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Exploring Seventh-Grade Students' and Pre-Service Science Teachers' Misconceptions in Astronomical Concepts

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Pre-service science teachers' conceptual understanding of astronomical concepts and their misconceptions in these concepts is crucial to study since they will teach these subjects in middle schools after becoming teachers. This study aimed to explore both seventh-grade students' and the science teachers' understanding of astronomical concepts and to diagnose the misconceptions of seventh-grade students and pre-service science teachers regarding some basic astronomy concepts derived from a three-tier test. The test was administered to 105 pre-service science teachers and 91 seventh-grade students. The best conceptual understanding was related to the properties of the Sun. The students and pre-service science teachers have some common misconceptions in astronomy. Pre-service teachers mostly have misconceptions not regarding complex concepts but instead in very basic knowledge of astronomy. There is a need to take serious measures to correct the misconceptions of the teachers, since under such circumstances it is optimistic to expect them to teach the subject correctly.

Keywords: astronomy misconceptions, pre-service science teachers, seventh-grade students, three-tier test, understanding concepts in astronomy.

INTRODUCTION

Classical features and definitions of concepts are mostly based on the ideas of Bruner, Goodnow, and Austin (1967). Concepts were defined by Novak (2008) as "perceived regularity in events or objects or records of events or objects, designated by a label"(p. 1). In this context, learning a concept occurs through the assimilation of new concepts into the existing concept propositional frameworks held by the student (Posner, Strike, Hewson, & Gertzog, 1982). Misconception occurs when concepts are constructed in a wrong way or when there is a lack of process of concept construction (Hammer, 1996). Misconceptions may result from formalized instruction as well as informal daily life experiences (Vosniadou & Brewer, 1994; Bell & Trundle, 2008). Students bring to learning tasks alternate frameworks, and

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their processes of concept construction are mostly based on Piaget's assimilation and accommodation concepts—which they are strongly resistant to change (Posner et al., 1982; Hammer, 1996). Therefore, misconception is not a lack of knowledge or a simple error in answering a question (Arslan, Cigdemoglu, & Moseley, 2012; Hasan, Bagayoko, & Kelley, 1999; Pesman & Eryılmaz, 2010). For this reason, a teacher has to identify students' misconceptions before teaching them a new concept, so teaching becomes crucial in terms of the reconceptualization of misconceptions (Arslan et al., 2012; Prather, Rudolph, & Brissenden, 2009). In this particular study, the term "misconception" is used to refer to students' and pre-service science teachers' incompatible ideas that have been constructed in a wrong scheme in their cognitive structure.

In the last decade, identifying misconceptions with two-tier (Treagust, 1988), three-tier (Kanli, 2014; Pesman & Eryılmaz, 2010; Taylor, Barker, & Jones, 2003), and four-tier tests (Caleon & Subramaniam, 2010) has been quite an effective form of diagnosing students' misconceptions. The first tier is a typical multiple-choice question in which students choose the right answer from a set of choices, whereas the second tier directs students to select a reason for the answer that they chose in the first-tier (Tan, Goh, Chia, & Treagust, 2002). The certainty-level questions form the third level, or the third tier, of misconception questions, where students state whether they are "certain" or "uncertain" about their answer to the second-tier question. Moreover, Hasan et al. (1999) indicated that students must rate their answer or reasoning using a certainty index. This is a simple and effective way to determine a student's level of certainty regarding each answer, and it is used by many researchers because it distinguishes a lack of knowledge from a misconception (Arslan et al., 2012; Pesman & Eryılmaz, 2010). Misconception tests can be used both for identifying students' misconceptions and for assessing their achievement scores (Arslan et al., 2012; Kanli, 2014; Pesman & Eryılmaz, 2010; Göncü, 2013).

State of the literature

- The misconception tests can be used both for identifying students' misconceptions and for assessing their achievement scores. Three-tier tests fulfill the disadvantages of traditional multiple-choice tests.
- Diagnosing the misconceptions of pre-service teachers is critical for enhancing their level of conceptual understanding. They will become the science teachers who are responsible for teaching these astronomical concepts.
- The teachers play a crucial role in assuring that students understand these science concepts. Unless science teachers have a personal interest in astronomy, they do not have the opportunity to learn basic astronomy concepts until they are studying in a university.

Contribution of this paper to the literature

- The three-tier misconception test developed in this study is for both to identify students' and pre-service teachers' misconceptions and to assess their conceptual understandings in basic astronomy concepts.
- Even the teachers have a higher cognitive level and they receive more detailed astronomy courses, there was no extreme difference between achievement scores of the participants. Furthermore, they even have some common misconceptions.
- Students have eight and the teachers have five misconceptions in astronomical concepts in this study. Therefore, if the cumulative average of the exam with traditional achievement tests is high, there will be a risk that the participants will be evaluated superficially, without a deeper analysis of their misconceptions.

MISCONCEPTIONS IN BASIC ASTRONOMY CONCEPTS

It is not possible to undertake classroom experiments for most astronomy concepts. Further, the lack of guided observations, lack of practice and targeted instructions in astronomical concepts make scientific understanding difficult for students and pre-service teachers (Plummer, 2014; Plummer & Krajcik, 2010; Steinberg & Cormier, 2013; Trundle, Atwood & Christopher, 2007a). Even scientifically misinterpreted definitions in various books related to lunar phases support students' misconceptions (Trundle, Troland & Pritchard, 2008).

Identifying students' misconceptions could enable in-service teachers to reorganize existing programs or to replace them with new methods of delivering astronomy lessons. Students' alternative conceptions or misconceptions might only be handled through targeted instruction, since traditional instruction or observations from the Earth allow them to gain only limited knowledge (Plummer & Krajcik, 2010). Studies have revealed that the conceptual understanding of students or pre-service teachers might be enhanced for celestial motion concepts (motion of the sun, moon, and stars) with a planetarium visit (Plummer, 2009, 2014; Plummer & Krajcik, 2010; Small & Plummer, 2014); for lunar concepts (phases of the moon, eclipse and motion of the moon) with computer simulations (Bell & Trundle, 2008) or inquiry-based 3D modelling (Trundle, Atwood & Chrtistopher, 2002, 2007a, 2007b); for basic astronomy concepts with 3D modelling (Küçüközer, Korkusuz, Küçüközer, & Yürümezoğlu, 2009); and for an introductory astronomy course with interactive strategies like systematic investigations and observations (Prather et al., 2009). Furthermore, diagnosing the misconceptions of pre-service teachers is critical for enhancing their level of scientific conceptual understanding that helps them improve their content knowledge, their ways of teaching, and the classroom instruction (Trumper, 2000; Trundle, Atwood, & Christopher, 2006). Pre-service teachers play a crucial role in assuring that students understand these science concepts, as they will become the science teachers who are responsible for teaching astronomical concepts.

Conceptual identification or diagnosing poorly structured concepts by assessing students' misconceptions is crucial for their conceptual understanding in science. Consequently, through the late 1990s, one of the most effective tools for diagnosing students' failure to structure concepts in basic astronomy was the Astronomy Diagnostic Test (ADT) with 21 multiple-choice questions and 12 demographic questions. The ADT was quite effective in evaluating participants' pre-existing knowledge about Basic Astronomy Concepts (BAC) as indicated by Turkoglu, Ornek, Gokdere, Suleymanoglu, and Orbay (2009). Brogt et al. (2007) analyzed the ADT and stated that it is far from being a true diagnostic tool since it is not sensitive enough to evaluate the effectiveness of various instructional methods within the extensive scope of introductory astronomy concepts. They recommended developing sensitive concept inventories that focus on students' acquisitions in the BAC.

The studies primarily focused only on elementary, middle school, and high school students' scientific conceptions in astronomical concepts (Barnett & Morran, 2002; Diakidoy & Kendeou, 2001; Göncü, 2013; Lightman & Sadler, 1993; Plummer, 2009; 2014; Plummer & Krajcik, 2010; Plummer & Maynard, 2014; Sadler et al., 2010; Small & Plummer, 2014; Trumper, 2000, 2006; Vosniadou & Brewer, 1994; Wilhelm, 2009) or pre-service or in-service teachers' scientific conceptions in astronomical concepts (Bell & Trundle, 2008; Kanli, 2014; Küçüközer, Bostan, & Işıldak, 2010; Ogan-Bekiroglu, 2007; Sadler, Sonnert, Coyle, Cook-Smith, & Miller, 2013; Trumper, 2001; Trundle et al., 2002, 2006; Wilhelm, Smith, Walters, Sherrod, & Mulholland, 2007). One of the two exceptional studies that include a comparison of groups might be the study of Trundle et al. (2007b) conducted with fourth graders. They compared the results of this study with those of their longitudinal studies (Trundle et al. 2002, 2006, 2007a) conducted with pre-service elementary teachers. They indicated that after fourth graders and pre-service elementary teachers received the same basic instruction, the two groups showed similar positive enhancement of their scientific conceptions in lunar concepts (Trundle et al., 2007b). The other study was carried out by Kanli (2014), who identified the misconceptions of 97 pre-service and 174 in-service science teachers by administering a three-tier test. In this study, Kanli indicated that as well as pre-service teachers, in-service teachers have serious misconceptions in the BAC. Therefore, the understanding of the BAC of pre-service teachers and middle school students should be analyzed in order to identify whether they construct true scientific knowledge and to identify whether they have common misconceptions.

Astronomy education, such as observing the motion of the moon, the planets, the Sun, and other stars, is very important both for learning physics—including scientific thinking skills as well as mathematics—and geometrical interpretations (Bektasli, 2013; Trumper, 2000, 2006). There are, actually, many misconceptions derived from related literature in the BAC. These are classified in Table 1.

The other studies in related literature focused on revealing misconception for different grade levels were collected under the main titles "lunar concepts (motion, phases, eclipse, and the face of the moon)" (Barnett & Morran, 2002; Bell & Trundle, 2008; Bulunuz & Jarrett, 2010; Küçüközer et al., 2009, 2010; Lightman & Sadler, 1993; Ogan-Bekiroğlu, 2007, Stover & Saunders, 2000; Trumper, 2000, 2001;

Table 1. Some misconceptions of students related to the BAC

Misconception	Literature (Source)	Sample
"The Sun is not a star; it is a celestial body by itself."	(Göncü, 2013) (Sadler et al., 2010) (Sharp, 1996) (Dunlop, 2000)	K-5 & K-7 K-4 to K-12 Year-6 students Elementary and middle school students
"The center of the universe is the Sun."	(Göncü, 2013) (Küçüközer, Bostan, & Işıldak, 2010) (Trumper, 2001 & 2006)	K-5 & K-7 Pre-service science & math teachers Pre-service teachers & high school students
"Pluto closer to the Sun than the Earth."	(Trumper, 2001) (Brunsell & Marcks, 2005)	Pre-service teachers Science teachers
"The center of the universe is the Milky Way."	(Göncü, 2013) (Küçüközer et al., 2010) (Trumper, 2001 & 2006)	K-5 & K-7 Pre-service science & math teachers Pre-service teachers & high school students
"The stars reflect the light coming from the Sun."	(Göncü, 2013) (Küçüközer et al., 2010)	K-5 & K-7 Pre-service science & math teachers
"A shooting star is a visible comet," "A shooting star is the displacement of a star."	(Göncü, 2013) (Küçüközer et al., 2009)	K-5 & K-7 Sixth grade students
"Galaxies cover whole celestial bodies," "The Sun reflects the incoming light from the other stars," "There is no difference between meteors and meteorites," "There is no difference between stars and planets," "All stars are the same size," "There is no difference between Space and the universe."	(Göncü, 2013) (Dunlop, 2000) (Sharp, 1996) (Küçüközer et al., 2010)	K-5 & K-7 Elementary and middle school students Year-6 students Pre-service science & math teachers
"There are many stars within the solar system," "Stars other than the Sun are closer to us than Pluto is to us," "The Earth orbits the Sun once a day, producing day and night," "The Earth's orbit is highly elliptical," "There is no gravity in space."	(Sadler et al., 2010) (Dunlop, 2000) (Trumper, 2000) (Lightman & Sadler, 1993) (Zeilik et al., 1998) (Frede, 2006) (Vosniadou & Brewer, 1994) (Plummer & Krajcik, 2010)	K-4 to K-12 Elementary and middle school students University Students High school students University students Pre-service elementary teachers First-third-fifth graders First-third-eight graders

Trundle, Atwood, & Christopher, 2002, 2006; Wilhelm, 2009), "motion, eclipse, and the position of the Sun" (Cin, 2007; Ogan-Bekiroglu, 2007, Plummer & Krajcik, 2010; Vosniadou & Brewer, 1994, Zeilik, Schau, & Mattern, 1998), "celestial motion and seasons" (Bulunuz & Jarrett, 2010; Dunlop, 2000; Frede, 2006; Plummer & Krajcik, 2010; Plummer & Maynard, 2014; Trumper, 2001), and "astronomical scale" (Schneps et al., 2014).

Astronomy-related units in elementary school science courses begin in the fourth grade in Turkey. However, most of the concepts in the seventh grade are based on the solar system and the BAC. Astronomy is a compulsory course in the last semester of science-teacher training programs at the university level in Turkey. Therefore, unless pre-service science teachers have a personal interest in astronomy, they do not have the opportunity to learn the BAC until they are studying at a university. To this end, Göncü & Korur (2012) first presented a unique three-tier astronomy test to identify the misconceptions of fifth and seventh graders. In Göncü (2013), the test included 15 questions for seventh graders, and it was administered to 343 students. The Cronbach's alpha reliability coefficient of the test was $\alpha = .79$. The item analysis of the test and all related validity issues were carried out thoroughly. However, the test focused only on the specific acquisitions of the unit "Solar System and Beyond: Space Conundrum."

In this particular study, the three-tier test was a revised form of the test used by Göncü (2013). The test for this study included five additional questions, and it was crucial in terms of evaluating all of the acquisitions of the seventh-grade unit. It was also important in terms of exploring whether these misconceptions were really misconceptions or if the students' incorrect answers resulted simply from their lack of knowledge. The extensive three-tier test is used to identify all determined or undetermined misconceptions of teachers and students in the related literature. For this very reason, the main research question of this study was, "What are the misconceptions of seventh-grade students and pre-service science teachers in basic astronomy concepts?" This study, therefore, aimed to do the following:

- Revise a comprehensive, valid, and reliable three-tier conceptual test, the 'Basic Astronomy Concepts Three Tier Conceptual Test' (BACTTIM) in order to cover all acquisitions of the unit for seventh graders,
- Explore students' understanding of the BAC from the data of the correct item scores derived from the BACTTIM,
- Explore pre-service science teachers' understanding of the BAC from the data of the correct item scores derived from the BACTTIM,
- Diagnose seventh-grade students' and pre-service science teachers' misconceptions in the BAC,
- Identify the common misconceptions in terms of the students' and pre-service teachers' perspectives, and
- Identify newly added misconceptions to the literature of the BAC.

METHOD

Population and Sample

Students' and pre-service science teachers' misconceptions were gathered from a sample of a pre-determined population (Fraenkel, Wallen, & Hyun, 2012). Both seventh-grade students in Burdur province (736 students) and pre-service science teachers that were final-year students in the science and technology teaching program from a public university in Turkey (105 pre-service science teachers) comprised the accessible population of this study. The reasoning behind selecting the seventh graders was that their curriculum includes most of the BAC. In the same way, the purpose for choosing the pre-service science teachers was that their

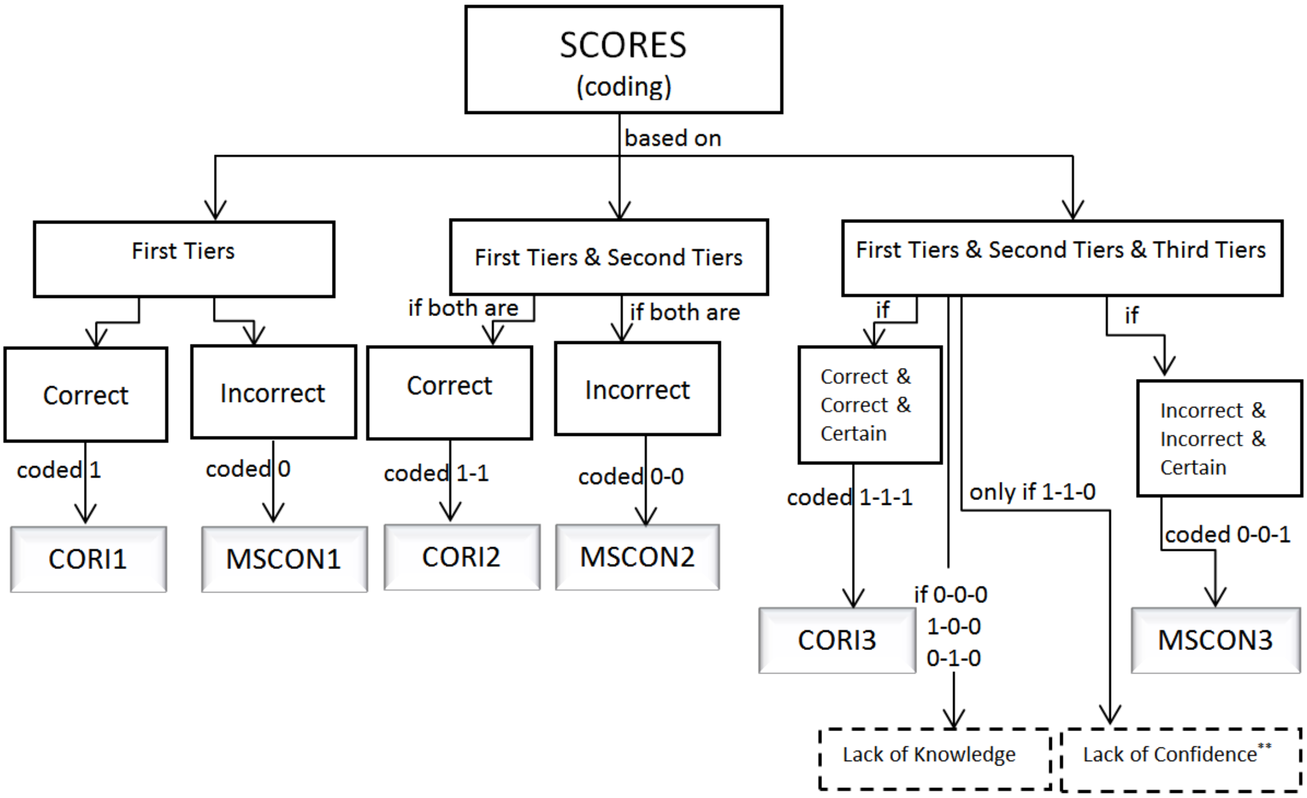
Astronomy course included the concepts related to the BAC, and they will teach these subjects in middle schools after becoming teachers. The participants were selected by convenience sampling. The sample included 105 pre-service science teachers and 91 students from seventh-grade, selected from four classes of two public middle schools that include the highest number of students in Burdur. Also, all of the fourth-grade pre-service science teachers from the public university were included in the study. The common application of the misconception evaluation was conducted after the participants had taken the corresponding lesson. The BACTTIM was administered to the participants at the end of the spring semester of the 2012-2013 academic year, after they had taken the related courses about astronomy. The application period of the test was 25 to 30 minutes within one class-hour.

Variables

The variables were the scores derived from the BACTTIM. The scores do not belong to individual students, but instead are the percentage scores for each item. The formation and way of coding the scores are presented in Figure 1. Lack of Confidence scores and Lack of Knowledge Scores were directly adapted from the study by Arslan et al. (2012).

Misconception Item First Tier Score (MSCON1): The number of "0's" for each item, multiplied by 100, and divided by the number of students in the group, to obtain the percentage.

Misconception Item Second Tier Score (MSCON2): The number of "0-0's" for each item in both the first and second tiers, multiplied by 100, and divided by the number of students in the group.



*Revised from the figure "A diagram of coding and scoring procedure" from Arslan et al. (2012, p.1675).

**It may also be found by subtracting the CORI3 from the CORI2.

Figure 1. The formation of the scores for all of the three tiers of the BACTTIM

Misconception Item Third Tier Score (MSCON3): The number of “0-0-1’s” for each item that has incorrect choices in both the first and second tier and “certain” choices in the third tier, multiplied by 100, and divided by the number of students in the group.
Correct Item Third Tier Score (CORI1): The number of correct choices “1’s” in the first tiers for each item, multiplied by 100, and divided by the number of students in the group.
Correct Item Third Tier Score (CORI2): The number of correct choices “1-1’s” in the first tiers for each item, multiplied by 100, and divided by the number of students in the group.
Correct Item Third Tier Score (CORI3): The number of correct choices in the first two tiers and “certain” choice in the third tier (1-1-1) for each item, multiplied by 100, and divided by the number of students in the group.
Lack of Knowledge Score: The number of scores (1-0-0, 0-0-0, 0-1-0 except 1-1-0), multiplied by 100, and divided by the number of students in the group.
Lack of Confidence: The number of uncertainty scores from what they know is correct (1-1-0). It is usually treated as “uncertain from correct-response” and differentiated from lack of knowledge (Arslan et al., 2012). The score was gathered by the number of “1-1-0’s,” multiplied by 100, and divided by the number of students in the group.

In Figure 1, the lack-of-confidence score is the score attained when the participants (seventh-grade students and pre-service science teachers) are uncertain about what they know even if it is correct. The lack-of-knowledge score represents the situation of students being uncertain about their response (whether it is correct or wrong) for the first two tiers. Some studies supposed that lack-of-knowledge scores covered the lack-of-confidence score (Hasan et al. 1999; Pesman & Eryılmaz, 2010), but according to Arslan et al. (2012), this is not the case. This is because there could be correct guessing (lucky guesses) in the first two tiers but the participant was not “certain” about his or her answer in the third tier. So, in this particular study, being uncertain about a correct response and correct reasoning (1-1-0) were accepted as the lack-of-confidence score. Furthermore, both false positive (1-0-1) scores (FALPOS) and false negative (0-1-1) scores (FALNEG), even if they involve “certain” on the third tier, mainly constituted the errors in the study, and they were used to measure the validity of the BACTTIM.

The instrument of the study: The BACTTIM

The curriculums of the participants were analyzed and found to have common acquisitions which are related to the concepts of astronomical scales, astronomical units, light years, the universe, space, the galaxy, tailed stars, the solar system, planets in the solar system, celestial bodies, examples of the celestial bodies (star clusters, tailed stars, planets, galaxies, etc.), the structure of the solar system, the structure of the galaxies, models related to the solar system, models related to the Moon and the Earth, the order of the planets with respect to the Sun, the differences between meteors and meteorites, the order of the size of the planets, the order of the size of the celestial bodies, and general properties of stars, planets, and satellites. These astronomical concepts are mostly covered by the BAC (Trumper, 2001). The seventh graders studied these concepts from the Science and Technology Course Book (Unit 7) that is printed according to the curriculum structured by the Ministry of National Education. The suggested time to cover these concepts was 14 class-hours. On the other hand, pre-service science teachers undertook a detailed and quite complicated curriculum. In addition to the BAC, they were taught in their lessons Kepler’s laws, asteroids and neutron stars, nebulas, super giant stars (red giants), white dwarfs, black holes, and common current views on the formation of galaxies, the universe, stars, and planets. The lessons took 28 hours over 14 weeks, and the BACTTIM was applied just after they finished the subject related to the BAC.

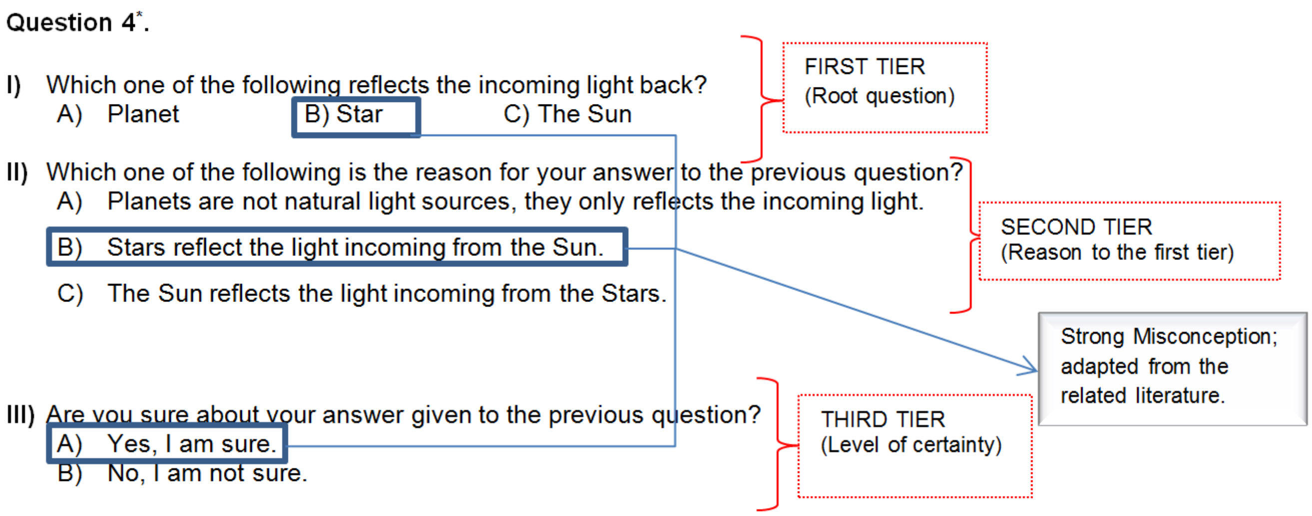
In order to cover all of the acquisitions of seventh graders within the BAC, five new questions were added to the test of Göncü (2013) by following the steps and the principles of three-tier misconception test preparation as suggested by Pesman and Eryılmaz (2010). These were (a) clarifying possible misconceptions with semi-structured interviews of the students and with examining strong misconceptions from related literature, (b) administering open-ended questions as "the reason of the first question" was left blank, and (c) administering the initial form of the test to 58 students from the seventh grade. There were 15 questions derived and adapted from the test used by Göncü (2013), numbered 1 to 15; and 5 questions added to this study, numbered 16 to 20. A sample question is given in Figure 2.

In order to check the validity issues, the newly added questions were delivered to experts. They suggested improvements, which were applied, and the last version of the BACTTIM was administered to 105 pre-service science teachers and 91 students from the seventh-grade. The original form of the BACTTIM is in Turkish and the sample item in Figure 2 was translated into English in order to add it to this article.

The validity and reliability issues of the BACTTIM

For the face validity—i.e., whether the items properly evaluate the misconceptions and assess the assigned acquisitions—the BACTTIM was examined and approved by two academicians who are experts in physics education, two students with master's degrees, and a science teacher in Burdur, Turkey. In order to establish the content validity, the experts also approved the table of specification. The BACTTIM was also reviewed in terms of grammar and wording.

The participants mostly have difficulty in discriminating what they know from what they do not know (Caleon & Subramaniam, 2010). The participants who marked the first two tiers correctly and got high CORI 2 scores are expected to be more confident on the third tier than the ones who got low CORI2 scores (Cataloğlu, 2002). In this respect, high correlation value indicated the items in the test worked properly and supported the construct validity of the test (Pesman & Eryılmaz, 2012). Therefore, the construct validity of the BACTTIM was determined by the high-level correlation between the CORI2 and confidence levels (level of certainty – how many participants selected "1" as their answer for the third-tier question). In



*The original question number given in the BACTTIM.

Figure 2. A sample item from the BACTTIM

this study, this correlation was calculated, and the Pearson product-moment correlation coefficient ($r=.576$, $p<.01$) indicates a strong relation among those scores since it is a high value; thus, it supports the construct validity of the BACTTIM.

The false positive scores (FALPOS) and false negative scores (FALNEG) may be used to determine the content validity of a test (Hestenes & Halloun, 1995; Pesman & Eryılmaz, 2010). The FALPOS score implied that students got the correct answer, but their reasoning is wrong, albeit they are sure that their reasoning is correct. When FALNEG scores increase, students reached a wrong answer through correct reasoning. Minimal values (below 10%) for the FALNEG and FALPOS provide higher content validity of the BACTTIM in three-tier tests (Arslan et al., 2012; Hestenes & Halloun, 1995).

In this particular study, all of the FALNEG values were under 10% (ranging between 0 and 8.62%). The FALPOS were expected to be higher than the FALNEG (Hestenes & Halloun, 1995). There are just two values, for Item 6 and Item 19, for which the FALPOS values (12.54 % and 13.52%, respectively) are just a little above 10%. However, these items were analyzed, and it was considered that they did not represent a threat to the content validity of the BACTTIM.

The BACTTIM was used to assess students' and teachers' conceptual understandings. Therefore, item analysis of the test was applied to determine an "item discrimination index" and an "item difficulty index" by using the ITEMAN. The range of the item discrimination index was evaluated by point-biserial values, which ranged between .294 and .603 with an average of .406. Almost all of the item discrimination index values were above .30 except one, which was very close to .30. However, they were within the limit for the desirable value of the point-biserial values (Crocker & Algina, 1986). The item difficulty index (Prop. Correct values) ranged between .66 and .90. The mean of the difficulty level index was .788, which indicates that the test was of moderate difficulty for both the lower and upper group of students. Answering three-tier multiple-choice tests was indicated as complex in the related literature (Arslan et al., 2012; Pesman & Eryılmaz, 2010; Göncü, 2013). The Cronbach's Alpha reliability coefficient was found to be .85 after adding five questions to the revised form of the BACTTIM. This value implied high reliability as reported by Fraenkel, Wallen, and Hyun (2012). Therefore, the reliability coefficient of the test increased with respect to the previous one.

Data analysis

Measuring misconceptions with more than one question gives more effective and more valid results while calculating the students' misconception percentage, but in some studies from the literature the total number of misconceptions is less than 10 (Arslan et al., 2012; Pesman & Eryılmaz, 2010). However, the BACTTIM was prepared to test 20 to 40 misconceptions with alternative sets. It was almost impossible to measure one misconception with more than one question in order to ensure students completed the test in one class-hour, so the number of three-tier questions in the BACTTIM was limited to 20. The misconceptions and their alternative sets in the BACTTIM are given in the Appendix.

Throughout the whole test and the first two tiers, the coding was noted only once for correct choices, as "1," and for wrong choices, as "0." For the last tier the "Yes, I am sure" choice was coded as "1," and the "No, I am not sure" choice was coded as "0." To form the misconception item scores, "0's" were counted and combined; to form the correct item scores, "1's" were counted and combined. The details of the coding are also presented in Figure 1. The third tier was the confidence tier, so it asked whether the participants were "Yes, I am sure" or "No, I am not sure" about their reasoning for the question that they had answered in the second tier.

In terms of the design of the study, a possible intimidation to internal validity was discussed as four main threats in survey research. The mortality, location and instrumentation, instrument decay, and confidentiality threats were prevented and controlled during the study. In terms of ecological generalizability, the testing procedure took place in ordinary classrooms in public high schools.

Limitations

This research was limited to four classes of two public middle schools and four classes of a science-teaching program of a university in Burdur. In terms of the subjects, it was limited to the unit of "The Solar System and Beyond: Space Conundrum" for the students and the respective units of the Astronomy course for the pre-service science teachers. The participants were limited to completing the BACTTIM within one class-hour. The participants' misconceptions and their conceptual understandings in the research were limited to how they understood the 20 questions of the BACTTIM.

RESULTS

Overall descriptive statistics for the third-tier scores

Table 2 summarizes the descriptive statistics, based on the third-tier score (1-1-1). The score was determined with respect to each student, not to the items. The mean, point–biserial values, and prop. correct values are listed. The mean scores are quite high, and they are close to each other in terms of the students' and teachers' values.

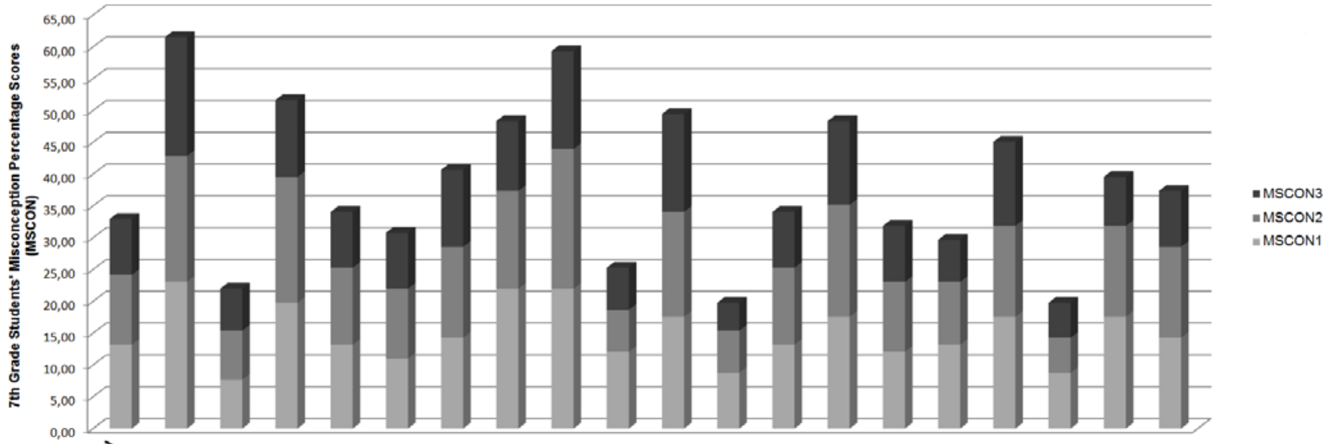
Table 2 indicates that the items are of moderate difficulty in the BACTTIM. The whole values are within an acceptable range. It can be concurred that the BACTTIM is a reliable and valid instrument with distracters in determining students' misconceptions in the BAC.

Middle-school students' misconceptions and correct item scores

All items are represented by bar graphs and the MSCON1, MSCON2, and MSCON3 are demonstrated as one bar with different colors. The bottom color identifies the

Table 2. Descriptive statistics for the third-tier scores

Participants:	**Seventh-Grade Students**	**Pre-service Teachers**
	Third-Tier Score	
Number of participants	91	105
Number of items	20	
Mean	81.80	87.47
Standard deviation	10.58	9.20
Minimum	50	60
Maximum	100	100
Cronbach's alpha	0.85	
Prop. Correct values-mean	0.79	
n of items (range 0.9-1.0)	4	
n of items (range 0.8-0.9)	12	
n of items (range 0.7-0.8)	3	
n of items (range 0.6-0.7)	1	
Point-biserial correlation coefficient-mean	0.406	
n of items (range 0.6-0.7)	1	
n of items (range 0.5-0.6)	-	
n of items (range 0.4-0.5)	9	
n of items (range 0.3-0.4)	9	
n of items (range 0.2-0.3)	1	



QUESTION No. →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	MEAN
MSCON1	13,18	23,08	7,69	19,78	13,18	10,99	14,29	21,98	21,98	12,09	17,58	8,79	13,18	17,58	12,09	13,18	17,58	8,79	17,58	14,29	14,94
MSCON2	10,99	19,78	7,69	19,78	12,09	10,99	14,29	15,38	21,98	6,59	16,49	6,59	12,09	17,58	10,99	9,89	14,29	5,49	14,29	14,29	13,08
MSCON3	8,79	18,68	6,60	12,09	8,79	8,79	12,09	10,99	15,38	6,59	15,38	4,40	8,79	13,19	8,79	6,59	13,19	5,49	7,69	8,79	10,06
Lack of Knowledge	13,19	15,38	6,59	13,19	10,99	8,79	4,40	10,99	12,09	9,89	8,79	10,99	7,69	12,09	9,89	12,09	6,59	10,99	12,09	15,38	10,60

Figure 3. Three-tier misconception and lack of knowledge scores of seventh-grade students

Table 3. Misconceptions and their percentages for seventh graders

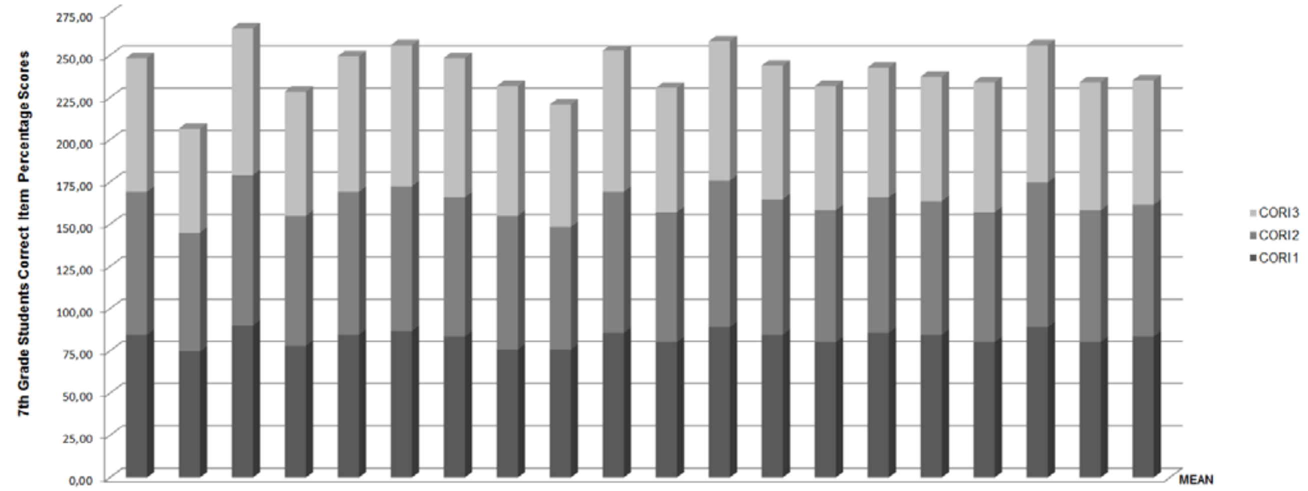
Ques. No. & Alter. Sets	Misconceptions	%
2.1.a 2.2.a 2.3.a	Meteors and meteorites are stones crashing to Earth.	18
4.1.b 4.2.b 4.3.a	The stars reflect the light incoming from the Sun.	12
7.1.b 7.2.b 7.3.a	Shooting stars are visible comets.	11**
8.1.a 8.2.a 8.3.a	Stars give off light and heat, but the planets cannot be seen.*	11
9.1.c 9.2.c 9.3.a	When a meteor crashes to the Earth it forms a meteor pit.	13
11.1c 11.2c 11.3a	The Sun is the biggest celestial body. Therefore, it is bigger than either the Galaxy or the comets.	15
14.1b 14.2b 14.3a	The infinite space outside the Earth is defined as the Universe; within this infinite space all of the celestial bodies are defined as the Galaxy.*	12
17.1a 17.2a 17.3a	The Earth is among the stars in the solar system.	13

** Newly added to the related literature.*
*** The total MSCON3 was 12.09 in Figure 3, indicating that 1.09 % of the score belongs to the other alternative set of misconceptions; that is, 7.1.a - 7.2.a - 7.3.a.*

MSCON1, and the top color identifies the MSCON3. Figure 3 shows that the MSCON1 and MSCON2 values are higher than are the MSCON3 values. Therefore, the participants' misconceptions were diagnosed thoroughly with the three-tier misconception tests that distinguish "lack of knowledge" and "lack of confidence" from the exact misconceptions. Figure 3 represents the percentages of misconceptions of seventh graders.

Figure 3 identifies the misconception percentages for all of the items. The percentages of the MSCON3 above 10% imply that there is a misconception associated with this item. Consequently, there are misconceptions associated with eight items. They are related to 16 alternative sets. The misconceptions of the seventh-grade students with percentages above 10% are presented in Table 3. The highest value of the MSCON3 belongs to Question 2, with a value of 18.68%. The lack of knowledge scores are also presented in Figure 3 and represent moderately high values for seventh graders. As shown, 10.60% of the students showed a lack of knowledge in the BAC.

Table 3 presents the six out of eight misconceptions that are literature-based misconceptions, defined as strong misconceptions, and the other two misconceptions that are unique to this study of seventh graders. The general



QUESTION No. →	1	2*	3	4*	5	6	7*	8*	9*	10	11*	12	13	14*	15	16	17*	18	19	20	MEAN
CORI1	84,62	74,73	90,11	78,02	84,62	86,81	83,52	75,82	75,82	85,71	80,22	89,01	84,62	80,22	85,71	84,62	80,22	89,01	80,22	83,52	87,23
CORI2	84,62	70,33	89,01	76,92	84,62	85,71	82,42	79,12	72,53	83,52	76,92	86,81	80,22	78,02	80,22	79,12	76,92	85,71	78,02	78,02	84,58
CORI3	79,12	61,54	86,81	73,63	80,22	83,52	82,42	76,92	72,53	83,52	73,63	82,42	79,12	73,63	76,92	73,63	76,92	81,32	75,82	73,63	81,20
Lack of Confidence	5,49	8,79	2,20	3,30	4,40	2,20	2,20	2,20	0,00	1,10	3,30	4,40	1,10	4,40	3,30	5,49	2,20	4,40	2,20	4,40	3,37

*The numbers of the items that the students have misconceptions

Figure 4. Three-tier correct item percentage scores of seventh-grade students

misconception average was found to be 10.06%. Therefore, without applying alternative methods, such as conceptual change texts, refutation texts, and so on, it is troublesome to eliminate misconceptions.

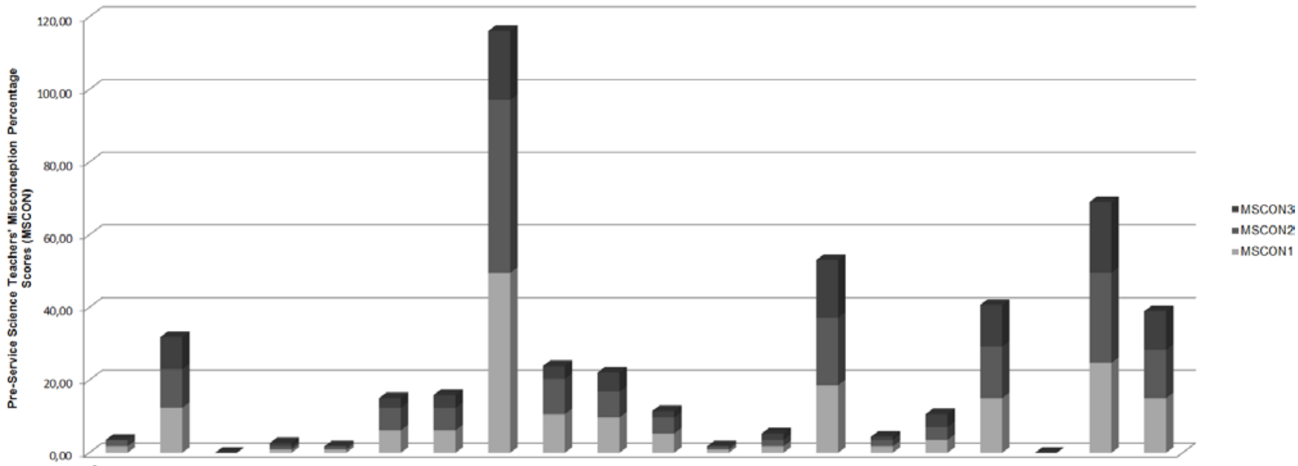
The three-tier test was also used to calculate the correct item percentage scores. Figure 4 represents the correct item percentage scores with respect to the number of tiers for seventh graders. All items are represented by bar graphs for the scores CORI1, CORI2, and CORI3, and are represented by different colors. The bottom of the bar graph identifies the CORI1 values, the middle part identifies the CORI2 values, and the top part identifies the CORI3 values. The lack-of-confidence scores of seventh graders are also presented in Figure 4.

Figure 4 shows that the CORI1 and CORI2 values are higher than the CORI3 values. The average of the lack-of-confidence scores was low, so the students were mostly "sure" in the third tier of the BACTTIM. Therefore, the scores decrease through the third tiers, so the students' conceptual understandings are measured better with three-tier conceptual tests than with classical one-tier exams. For the items that students have misconceptions about (question numbers 2, 4, 7, 8, 9, 11, 14, 17), the CORI3 values varied between 61.54% and 86.81%, which were not low. Furthermore, the average CORI3 was 81.20%, which indicates that there is a moderately high conceptual understanding by seventh-grade students. The best conceptual understanding was related to question number 3, "What type of celestial body is the Sun?" Almost 87% of the seventh graders answered both two tier questions correctly and indicated on the third tier question that they were sure about their answers (the highest CORI3 value).

Pre-service science teachers' misconceptions and correct item scores

Figure 5 represents the percentages of misconceptions with respect to the number of tiers for pre-service science teachers. The values of MSCON1, MSCON2, and MSCON3 are in decreasing order in Figure 5.

The misconception percentages for the three items were zero, indicating there are no misconceptions associated with these questions. On the other hand, there are misconceptions for pre-service teachers associated with five items (above 10%), with the highest percentage being for Question 8, as presented in Figure 5. The pre-service science teachers' total misconception percentage was 6.68%, which is lower



QUESTION No. →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	MEAN
MSCON1	1,77	12,39	0,00	0,88	0,88	6,19	6,19	49,50	10,62	9,73	5,31	0,88	1,77	18,58	1,77	3,54	15,04	0,00	24,78	15,04	9,34
MSCON2	1,77	10,62	0,00	0,88	0,88	6,19	6,19	47,60	9,73	7,08	4,42	0,88	1,77	18,58	1,77	3,54	14,16	0,00	24,78	13,27	8,81
MSCON3	0,00	8,85	0,00	0,88	0,00	2,65	3,54	19,05	3,54	5,31	1,77	0,00	1,77	15,93	0,88	3,54	11,50	0,00	19,47	10,62	6,68
Lack of Knowledge	4,42	4,42	0,00	0,00	0,88	6,19	3,54	11,50	7,96	4,42	6,19	3,54	1,77	6,19	1,77	2,65	6,19	0,00	12,39	12,39	4,82

Figure 5. Three-tier misconception and lack of knowledge scores of pre-service teachers

Table 4. Misconceptions and their percentages for the pre-service teachers

Ques. No. & Alter. Sets	Misconceptions	%
8.1.a 8.2.a 8.3.a	Stars give off light and heat, but planets cannot be seen.*	17**
14.1a 14.2a 14.3a	The infinite space outside of the Earth is defined as Space; within this infinite space all of the celestial bodies are defined as the Galaxy.*	15
17.1a 17.2a 17.3a	The Earth is among the stars in the solar system.	10
19.1b 19.2b 19.3a	If the distance from the Earth to Pluto is 1 cm, then the stars we see at night are less than 1 cm distant from Earth. (SCALING Misconception)	19
20.1a 20.2a 20.3a	A light-year is a unit of time.	10

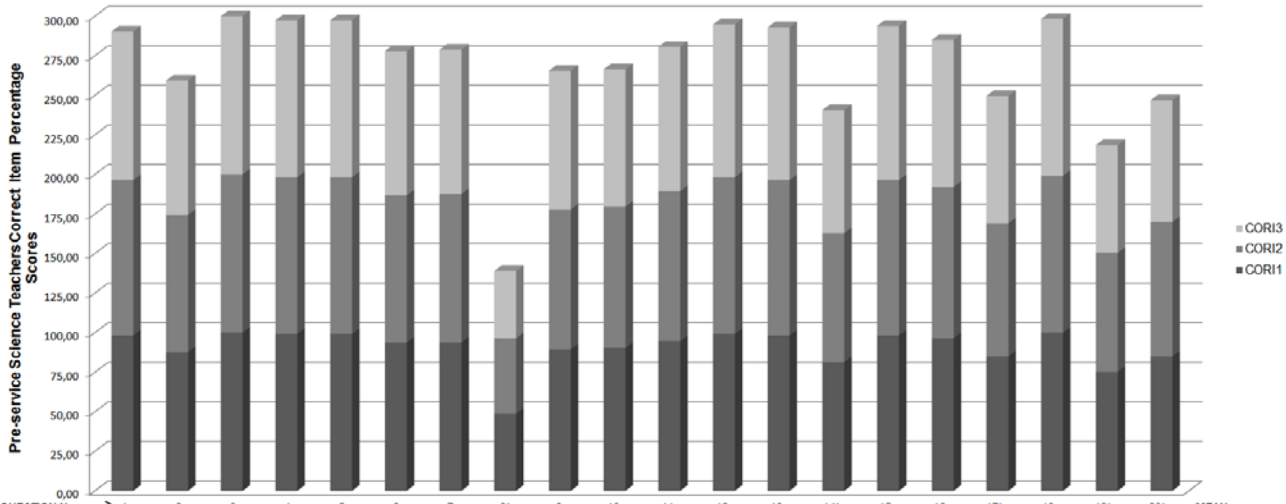
** Newly added to the related literature.*
*** The total MSCON3 was 19.05 in Figure 5, indicating that 2.05 % of the score belongs to the other alternative set of misconceptions; that is, 8.1.b - 8.2.b - 8.3.a.*

than the students' percentage. However, there are still five questions whose MSCON3 were above 10%, which means that the pre-service science teachers have five misconceptions. The misconceptions, with percentages, are presented in Table 4.

It was understood that there is a need to take serious measures to remove the misconceptions revealed through Questions 8, 14, 17, 19, and 20, since pre-service science teachers will start to teach these subjects when they become teachers. It is optimistic to expect them to teach subjects correctly when they have misconceptions regarding them. As is presented in Table 4, two out of five misconceptions are unique misconceptions that are derived in this particular study.

Figure 6 represents the percentages of correct item scores in terms of number of the tiers. The demonstration of the graph is the same as in the students' graph in Figure 4. The average of the CORI1 and the CORI2 values are higher than the CORI3 values. It is clear that the teachers' correct item percentage scores can be evaluated more efficiently and confidently with the BACTTIM. The lack-of-confidence values, as presented in Figure 6, are also quite low (almost 2.7%), which indicates that the teachers were confident about what they knew.

Figure 6 illustrates that the CORI1 and CORI2 values are higher than the CORI3 values. The average of the lack-of-confidence scores was very low, so the pre-service teachers were mostly "sure" in the third tier of the BACTTIM. For the items that



QUESTION No. →	1	2	3	4	5	6	7	8*	9	10	11	12	13	14*	15	16	17*	18	19*	20*	MEAN
CORI1	98,23	87,61	100,00	99,12	99,12	93,81	93,81	48,67	89,38	90,27	94,69	99,12	98,23	81,42	98,23	96,46	84,96	100,00	75,22	84,96	90,66
CORI2	98,23	86,73	100,00	99,12	99,12	92,92	93,81	47,79	88,50	89,38	94,69	99,12	98,23	81,42	98,23	95,58	84,07	99,12	75,22	84,96	90,31
CORI3	93,81	84,96	100,00	99,12	99,12	91,15	91,15	42,48	87,61	86,73	91,15	96,46	96,46	77,88	97,35	92,92	80,53	99,12	68,14	76,99	87,65
Lack of Confidence	4,42	1,77	0,00	0,00	0,00	1,77	2,65	5,31	0,88	2,65	3,54	2,65	1,77	3,54	0,88	2,65	3,54	0,00	7,08	7,96	2,65

*The numbers of the items that the pre-service science teachers have misconceptions

Figure 6. Three-tier correct item percentage scores of pre-service teachers

students have misconceptions about (question numbers 8, 14, 17, 19, and 20), the CORI3 values varied between 42.48% and 80.53%. The CORI3 value for question number 8, "How do we understand if a celestial body is a star or a planet when we look at the sky?" was very low. The misconception percentage of this item was very high (19.05%). The question was not very complicated, but it is clear that most of the pre-service science teachers did not develop clear conceptual understandings related to this question. Furthermore, the pre-service science teachers still had misconceptions related to the five items of the BACTTIM. However, the average CORI3 was 87.65%, which indicates there is a very high conceptual understanding within the total of the test.

CONCLUSION

This study focused on identifying the conceptual understanding and misconceptions of seventh-grade middle-school students and pre-service science teachers in the BAC, by using the BACTTIM, which was a unique instrument in relation to the related literature for diagnosing misconceptions. The BACTTIM contains moderate-level questions, and it is a valid, reliable, and powerful instrument. It may fill the gap stated in the literature (Brogt et al., 2007), as there is a need to develop a new conceptual test to identify students' misconceptions and to assess their conceptual understandings of basic astronomy concepts. It is very important to determine with this test which participants being evaluated—the pre-service science teachers' or the seventh-grade students'—need help or have misconceptions. Moreover, if the "measuring conceptual understanding" property of the BACTTIM is taken into consideration, its use by teachers as an achievement test will be appropriate. This aim of three-tier tests was also discussed in the findings of similar studies (Arslan et al., 2012; Kanli, 2014; Pesman & Eryilmaz, 2010). The BACTTIM may be administered to any group of students and pre-service science teachers to identify basic astronomy misconceptions.

The percentage of the average scores of the students for the CORI1, CORI2, and CORI3 were 87.23%, 84.58%, and 81.20%, respectively. For pre-service teachers, the CORI1, CORI2, and CORI3 scores were 90.66%, 90.31%, and 87.65%, respectively. These results showed there was no extreme difference between the correct item percentage scores of the students and teachers. The similar conclusion of Trundle et al. (2007b) was supported these results. Teachers having a higher cognitive level, receiving more detailed astronomy courses, and having more course hours led to the high average of the CORI. However, this difference is not high enough to be considered statistically important. Having high correct item scores, namely, higher achievement, on the BACTTIM did not imply that the misconceptions had disappeared. Therefore, in achievement tests or diagnostic tests, if the cumulative average of the exam is high, there will be a risk that the students will be evaluated superficially, without a deeper analysis of their misconceptions. The result was supported by similar findings in related studies (Brogt et al., 2007; Kanli, 2014; Prather et al., 2009; Sadler et al., 2013).

Within this perspective, the seventh-grade students' and pre-service science teachers' correct item percentage scores were moderately high throughout the test, meaning that they had high achievement on the questions on the BACTTIM. The pre-service science teachers had clear conceptual understandings about "The Sun is a star," "nature of emitted light from meteors," "order of the inner planets," and "nature of light from the stars." In contrast, in a study with pre-service math and science teachers, Küçüközer et al. (2010) found the misconception "Stars reflect the light coming from the Sun". Seventh graders, in a similar manner, had accurate scientific concepts related to "The Sun is a star." However, there are studies from the elementary to high school level that found the misconception "The Sun is not a star" (Diakidoy & Kendeou, 2001; Dunlop, 2000; Göncü, 2013; Sadler et al., 2010; Sharp, 1996). Therefore, in a few questions, participants' true conceptual understanding may result from their elementary or middle school teachers teaching these concepts seriously or using different methods of teaching.

For the students, there are eight misconceptions and for the pre-service science teachers there are five misconceptions having percentages greater than 10%. The students and the pre-service teachers even had two misconceptions in common. The first one was "The Earth is among the stars in the solar system." which was a popular misconception identified in the literature (Dunlop, 2000; Sadler et al., 2010; Sharp, 1996; Trumper, 2000). The second was a new misconception mentioned within the related literature: "Stars give off light and heat, but the planets cannot be seen." If pre-service science teachers do not choose to study science after secondary school, then they do not have courses including astronomy subjects in Turkey. Because of this, their knowledge levels are limited to basic astronomy. As a result, it was found that the misconceptions teachers and students have are nearly the same. Another very similar but not common misconception for the pre-service science teachers and middle school students is related to the subject of "the differences between space and a galaxy" and "the difference between a universe and galaxy," respectively. The main reason the participants might not have constructed a clear conceptual understanding related to the definitions of galaxy, universe, and space within the formal instruction they received. Furthermore, when other misconceptions of the pre-service science teachers are analyzed, it can be concluded that they failed to construct clear understandings related to the "definition of the light-year" and "distances in both the solar system and the universe." On the other hand, the middle school students did not have strong conceptual understanding related to "differences between meteor and meteorite," "nature of shooting stars," "source of light of a star," and "comparison of the sizes between sun, galaxy and the universe," even though these concepts were included in their course books. As can be seen in Table 1, these misconceptions for both the teachers and students are in consistent with the ones found in the previous studies (Dunlop, 2000; Frede, 2006; Göncü, 2013; Küçüközer et al., 2009; 2010; Lightman & Sadler, 1993; Plummer & Krajcik, 2010; Sadler et al., 2010; Trumper, 2000; Vosniadou & Brewer, 1994; Zeilik et al., 1998). Therefore, it was concluded that the pre-service science teachers mostly have misconceptions, not in complex concepts, but rather in very basic astronomical knowledge. In addition to having definite conceptual knowledge of most of the concepts, the teachers also have serious misconceptions within the BAC, which should be eliminated before they qualify as teachers.

It is obvious that these misconceptions cannot be prevented by formal lessons, since in this study it is found that the students and pre-service teachers solidify their misconceptions. After the misconceptions have been identified, they may be removed with proper methods described in the literature rather than formal instruction (Bell & Trundle, 2008; Küçüközer et al., 2009; Plummer & Krajcik, 2010; Small & Plummer, 2014; Taylor et al., 2003; Trumper, 2001; 2006; Prather et al., 2009; Trundle et al., 2006; 2007a; 2007b). Therefore, in teacher-training institutes, it is not enough to have a compulsory or elective astronomy course; in addition, the method of instruction should be organized to overcome the misconceptions of the pre-service teachers to ensure scientific concepts are understood accurately.

The present study and related studies (Sadler et al., 2010; 2013) indicate that teachers possessing these misconceptions means that it is quite optimistic to believe that the teachers have good conceptions in the BAC or they are able to diagnose misconceptions held by the students. Within this context, just as the importance of teaching basic astronomy subjects in middle schools cannot be denied, pre-service science teachers need to increase their pedagogical content knowledge. This conclusion is also consistent with the views that pre-service teachers should improve their scientific knowledge to improve the quality of their instruction (Bell & Trundle, 2008; Steinberg & Cormier, 2013; Trundle, 2006, 2007a).

The participants' lack-of-confidence values are very close to each other. Both the teachers and students were not "sure" even when they answered the first two tiers of the questions correctly. The reason could be that the teachers had not taken any astronomy-related courses since their middle-school years. The students, probably, could not construct clear understandings since they had just learned the subjects for the first time. Therefore, teachers and researchers usually need to distinguish students' lack of knowledge and/or lack of confidence from their misconceptions. One of the crucial results of this study, as stated in various related studies in the literature (Arslan et al., 2012; Pesman & Eryılmaz, 2010; Göncü, 2013), is that the wrong answers measured in one-tier tests are not always related to misconception. Furthermore, one-tier tests do not prove that the students know a concept correctly once they have answered a test question correctly. Therefore, three-tier tests are effective measuring tools since first- and second-tier wrong answer scores overestimate the percentage of misconceptions. In this particular study, the participants' misconceptions were differentiated from their lack of knowledge, lack of confidence, or simple mistakes in astronomy concepts. The researchers in scientific fields can research the effects of reliable approaches and methods, such as texts based on undermining conceptual changes, in order to amend the students' deficits related to misconceptions.

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Appendix

Table A1. Alternative sets forming the misconceptions of the BACTTIM

No.	Misconceptions	Alternative Sets
1	We can see all stars in the sky at night. All the stars glimmer with the same brightness.	1.1 a, 1.2 a, 1.3 a; 1.1 c, 1.2 c, 1.3 a
2	Meteors and meteorites are stones crashing to the Earth. Meteors, because of their solid structure, reach the surface of the Earth without rupturing.	2.1 a, 2.2 a, 2.3 a; 2.1 c, 2.2 c, 2.3 a
3	The Sun is a planet. The Sun is a highly-energetic asteroid.	3.1 b, 3.2 b, 3.3 a; 3.1 c, 3.2 c, 3.3.a
4	Stars reflect the light incoming from the Sun. The Sun reflects the light incoming from the stars.	4.1 b, 4.2 b, 4.3 a; 4.1 c, 4.2 c, 4.3.a
5	(The order of magnitude) The Sun>The Milky Way>Jupiter>The Earth (The order of magnitude) Jupiter>The Milky Way >The Sun>The Earth	5.1 a, 5.2 a, 5.3 a; 5.1 b, 5.2 b, 5.3 a;
6	The center of the universe is the Milky Way. The center of the universe is the Sun.	6.1 b, 6.2 b, 6.3 a; 6.1 c, 6.2 c, 6.3.a
7	A shooting star is displacement of a star. Shooting stars are visible comets.	7.1 a, 7.2 a, 7.3 a; 7.1 b, 7.2 b, 7.3 a;
8	Star gives off light and heat, but the planets cannot be seen. There is no difference between stars and planets.	8.1 a, 8.2 a, 8.3 a; 8.1 b, 8.2 b, 8.3.a
9	(The figure from the Earth of pit of a meteorite) When an asteroid crashes to the Earth, it forms an asteroid pit. When a meteor crashes to the Earth, it forms a meteor pit.	 9.1 b, 9.2 b, 9.3 a; 9.1 c, 9.2 c, 9.3.a
10	Comets do not produce their own light, whereas planets do. Stars produce their own light, whereas The Sun does not.	10.1 b, 10.2 b, 10.3 a; 10.1 c, 10.2 c, 10.3.a
11	Comets are bigger than either the Sun or Galaxy. The Sun is the biggest celestial body. Therefore, it is bigger than either the Galaxy or the comets.	11.1 b, 11.2 b, 11.3 a; 11.1 c, 11.2 c, 11.3.a
12	(The reason for emitting light from a meteor when it enters the atmosphere) As it is a star, so it gives off light in the atmosphere. It reflects the Sun's beams.	 12.1 a, 12.2 a, 12.3 a; 12.1 c, 12.2 c, 12.3.a
13	All stars are the same size. Because the amount of light taken in from the Sun by different stars is not the same, the amount of light emitted from those stars is different, as well.	13.1 b, 13.2 b, 13.3 a; 13.1 c, 13.2 c, 13.3.a
14	The infinite space outside of the Earth is defined as Space; within this infinite space all of the celestial bodies are defined as the Galaxy. The infinite space outside of the Earth is defined as the Universe; within this infinite space all of the celestial bodies are defined as the Galaxy.	14.1 a, 14.2 a, 14.3 a; 14.1 b, 14.2 b, 14.3 a;
15	The only star that is visible during the daylight hours is the Moon. The only star that is visible during the daylight hours is the North Star.	15.1 a, 15.2 a, 15.3 a; 15.1 c, 15.2 c, 15.3.a
16	One astronomic unit is the distance between the Earth and Mars. One astronomic unit is the distance between Mars and the Sun.	16.1 a, 16.2 a, 16.3 a; 16.1 c, 16.2 c, 16.3.a
17	The Earth is among the stars in the solar system. The Earth is the only planet around the Sun in the Milky-Way Galaxy.	17.1 a, 17.2 a, 17.3 a; 17.1 b, 17.2 b, 17.3 a;
18	(What is the order of the inner planets starting from closest to the Sun) Mercury-Venus-Mars-Earth Mercury-Earth-Venus-Mars	 18.1 b, 18.2 b, 18.3 a; 18.1 c, 18.2 c, 18.3.a
19	If the distance from the Earth to Pluto is 1 cm, then the stars we see at night are also 1 cm distant from the Earth. If the distance from the Earth to Pluto is 1 cm, then the stars we see at night are less than 1 cm distant from the Earth.	19.1 b, 19.2 b, 19.3 a; 19.1 c, 19.2 c, 19.3.a
20	A light year is a unit of time. A light year is smaller than an astronomic unit.	20.1 a, 20.2 a, 20.3 a; 20.1 c, 20.2 c, 20.3.a