relevant sources, the researcher created all initial questions in the texts. Some examples of the questions are; 'Was the universe formed as a result of an explosion in the sun?', 'Are red-colored stars hotter? ', 'Does the Moon revolve around its axis?', 'Are asteroids and meteorites the same thing?', 'Why do constellations appear in constellations?', 'How are the seasons formed?', 'In which phase of the Moon does a solar eclipse occur? ', 'Can we find direction in the southern hemisphere with the pole star?', 'Where is the center of the Universe?', 'Is our Sun the biggest star?', 'Can we see all the constellations?', 'Do the positions of constellations change in the sky?', 'Is the lunar eclipse observed everywhere on Earth?', 'In which phase of the Moon does the lunar eclipse occur?'.

Creating the discontent section. This section examined the related literature, and the nonscientific thoughts that cause misconceptions about the concept were revealed. Thus, an imbalance was created in students with misconceptions about the subject, and they were made to think by arousing curiosity about the subject.

Creating the comprehensibility section. This section gives the scientific facts about the subject clearly and understandably based on the information obtained from many sources.

Creating the rationality (rationality) section. The concepts with misconceptions were explained scientifically in the previous section. For this explanation to be permanent and supported, this section of the study was created by giving examples that students know correctly and that they can logically accept as true.

Creating the efficiency section. This section ensured that the students used the concepts they had misconceptions about and then learned the correct meaning, thanks to the sections they read in the text. In other words, it was aimed to test and evaluate whether the students had learned fully or not.

An example of the developed Conceptual Change texts is given in the Appendix.

Creating classical texts

In the classical texts, only the scientific expressions of the concepts in the study were included. The conceptual change approach, which was considered in creating the conceptual change texts, was not used in creating the classical texts.

Implementation of texts

The researchers personally participated in the implementation process of the texts and carried out the process. At the same time, the lecturer responsible for the course also participated at every stage from the beginning to the end of the process. While the conceptual change texts developed for the first experimental group were utilized weekly as the subjects progressed, classical texts were utilized in parallel with this in the second experimental group. In the traditional teaching group, the lessons continued to progress in the normal period. This process consisted of 14 weeks in total. Thus, it was ensured that the topics to be covered each week were the same in the experimental and control groups. The implementation process of conceptual change texts and classical texts is given briefly below.

The implementation process of the conceptual change texts can be briefly summarized as follows:

- Before the texts were distributed to the pre-service teachers, initial questions were asked, and they were asked to answer them verbally. During this process, the researcher did not intervene and only listened to different opinions, thus enabling the pre-service teachers to exchange ideas.
- Then, the conceptual change texts were given to each pre-service teacher, but they were not allowed to read the texts individually; that is, they were allowed to continue with the path to be followed by the researcher.
- At the end of each paragraph in the texts, pre-service teachers were asked about the

main idea in these paragraphs and were allowed to discuss them in the classroom.

- At the end of each chapter of the conceptual change texts, this discussion period was kept a little longer, and they were allowed to move on to the next chapter.
- After the conceptual change texts to be taught that week were completed, the class hour was finished.

The implementation process of the classical texts can be briefly summarized as follows:

- The texts were given to each pre-service teacher, but it was ensured that they did not read the texts individually; that is, they continued with the path that the researcher would follow.
- At the end of each paragraph in the texts, the pre-service teachers were asked about the main idea in these paragraphs and were allowed to discuss them in the classroom.
- The lesson ended after the classical texts to be read at that week were finished.

Data analysis

The data were analyzed using the SPSS 22.0 package program. Statistics such as skewness and kurtosis coefficients, mode and median were used to determine the distribution of the results given by the preservice teachers and whether the data obtained was normal. One-way ANOVA for unrelated samples was used to determine the differences between the AAT pre-tests of the experimental and control groups and the differences between the post-tests of the same groups. A dependent t-test was used to determine the differences between the AAT pre-test and post-test of the experimental and control groups.

Table 3. Descriptive Statistics Results of Astronomy Achievement Pre-Test and Post-Test Scores of Students in Control and Experimental Groups

Test	**Group**	**N**	$\bar{X}$	**S**	**Median**	**Mode**	**Kurtosis**	**Skewness**	**Shapiro-Wilk**
Pre-test	Control	26	10,15	3,08	10	8	-,74	,34	,271
	Experiment 1	27	11,18	3,88	11	10	-,06	-,01	,866
	Experiment 2	24	11	4,55	10	10	,912	1,088	,019
Post-test	Control	26	16,5	4,06	16,5	16	-,72	,03	,569
	Experiment 1	27	21,15	4,85	22,0	25	-1,20	-,08	,167
	Experiment 2	24	18,71	5,40	18,5	16	-1,05	,12	,228

As seen in the table, the mean astronomy achievement scores of the control and experimental groups after the intervention were higher than the mean astronomy achievement scores before the intervention. To determine whether this difference between the averages was statistically significant, it was first checked whether the test results showed a normal distribution. If the sample size is larger than 35, the Kolmogorov-Smirnov (K-S) test (McKillup, 2012) can be used, and if it is smaller, the Shapiro-Wilk test (Shapiro & Wilk, 1965) can be used. Shapiro-Wilk, kurtosis and skewness coefficients were used to evaluate the normal distribution of the data. When the data in the table are examined, it is seen that the skewness and kurtosis coefficients of the achievement test pre-test and post-test scores of both the control and experimental groups are between -1.5 and +1.5, the mode, median and arithmetic mean values are close to each other. The significance values of the Shapiro-Wilk analysis are greater than 0.05. In the related literature, the results of the kurtosis skewness values of the variables between +1.5 and -1.5 (Tabachnick & Fidell, 2013), +2.0 and -2.0 (George & Mallery, 2010) are accepted as normal distribution. In addition, the arithmetic mean, mode and median being equal or close to each other in the distribution is evidence of the normality of the data. (Fidell, 2013; Howitt & Cramer, 2011; Lind et al., 2006; Tabachnick & McKillup, 2012; Wilcox, 2012b). This shows that the pre-and post-test data are normally distributed. Based on this result, parametric tests were used to analyze the research data.

Results

Table 4 presents the descriptive statistics of the pre-test scores of the AAT, which was conducted to compare the prior knowledge of the experimental and control groups on astronomy topics before the intervention, and the results of the one-factor ANOVA on the pre-test scores of the AAT are given in Table 5.

Table 4. Descriptive Statistics of Pre-Test AAT Scores of Experimental and Control Groups

Method	**N**	**$\bar{X}$**	**S**
CCT	27	11.19	3.88
CT	24	11.00	4.55
TL	26	10.15	3.08

According to the data in Table 4, the mean scores of the AAT pre-test were $\bar{X}$=11.19 for the CCT group, $\bar{X}$=11.00 for the CT group and $\bar{X}$=10.15 for the TL group, and the standard deviations were S=3.88 for the CCT group, S=4.55 for the CT group and S=3.08 for the TL group.

Table 5. One-Factor ANOVA Results for Comparison of Pre-Test AAT Scores of Experimental and Control Groups

Source of Variance	**Sum of Squares**	**df**	**Mean Squares**	**F**	**p**	**Significant Difference**
Between groups	15.79	2	7.89	.53	.592	-
Within groups	1105.46	74	14.94			
Total	1121.25	76				

When Table 5 is examined, it is seen that there is no significant difference between the pre-intervention AAT scores of the experimental and control groups ($F_{(2-74)}$ = .53; p> .05). This result shows that the groups had equivalent prior knowledge in astronomy before the intervention.

The descriptive statistics of the post-test AAT scores of the experimental and control groups after the intervention are given in Table 6, and the one-factor ANOVA results of the post-test AAT scores are given in Table 7.

Table 6. Descriptive Statistics of Post-Test AAT Scores of Experimental and Control Groups

Method	N	$\bar{X}$	S
CCT	27	21.15	4.86
CT	24	18.71	5.40
TL	26	16.50	4.06

According to the data in Table 6, the mean scores of the AAT post-test were $\bar{X}$=21.15 for the CCT group, $\bar{X}$=18.71 for the CT group and $\bar{X}$=16.50 for the TL group, and the standard deviations were S=4.86 for the CCT group, S=5.40 for the CT group and S=4.06 for the TL group. It is seen that the mean scores of the CCT group are considerably higher than the mean scores of the TL group, and there is a slight difference from the mean scores of the CT group.

Table 7. One-Factor ANOVA Results for the Comparison of Post-Test AAT Scores of Experimental and Control Groups

Source of Variance	Sum of Squares	df	Mean Squares	F	p	Significant Difference
Between groups	286.59	2	143.29	6.25	.003	CCT - TL
Within groups	1696.87	74	22.93			
Total	1983.46	76				

When Table 7 is examined, it is determined that there is a significant difference between the post-test AAT scores of the experimental and control groups ($F_{(2-74)}$ = 6.25; p< .05). It is seen that there is a significant difference between CCT and TL groups, but there is no significant difference between CCT and CT and CT and TL groups. According to these data, it can be observed that the CCT method is more instructive and useful than the CT and TL methods.

The t-test results for dependent groups were conducted to determine whether there was a significant relationship between the pre-test and post-test scores of the TL group, as shown in Table 8.

Table 8. Dependent Groups t-Test Results for the TL Group's ATT Pre-Test and Post-Test Scores

	N	$\bar{X}$	S	df	t	p
Pre-test	26	10.15	3.08	25	7.18	.000
Post-test	26	16.50	4.06			

According to the data in Table 8, it was determined that there was a significant relationship between the pre-test and post-test AAT scores of the TL group ($t_{(25)}$=7.18; p<.05). The mean pre-test score was $\bar{X}$=10.15 with standard deviation S=3.08, while the mean post-test score was $\bar{X}$=16.50 with standard deviation S=4.06. Thus, it is seen that this significant relationship is in favor of the post-test.

The results of the t-Test for dependent groups to determine whether there is a significant relationship between the pre-test and post-test scores of the CT group are shown in Table 9.

Table 9. Dependent Groups t-Test Results for the CT Group's AAT Pre-Test and Post-Test Scores

	N	$\bar{X}$	S	df	t	p
Pre-test	24	11.00	4.55	23	7.35	.000
Post-test	24	18.71	5.40			

According to the data in Table 9, there is a significant relationship between the pre-test and post-test scores of the CT group ($t_{(23)}$=7.35; p<.05). The mean pre-test score was $\bar{X}$=11.00, and the standard deviation was S=4.55, while the mean post-test score was $\bar{X}$=18.71 and the standard deviation was S=5.40. Thus, it is seen that this significant relationship is in favor of the post-test.

The results of the t-test for dependent groups, which was conducted to determine whether there was a significant relationship between the pre-test and post-test AAT scores of the CCT group, are given in Table 10.

Table 10. Dependent Groups t-Test Results Regarding the AAT Pre-Test and Post-Test Scores of the CCT Group

	N	$\bar{X}$	S	df	t	P
Pre-test	27	11.19	3.88	26	15.01	.000
Post-test	27	21.15	4.86			

When Table 10 was analyzed, it was determined that there was a significant relationship between the pre-test and post-test scores of the AAT of the CCT group ($t_{(26)}$=15.01; p<.05). The mean pre-test score was $\bar{X}$=11.19 with standard deviation S=3.88, while the mean post-test score was $\bar{X}$=21.15 with standard deviation S=4.86. Thus, it is seen that this significant relationship is in favor of the post-test.

Conclusion and Discussion

To find out whether there was a significant difference between the pre-test astronomy achievement scores of the groups to which conceptual change text, classical text and traditional learning methods were used, the experimental and control groups were given the AAT pre-test before the intervention, and the pre-test scores of the groups were compared. As a result of this comparison, it was seen that there was no difference between the experimental and control groups in terms of their achievement in astronomy. In other words, the groups in the study had similar achievement levels before the intervention.

In the study, to understand whether there was a significant difference between the post-test AAT scores of the groups, the experimental and control groups were given the AAT post-test after the implementation, and the post-test scores of the groups were compared. As a result of this comparison, it was observed that there was a significant difference only between the CCT and TL groups. In other words, the conceptual change texts on astronomy topics significantly outperformed the traditional learning method in the achievement of pre-service science teachers on astronomy topics. In other words, conceptual change texts significantly affected learning astronomy concepts. It was seen that the mean post-test achievement scores of the CCT group were higher than the CT group, and the CT group was higher than the TL group. However, the results obtained from the mean post-test scores of the AAT were not enough to create a significant difference between all groups. Only the significant difference observed between the CCT and TL groups can be attributed to the distinctive nature of conceptual change texts (CCT) compared to traditional learning (TL). Conceptual change texts may have allowed pre-service science teachers to engage deeply with and reassess their prior knowledge by providing a structured approach to confronting and correcting misconceptions. By highlighting misconceptions and providing alternative, scientifically accurate explanations, CCTs may have supported conceptual understanding, making them more effective than traditional methods in facilitating learning. In contrast, the traditional learning (TL) method may not provide the necessary interventions to address students' misconceptions directly. The fact that the traditional learning method and classical texts were less interesting or did not provide sufficient opportunities for reflection and correction of misconceptions may also have caused these results. Thus, while traditional methods may have been more passive and less sensitive to the individual learning needs of the participants, CCTs may have led to a more active process.

Studies examining conceptual change texts' effect on pre-service science teachers' astronomy education are limited in the literature. Creating conceptual change texts requires much time and effort (Roscoe et al., 2008). Working on astronomy education subjects in which abstract concepts are explained requires expertise. Therefore, it is observed that studies on these subjects are limited. However, there are studies on pre-service science teachers on other topics. For example, Yürük and Eroğlu (2016) found that conceptual change texts significantly differed from other text types in their study on 'Heat and Temperature' in pre-service science teachers. This study shows that conceptual change texts are effective in science education. In another study, Karyağdı and Aydın (2023), investigated the effects of technology-supported conceptual change activities with pre-service science teachers and found that pre-service teachers' answers to conceptual change evaluation questions after the application were more scientific than their answers before the application. Taşlıdere (2014), investigated the effect of the conceptual change approach on the elimination of misconceptions about direct current circuits. The results show that the conceptual change approach is effective in reducing misconceptions. In studies conducted according to other age levels, it is possible to observe the positive effect of conceptual change texts on astronomy subjects. For example, Şahin et.al.,Çepni (2013) aimed to eliminate alternative concepts in the subject of 'Let's Recognize Celestial Bodies' with conceptual change texts, and as a result of the research, it was found that conceptual change texts significantly reduced students' alternative concepts. Again, Şenel Çoruhlu and Çepni (2015) examined the effect of guidance materials prepared by the 5E model enriched with conceptual change pedagogies on students' conceptual changes in astronomy subjects and as a result of the research, it was found that the guidance materials applied in the experimental group were significantly more effective compared to the current teaching methods. Although studies directly examining the effect of conceptual change texts on pre-service science teachers' astronomy education are limited, studies investigating the general effects of science education and misconceptions in astronomy subjects reveal the potential benefits of conceptual change texts in this field.

This research result is in line with the results of many studies conducted both in Türkiye and abroad (Akkuş, 2004; Akpınar, 2012; Alkhawaldeh, 2015; Altuntaş-Aydın, 2011; Arıkurt, 2014; Budak, 2017; Chambers & Andre, 1997; Çaycı, 2007; Çil & Çepni, 2016; Demirci, 2011; Dilber, 2006; Ersoy, 2012; G. Demircioğlu, Altuntaş-Aydın & Demircioğlu, 2012; Kılıçoğlu, 2011; Korur, Enil & Göçer, 2016; Önder, 2011; Özay, 2008; Özkan, 2013; Özkan & Sezgin-Selçuk, 2015; Palmer, 2003; Sinanoğlu, 2017; Şarlayan, 2017; Şenel- Çoruhlu Çepni, 2016; Ural-Keleş & Aydın, 2012; Uyanık & Dindar, 2016; Ünlü, 2014; Vatansever, 2006; Yıldırım, 2016; Yürük, 2007). All these results show that conceptual change texts play a very important role in student achievement and lead to the conclusion that such studies should be included more widely.

In the current studies, the post-test AAT scores of the control group showed a significant increase. These results showed that the traditional teaching method also provided a positive change for pre-service science teachers. However, this change was not as big and effective as in the classical text and conceptual change text groups.

When similar studies are examined in the literature, there are studies in which no increase in the achievement of the groups taught with the traditional learning method is observed (Çakmak, 2016; Demirel & Anıl, 2017). However, when we look at the studies in which conceptual change texts and traditional teaching methods were compared, it was concluded that the achievement of the groups in the traditional learning method increased in most of them, but this increase was not as high as in the experimental group (Budak, 2017; Yıldırım, 2016).

The study's findings indicate a significant relationship between the pre-test AAT and post-test AAT scores of the CT group. It was seen that the effect of this teaching method was higher than the TL method and lower than the CT method. The reason why the CT group was more successful than the CT group was that the text contents were different. While classical texts contain only information, conceptual change texts contain information about the subject and different sections related to the subject to correct the wrong information they had before and to ensure the retention of this information. Akgül (2010) investigated the effect of conceptual change texts, reputation texts and classical texts on the achievement of pre-service science teachers and found a significant relationship between the pre and post-tests of pre-service teachers in the classical text group. In a similar study, he concluded that there was a negative change in the post-test scores of the students in the classical text group (Akpınar, 2012).

Another result of the studies showed that there was a significant and positive change in the AAT scores of the CCT group. In achieving this success, it is also very important that the pre-service teachers first realize the wrong information they have in the conceptual change texts and then realize why they are wrong. After this stage, the fact that they learned the correct information with examples to support it made this method effective and different from the CT and TL methods. Addido et al. (2022) investigated the effect of the conceptual change model on improving pre-service science teachers' conceptual understanding of force and motion. They showed that the conceptual change model effectively eliminated misconceptions and increased conceptual understanding.

The effect of conceptual change texts in teaching the concepts in astronomy subjects is quite high. The preservice teachers who read the texts become aware of their misconceptions and learn why they have such misconceptions, and then effective learning begins. In addition, the fact that conceptual change texts start with motivational questions and include examples from our daily lives in the following sections creates great curiosity in the reader. It makes them more eager to learn the subject.

Based on the study results, the following suggestions can be made for researchers in this field. It is seen that the CCT method has a positive effect on academic achievement. The subject area in astronomy can be kept narrower, and the CCT method can be utilized.

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Declaration

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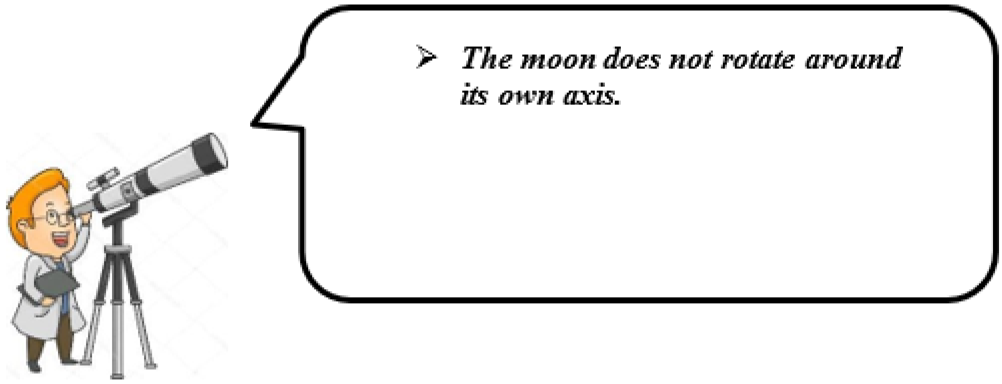
Ethics statements: Ethical research conduct has been met through voluntary basis of participation and anonymity of the participants.
Conflict of interest: The author declares that there are no competing interests upon the publication of this research.
Data availability: Data are available upon requests.

Appendix 1: *Example of a Conceptual Change Text*

DOES THE MOON REVOLVE AROUND ITS AXIS?



❖ Some pre-service teachers' opinions about the motion of the Moon around its axis are given below.

The Moon is the first thing our eyes look for, especially when we look at the night sky. Do we always see the same face of the Moon that illuminates the night sky? Can we observe its whole face at different times or days? So, can you tell me if the Moon revolves on its axis? Does it rotate on its own? Does the rotation or non-rotation around its axis affect the visible face of the Moon? Some pre-service teachers' opinions about the motion of the Moon around its axis are given below.

Some preservice teachers think the Moon does not rotate around its axis. However, this thought is not correct. There are two reasons why they think this way. The first reason is that we always see the same face of the Moon. The other reason is that they think the Moon is only visible at night and always stays in the same place.

The unseen face of the Moon has always remained mysterious and has even been the subject of many conspiracy theories. It was not until 1959 that the **Luna 3** spacecraft sent the first photographs of the back side of the Moon (see Figure 1). Thus, the Moon is no longer a mystery or a subject of conspiracy theories.

In 1968, US astronaut ***William Anders*** became the first person to see the back side of the Moon with the Apollo 8 mission. Now that we have told you about the first person to see the back side of the Moon, we can move on to why we always see the same side. The answer to this, as always, lies in the marvelous design of the universe!

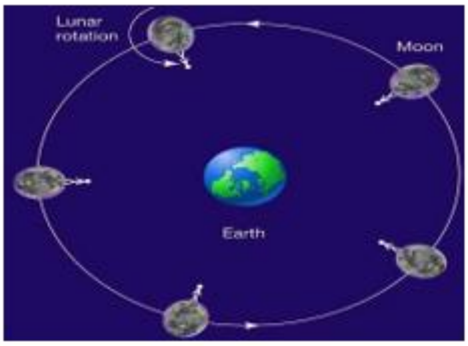
The face of the Moon as seen

The face of the Moon invisible

The Moon, our only natural satellite, has three different movements. These are its movement around its axis, its movement around the Earth and the Sun together with the Earth. However, it is enough to know that it completes its movement around the Sun with the Earth in 365 days and 6 hours. What is important for us now are the other two movements.

The distance of the Moon, the closest celestial body to the Earth, is approximately 384 thousand kilometres. The Moon is both this **close to** our Earth and **smaller** than our Earth. Therefore, the Moon is under the influence **of a large gravitational pull** exerted by the Earth.

Picture 2

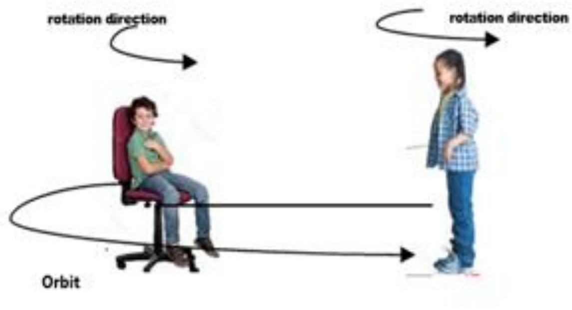


Because the gravitational force causes the Moon to rotate very slowly around its axis, if you compare it with 1 full rotation of the Earth around its axis, you will see that the Moon rotates very slowly (the Earth completes one full rotation in 1 day). Thus, the Moon completes **one complete rotation** around its axis and **one complete orbit** around the Earth simultaneously, i.e. 27.3 days. This phenomenon is also called Locked Orbit motion. Therefore, when viewed from the Earth, the **same face of** the Moon is always seen. As shown in Figure 2, the Moon always has the same face towards the Earth (dimensions do not represent reality). However, due to factors such as ecliptic orbits, speed changes in the orbit and gravitational effects, the face of the Moon seen from the Earth is not precisely half (50 per cent) of the Moon, but slightly more, about 59 per cent. You can observe the Moon at different times, on different days and even in different parts of the world, but you will never be able to see its invisible face from Earth.

Since the Moon has a face that is never visible from the Earth, you may ask **whether** this face **will always remain in darkness**. However, our answer to this question will be **no**. Because even though we cannot see it, this invisible face of the Moon is illuminated **when it receives sunlight.**

EXAMPLES FROM DAILY LIFE

Let's reinforce this topic with a model, as shown in figure 3. For this, you will need a swivelling chair. Have one of your friends turn around in the centre of the classroom to represent the Earth. Have another friend sit on the chair and represent the chair and the Moon. Tie a string to the chair and give the other end to the friend representing the Earth.



Picture 3

Think of the rope here as the force of gravity, even though it does not represent it in reality. As soon as your friend in the chair accelerates around himself, your friend holding the rope pulls the rope towards him, allowing the chair to go around itself (i.e. the Earth). Thus, while the chair rotates around itself, it also rotates around the friend holding the rope, and throughout this whole practice, your friend representing the Earth **always** sees the **front side of** your friend in the chair.

NOW IT'S QUESTION TIME

1) If the moon **did not revolve** around its own axis, would we be able to see its other side? Why?

……………………………………………………………………………………………

2) If the moon **rotated only** around its own axis, would we be able to see its other side? Why

……………………………………………………………………………………………

3) If the moon rotated **faster** around its axis, would we be able to see its other side? Why?

……………………………………………………………………………………