Sakarya University Journal of Education

e-ISSN : 2146-7455
Publisher : Sakarya University

Vol. 15, No. 2, 117-137, 2025
DOI: https://doi.org/10.19126/suje.1618404

Research Article

Analyzing Student Drawings of Cosmology Concepts

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Received: 12.01.2025
Accepted: 09.05.2025
Available Online: 08.08.2025

Abstract: Drawing technique is an effective technique used to reveal the thoughts and misconceptions of science concepts created by students. The aim of this study is to reveal the thoughts and misconceptions of secondary school 7th grade students about cosmology concepts in the subject area of 'Earth and Universe' in science course. The research was organised in case study design, which is one of the qualitative research methods. Fourteen (7 female, 7 male) 7th grade students in a state secondary school were selected as participants by criterion sampling method. The data were collected with the help of a drawing form designed by the researcher taking into account the cosmology topics and achievements in the subject area of 'Earth and Universe' in the 2018 curriculum of the 7th grade science course, and the data obtained were analysed by content analysis method. The most important finding of this study is that visual-aesthetic concern in student drawings is more important than scientific accuracy. In addition, it was determined that students explained cosmology concepts by associating them with different concepts, were influenced by daily life, textbooks and audio-visual educational materials while creating their drawings, and had misconceptions about basic astronomy concepts. It is thought that this study will contribute to the field by revealing the findings about the misconceptions of secondary school students as well as their thoughts and conceptions about cosmology concepts.

Keywords: Cosmological Concepts, Student Drawings, Misconceptions, Case Study

1.Introduction

Starting from childhood, people learn, categorise and discover the relationship between concepts in their minds. Thus, they give meaning to their knowledge, reorganise and restructure it. The process of learning and restructuring concepts in the mind of human beings continues throughout life (Gödek et al., 2019). Concepts, which are the basic elements of thought processes, are also the main elements that form the cognitive structure of individuals (Klausmeier, 1992). Images are created in our minds by determining the different aspects of concepts and bringing together their common features (Laçin Şimşek, 2022). In science education, while learning scientific concepts, students spontaneously pass through an intertwined information transition stages in which the ideas they initially acquired and the intended information coexist (Liu, 2021). For this reason, it is important to determine what kind of understanding students have about the concepts. Some of the basic concepts in the field of science are concepts that we encounter in daily life, some of which we easily experience and some of which we do not have the chance to experience (Görecek Baybars & Çil, 2019). The fact that science subjects and concepts are complex and abstract makes it difficult for students to visualise these subjects and concepts in their minds (Düşkün, 2011). Students postpone learning abstract concepts that they have difficulty in learning or choose to place them in the schemes they have previously created. For this reason, they cannot learn or mislearn the new concepts they encounter. A concept that is fundamentally mislearned is the precursor of the next mislearning (Direkci, 2014). Mislearning brings misconceptions along with it. A misconception is a systematic, permanent, widespread understanding and explanation that is resistant to change, systematic, permanent, and common, unlike what is accepted scientifically in science education (Gödek et al., 2019). It is not possible to identify and eliminate these misconceptions with ordinary activities, and there are many techniques that can be used to eliminate misconceptions (Laçin Şimşek, 2022). Students' drawings are a method used to identify misconceptions and understandings in science research (Çardak, 2009; Dikmenli, 2010). For this reason, in the process of

Cite as(APA 7): Çetin, N. (2025). Analyzing student drawings of cosmology concepts. *Sakarya University Journal of Education, 15*(2), 117-137. https://doi.org/10.19126/suje.1618404

teaching science subjects and concepts, it is important to determine students' thoughts and comprehension about these subjects and concepts as well as their misconceptions through drawings One of the specific objectives of the 2018 Science Curriculum is 'to provide basic knowledge about astronomy, biology, physics, chemistry, earth and environmental sciences, and science and engineering applications' (MoNE, 2018). This aim is stated in the Science Course Curriculum of the Turkish Century Education Model, which started to be implemented as of 2024, as 'Students to have basic knowledge about physics, chemistry, biology, astronomy, earth and environmental sciences' and 'Discovering that the universe and the world in which they live are a whole of systems and becoming aware that they are a part of this whole' (MoNE, 2024). In this direction, it is aimed to provide students with basic astronomy concepts with the acquisitions in the subject area of 'Earth and Universe' at the 3rd-8th grade levels. When we look at the acquisitions in the 'World and Universe' subject area, it is seen that in addition to basic astronomy concepts, there are also concepts of cosmology (such as star, black hole, galaxy, universe). Cosmology, as a young scientific discipline that has developed rapidly in recent years, can be defined as the general science of the universe or the science of the physical laws of the universe (Goenner, 2010). Dark matter, dark energy, black holes, black holes, early universe, galaxy and formation phases can be given as examples of the subjects that cosmology is interested in (Kayalı & Bakırcı, 2022). When the literature is examined, it is noteworthy that the number of studies on these concepts is high due to the fact that astronomy topics and concepts are suitable for mislearning by students. In the national and international literature on astronomy education (Aksan et al., 2017; Alın & İzgi, 2017; Babaoğlu & Keleş, 2017; Bailey, 2007; Bolat et al., 2014; Bülbül et al., 2013; Can & Görecek-Baybars, 2018) and on the concept of 'Universe', one of the basic astronomy concepts (Aksan & Çelikler, 2019; Bostan Sarıoğlan et al., 2016; Conlon et al., 2017; Çalışkan, 2023; Hansson & Redfors, 2006; Lemmer et al., 2003; Spiliotopoulou Papantoniou, 2007; Uluay, 2020). Looking at the studies in the national literature, it is seen that there are not enough studies on modern astronomy topics such as big bang and black hole (Kurnaz et al., 2016). In the international literature, although cosmology is one of the commonly taught astronomy topics, there are limited number of studies (Lightman et al., 1987; Prather et al., 2002; Siegal et al., 2004; Simonelli & Pilachowski 2003; Wallace et al., 2012).

When the studies are evaluated, it is seen that the learning-teaching situations of astronomy subjects such as the shape of our planet, the earth and the universe, stars, gravity are frequently preferred by the researchers. However, when evaluated in terms of learning situations, it is understood that the studies are more oriented towards determining misconceptions and determining the level of understanding (Bela et al., 2023; Bitzenbauer et al., 2023; Durukan et al., 2023; Wilhelm et al., 2022). In addition, it is seen that studies on modern astronomy and cosmology topics such as the big bang, the expansion of the universe, and black holes remain in the background (Kurnaz et al., 2016). For this reason, the aim of the study is to reveal the 7th grade secondary school students' thoughts and concepts as well as misconceptions about the cosmology concepts in the subject area of "Earth and Universe" in the science course. It is thought that the study will contribute to future research on cosmology topics and concepts. In addition, the original aspect of this study is the comparison of student drawings of the concepts and the actual visuals of cosmology concepts. The cosmology concepts to be considered in the study were limited to the concepts of star, black hole, galaxy and universe in the subject area of 'World and Universe' in the 2018 science curriculum. In this study, students 'thoughts and comprehension of the cosmology concepts, as well as their misconceptions, were tried to be determined by using the drawing technique and comparing the students' own drawings with the actual visuals of the cosmology concepts. The research questions determined in line with this objective are

a) What are the thoughts and conceptions of 7th grade secondary school students about cosmology concepts?

b) What are the misconceptions of secondary school 7th grade students about cosmology concepts?

c) What are the similarities and inconsistencies that emerge when the drawings of secondary school 7th grade students about cosmology concepts are compared with the actual visuals of the concepts?

2. Method

In the study, the case study design, which is accepted as one of the qualitative research methods, was used to reveal the thoughts and conceptions of secondary school 7th grade students towards the cosmology concepts in the subject area of 'Earth and Universe' in the 2018 curriculum of the science course. Creswell defined case study as a qualitative approach that examines a limited real-life system in depth with different data sources (Creswell, 2021). Case study has distinctive features such as providing originality by establishing a strong contextual relationship between cause and effect, associating analysis and descriptions, emphasising specific events, collecting multiple data and focusing on the natural environment. However, in order to eliminate the ambiguity of 'what the situation corresponds to' that may occur with the preference of this design, the researcher should clarify the unit of analysis used in the study, how he/she defines the situation and the boundaries of the research (Cohen et al., 2021). In this study, the 7th grade secondary school students' thoughts and understandings about these concepts were analysed as a case. Since the determined case contains a single unit of analysis, the research was structured according to the holistic single case design.

2.1. Research context

This study was conducted in a public secondary school in a middle socioeconomic level region. The collection of the study data was completed in 3 weeks (4+4+4=12 lesson hours) in the second semester of the 2023-2024 academic year. Of the total of 12 lesson hours, 4 lesson hours were devoted to student drawings related to the determined concepts and 8 lesson hours were devoted to individual interviews with students.

2.2. Participants

In the selection of the participants in this study, criterion sampling method, which is one of the purposeful sampling methods, was used as a sampling method because it allows in-depth study of the situations. In the selection of the individuals to be included in the study, the status of having seen the subjects and concepts of the 'Earth and Universe' subject area in the 2018 science curriculum and the grade level in which these subjects are included in the curriculum were accepted as criteria. Within the framework of the determined criteria; 7th grade students were selected as participants by accepting that they had the acquisitions in the 5th grade 'Sun-Earth and Moon' unit, 6th grade 'Solar System and Eclipses' unit and 7th grade 'Solar System and Beyond' unit of the 'Earth and Universe' subject area. The participants consisted of 14 volunteers, 7 girls and 7 boys. There is one 7th grade class (n=14) in the secondary school where the study was conducted. Before the application and interviews, the participants were informed about the process, it was stated that participation was voluntary and they could leave the study whenever they wanted.

2.3.Data collection

The data of this study were obtained by drawing form and individual interviews with the students. The drawing form (Appendix A.), which consists of five questions that will enable students to reveal their thoughts and comprehension of cosmology concepts, was prepared by the researcher by consulting expert opinions. The content of the questions in the drawing form was prepared by taking into account the cosmology topics and concepts in the subject area of 'Earth and Universe' in the 7th grade science course 2018 curriculum. In the process of collecting data with the drawing form, each student was given a blank A4 paper about the five concepts determined, and they were asked to think about these concepts, reflect their thoughts on the paper through drawing, and explain their drawings with the expressions they would write under them. The students were given 20 minutes to complete their drawings for each

concept, during which time they used their own pencils, crayons and erasers. Before starting the drawings, the researcher made explanations about the students' drawing skills so that they would not have aesthetic and grade concerns. Data were also obtained through individual interviews in order for the students to reveal their ideas about what they wanted to explain and what they wanted to show in their drawings. During the interviews, care was taken to ensure that the questions directed to the students were of a quality that would allow them to explain their drawings related to each concept.

2.4. Data analysis

In this study, student drawings were determined as the unit of analysis. Content analysis method was used to analyse the data obtained from the data collection tools related to this purpose. Before starting the analysis, a code was assigned to each participant to avoid using the real names of the participants. The randomly ordered student names were numbered from 1 to 14 as 'S.1, S.2, S.3.....S.14'. After collecting the data, the researcher edited the student drawings, the explanations made about the drawings and the transcript texts obtained from the individual interviews to make them suitable for analysis. The drawing form of the disadvantaged student, who was coded as S.12. and participated in the whole process, was eliminated from the data because it was not related to the concepts determined. After editing, the drawings were analysed by considering the level of expression and relationship of the related concept, and then the explanations under the drawings were examined. In the analysis of the drawings, the data obtained were meticulously read twice by the researcher and the first key concepts were extracted. In the next stage, the drawings that were found to have common characteristics and the explanations made by the students about their drawings were brought together to form categories and themes related to the categories. When evaluated from this framework, it can be said that an inductive category-theme determination method was preferred. The determined categories and themes and sample student drawings are given in the findings section. It is known that the explanations under the student drawings are effective in revealing the targeted responses (Carless & Lam, 2014). For this reason, inferences were made about the expressions that students used most frequently while expressing the related concept under their drawings. Sample written expressions of the students for the related concept are given in the findings section. After analysing the drawings and explanations, the drawings were clarified through individual interviews to reveal the points that were not understood in the drawings. The misconceptions found to exist in the students during the individual interviews are presented in Table 1. In the last stage, the poster created with the visuals of cosmology concepts was shown to the students and their opinions about the visuals were taken and they were asked to compare their own drawings with the visuals.

2.5. Trustworthiness

The concepts of credibility and transferability were developed in qualitative research instead of the concept expressed as validity in quantitative research, and the concepts of consistency and verifiability were developed instead of the concept expressed as reliability (Lincoln & Guba, 1985). While revealing the value of a qualitative research, it is very important to provide criteria appropriate to the structure of the research (Arslan, 2022). In order to ensure the credibility criterion of the study, appropriate methods were selected for the purpose, data collection tools and data types were diversified. It was tried to add depth to the study by revealing how much the data support each other with the different data collection tools used. In order to meet the criterion of transferability, the participants to be included in the study were determined through criterion sampling, which is one of the purposeful sampling methods, and the participants who met the specified criteria were included in the study. Each stage of the data analysis process was explained in detail, examples from the participants' own drawings and written expressions were included while interpreting the data, and validity was tried to be ensured by directly including the statements in the interviews regarding the drawings. In order to ensure the consistency criterion, expert opinions were consulted in the formation of the categories and themes

reached as a result of the data analysis. The codes, categories and themes obtained from the drawings created by the students were evaluated by a competent instructor who has carried out studies in the field of science education, and necessary corrections and improvements were made as a result of the evaluation and suggestions.

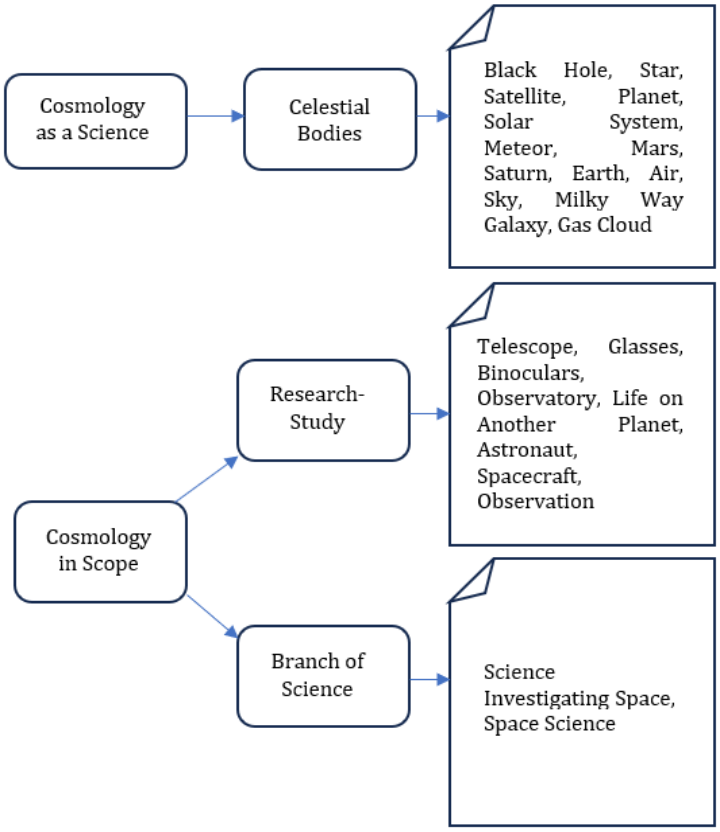
3. Findings

The findings obtained as a result of the analysis of the data are given under the headings of the findings related to the students' drawings, the findings related to the written explanations about the drawings and the findings related to the individual interviews, respectively.

3.1. Findings related to students' drawings

Figure 1

Codes, Categories and Themes Obtained from Students' Drawings Related to the Concept of "Cosmology"



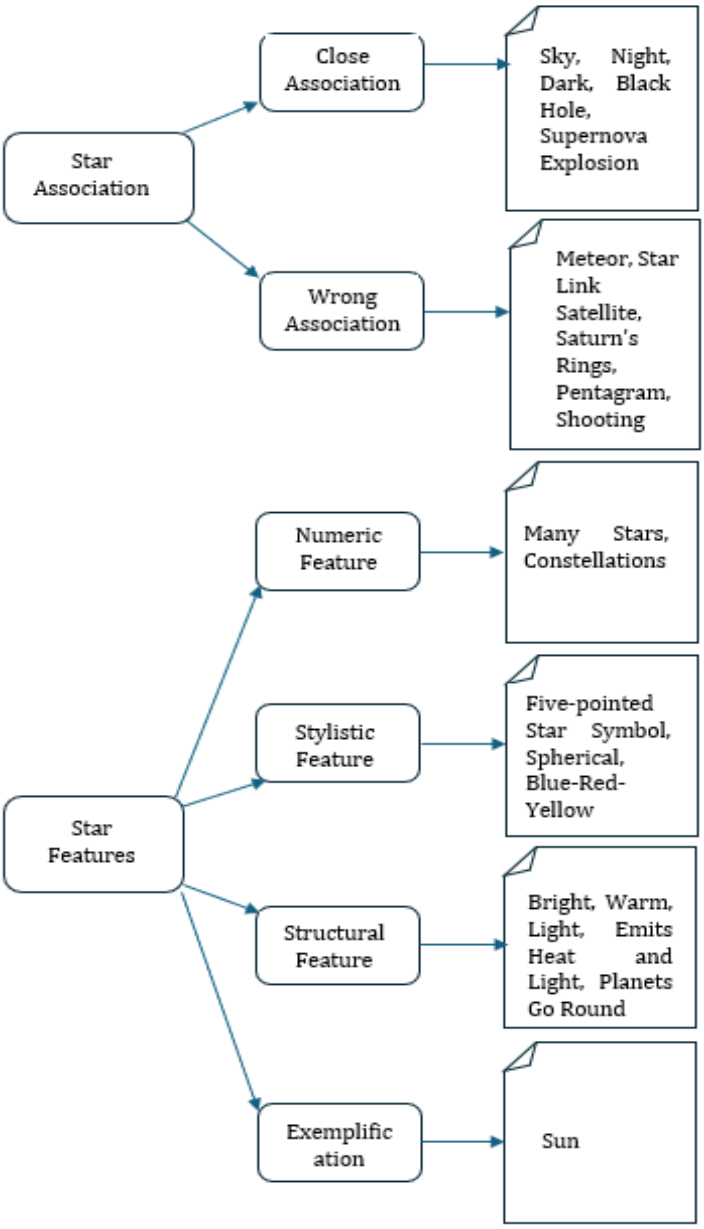
When Figure 1 is analysed, it is seen that the drawings related to the concept of cosmology are grouped under two themes as 'Cosmology as Science' and 'Cosmology as Scope'. The findings related to the theme of 'Cosmology as Science' showed that students made drawings coded as 'telescope, glasses, binoculars, observatory, life on another planet, astronaut, spacecraft, observation'. The findings related to the theme of 'Cosmology as a Scope' showed that students made drawings coded as 'black hole, star, satellite, planet, solar system, meteor, mars, saturn, earth, air, sky, milky way galaxy, gas cloud'. Sample student drawings of these findings are given below.

Figure 2

Sample Drawings of Cosmology as Science (S.14) and Cosmology as Scope (S.6) Category

Figure 3

Codes, Categories and Themes Obtained from Students' Drawings Related to the Concept of "Star"



When Figure 3 is analysed, it is seen that the drawings of the star concept are grouped under two themes as 'Star Associations' and 'Star Properties'. The findings related to the 'Star Associations' theme showed that the students made drawings coded as 'sky, night, darkness, black hole, supernova explosion, meteor, Star Link satellite, saturn rings, pentagram symbol, shooting star'. The findings related to the 'Star Properties' theme showed that students made drawings coded as 'many stars, constellation, pentacle symbol, spherical, blue-red-yellow spheres, bright, hot, light, emits heat and light, planets circling, sun'. Sample student drawings of these findings are given below.

Figure 4

Sample Drawings of Star Associations (S.1) and Star Properties (S.2) Category

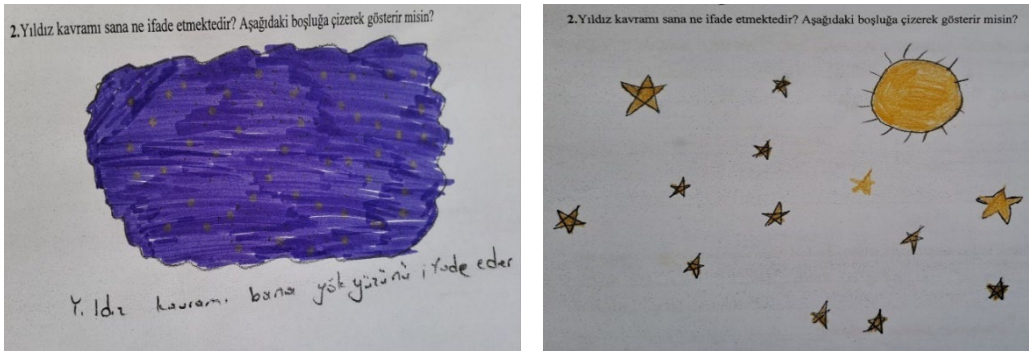
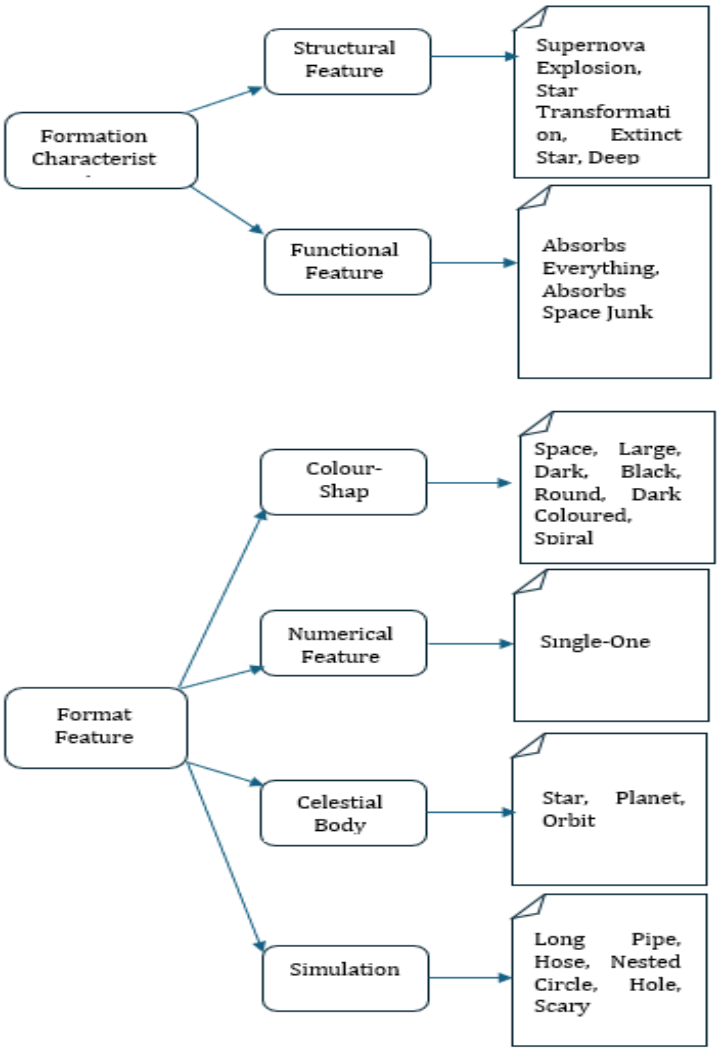


Figure 5

Codes, Categories and Themes Obtained from Students' Drawings Related to the Concept of "Black Hole"



When Figure 5 is analysed, it is seen that the drawings of the black hole concept are grouped under two themes as 'Formation Feature' and 'Form Feature'. The findings related to the 'Formation Feature' theme showed that the students made drawings coded as 'supernova explosion, star transformation, star whose life is over, infinite, rotating, deep, pulls everything into itself, pulls space junk into itself'. The findings related to the 'Shape Feature' theme showed that the students made drawings coded as 'space, big, dark, black, round, dark colour, spiral, spherical, single, one, star, planet, orbit, long pipe, hose, intertwined circle, hole, scary'. Sample student drawings of these findings are given below.

Figure 6

Sample Drawings of the Formation Feature (S.5) and Form Feature (S.7) Category

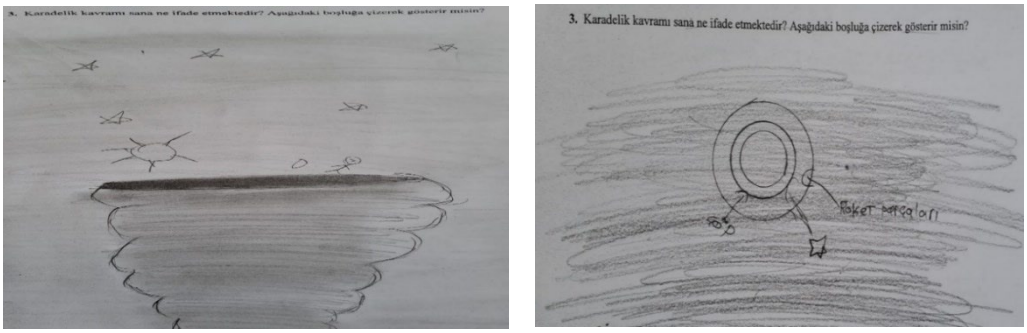
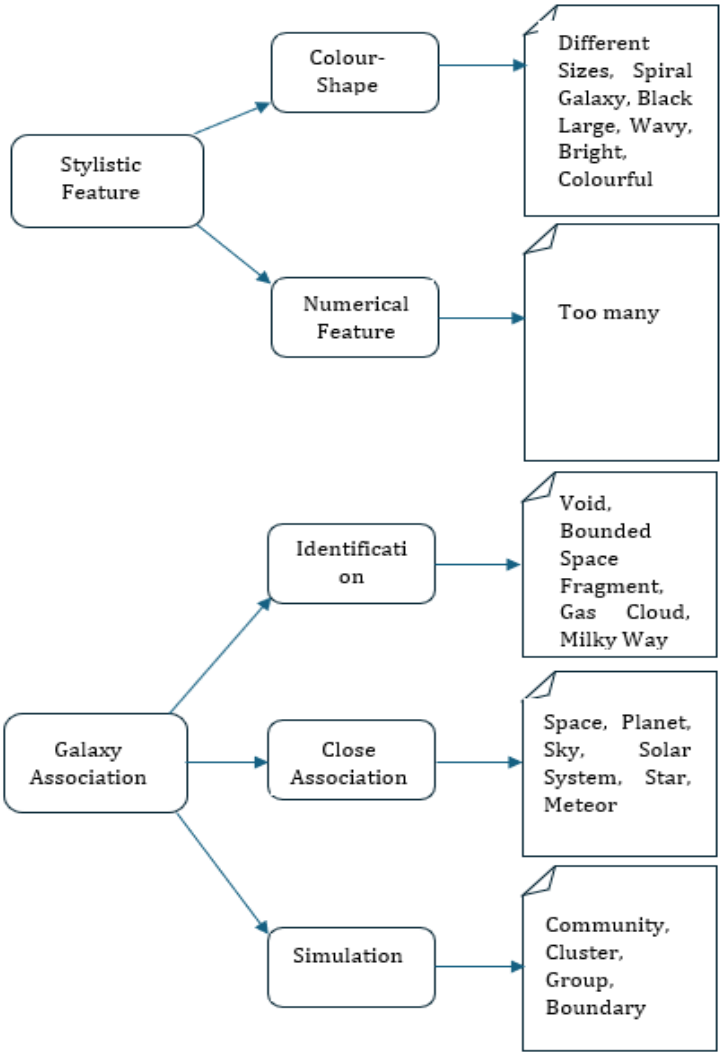


Figure 7

Codes, Categories and Themes Obtained from Students' Drawings Related to the Concept of "Galaxy"



When Figure 7 is analysed, it is seen that the drawings of the galaxy concept are grouped under two themes: 'Galaxy Association' and 'Formal Feature'. The findings related to the theme of 'Galaxy Association' showed that the students made drawings coded as 'space, limited piece of space, gas cloud, Milky Way galaxy, space, planet, sky, solar system, star, meteor, community, cluster, group, boundary'. The findings related to the 'Formal Feature' theme showed that the students made drawings coded as 'round, different sizes, spiral galaxy, big, wavy, bright, colourful, black, many'. Sample student drawings of these findings are given below.

Figure 8

Sample Drawings *Belonging to the Category of Galaxy Association (S.4) and Formal Feature (S.9)*

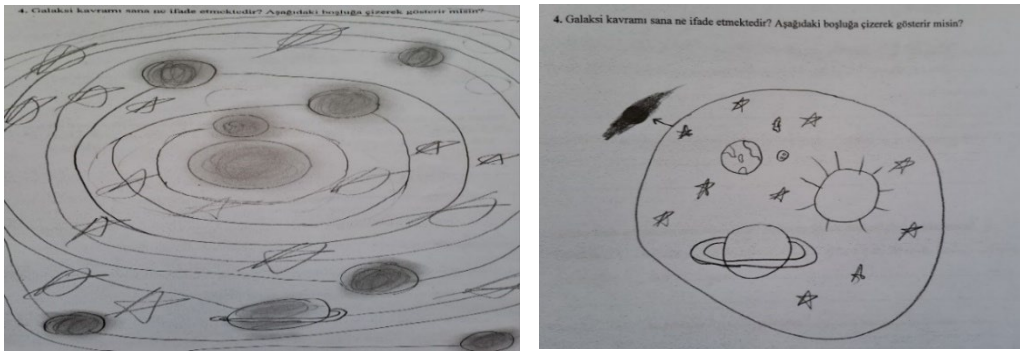
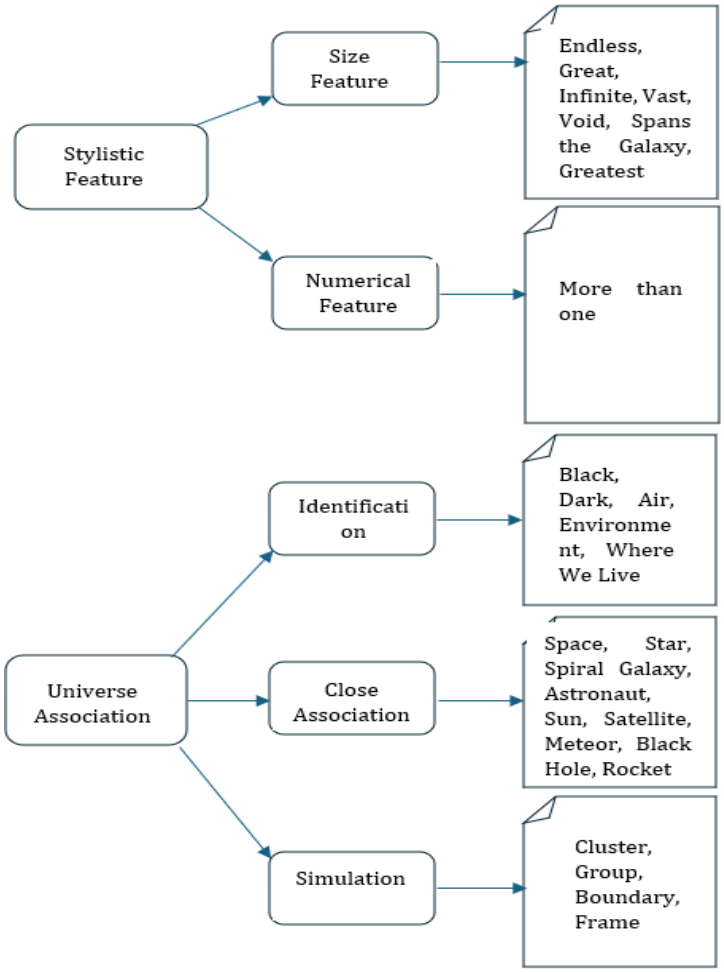


Figure 9

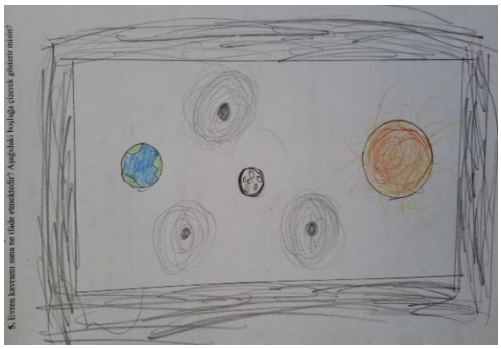
Codes, Categories and Themes Obtained from Students' Drawings Related to the Concept of "Universe"

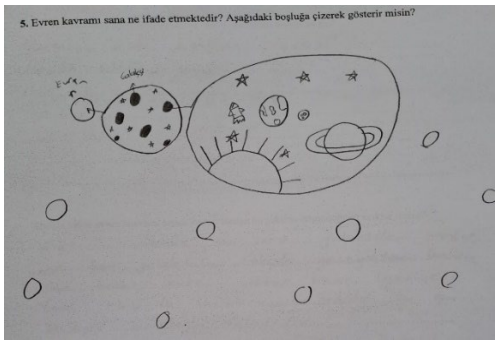


When Figure 9 is analysed, it is seen that the drawings of the universe concept are grouped under two themes: 'Universe Associations' and 'Formal Characteristics'. The findings related to the theme of 'Evocation of the Universe' showed that the students made drawings coded as 'black, dark, air, environment, the place we live in, space, star, spiral galaxy, astronaut, sun, satellite, meteor, planet, black hole, space rocket, Milky Way galaxy, cluster, group, clear boundaries, border, frame'. The findings related to the 'Formal Feature' theme showed that the students made drawings coded as 'no end, big, infinite, vast, space, covers the galaxy, biggest, everything, covers space, more than one'. Sample student drawings of these findings are given below.

Figure 10

Sample Drawings Belonging to the Category of Universe Association (S.10) and Formal Feature (S.9)





3.2. Findings related to students' written explanations about their drawings

In the drawing form where the data were collected, there are questions that allow students to explain the drawings they created about the determined cosmology concepts (What is the reason for drawing a picture like this for the concept of .....? Can you explain the reason for thinking this way?). The answers given by the students to these questions about the concepts of cosmology, star, black hole, galaxy and universe were analysed and the expressions they frequently used to explain the related concept were determined. It was observed that the students mostly emphasised the aspect of investigation and research in their explanations of the concept of cosmology, the shape and colour of the star in their explanations of the concept of star, the feature of being absorbed in their explanations of the concept of black hole, the feature of being big in their explanations of the concept of galaxy and the feature of being infinite in their explanations of the concept of universe. The findings were supported with examples of students' concept explanations.

Table 1

Key Emphasis in Students' Explanations

Concept	Key emphasis in students' explanations	Direct quotations
Cosmology	Investigation and research	*I think cosmology means space science. (S.14)*
Stars	Shape and color	*Stars are round, large objects in space that can be seen at night. (S.13)*
Black holes	Pulling property	*A black hole is a hole in space that goes on forever, sucking in rocket fragments and rubbish. (S.5)*
Galaxies	Large size	*The galaxy includes the solar system and even the Earth. (S.11)*
Universe	Infinite nature	*The universe is infinity. I think of infinity and space. (S.8)*

When Table 1 is examined, students identified the concept of 'Cosmology' with space science and space research in general, while they defined the concept of 'Star' with its shape and colour features. This shows that students tend to construct basic concepts based on their observations. In the concept of 'Black hole', some students associated this concept with 'gravitational force'. In the expressions related to the concepts of 'Galaxy' and 'Universe', students focused on the concepts of magnitude and infinity.

3.3. Findings related to individual ınterviews with students

In the individual interviews with students' drawings, it was found that many students had many misconceptions about the selected cosmology concepts. These misconceptions of the students are given in the table below. The findings were supported with sample student expressions.

Table 2

Participants' Misconceptions about Cosmology Concepts

Misconceptions	**Participant codes**												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**13**	**14**
Five-pointed star symbol	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Stars come out at night	✓			✓		✓				✓			
Star colour is yellow			✓		✓					✓			
Galaxy = solar system				✓						✓	✓	✓	
Galaxy= nebula											✓		
Space=universe			✓			✓		✓					
Planets in the solar system are aligned in the same order		✓		✓			✓			✓		✓	
Solar system=solar setup			✓										
Venüs=satürn= Jüpiter			✓				✓		✓	✓			
Meteorite= Meteor= Star	✓						✓						✓
Black hole is a hole in the centre								✓					
Black hole= supernova explosion					✓								
Moon craters= pit= hole					✓	✓				✓			
Planets shine						✓							
Saturn's rings are made of stars										✓			
Space is limited					✓				✓				
Heat and temperature			✓					✓		✓			

Some of the student expressions with misconceptions in the table;

'I wanted to draw a hill because the stars come out at night.' (S.1) - (Stars come out at night.)

'Because the planets are actually lined up in such a universe. They have certain distances.' (S.2)- (In the solar system, the planets are aligned in the same line.)

'This concept brings space to my mind, that is, the universe comes to my mind.' (S.3)- (Space=Universe)

'I drew stars, then I drew the solar system, then I drew a rocket.' (S.3)- (Solar System= Solar System)

'Teacher, the sun warms us up, it emits heat.' (S.3)- (Heat and temperature)

'This is what I drew in space; Sun, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune. Milky Way galaxy.' (S.4)- (Galaxy= Solar system)

'I drew the sign that came to my mind because it is a shape that everyone knows.' (S.6)- (Five-pointed star symbol)

'Anyway, meteorites are also a star, but there, for example, I drew a little more to increase the number of stars.' (S.7)- (Meteorite= Meteor= Star)

'I made it like this because the planets rotate in order around the sun.' (S.7)- (In the solar system, the planets are in the same order.)

'When I thought of a black hole, I thought of it as a hole.' (S.8)- (Black hole is a hole in the centre.)

'There are stars (rings) around it (Saturn).' (S.10)- (Saturn's rings consist of stars.)

'Those drawings are the heat, the heat coming from the sun, the reflected thing.' (S.10)- (Heat and temperature)

'Yes, teacher, I was going to draw all the planets in the Milky Way galaxy and this much came to my mind.' (S.13)- (Galaxy= Solar system)

When Table 2 is analysed, it is seen that the misconception identified in all of the students is that the star shape is similar to the pentagram symbol. It is also seen that the misconception 'the planets in the solar system are aligned in the same order' is present in many students. Another remarkable finding is that there is no student who does not have a misconception. It is seen that students have at least one misconception about the subject.

4. Conclusion and Discussion

In this study, it was aimed to reveal the 7th grade middle school students 'conceptions and misconceptions about the concepts of cosmology in the subject area of "Earth and Universe" in the science course and to determine the similarities and inconsistencies between the actual visuals and the students' drawings.

As a result of the research, 3 categories belonging to the concept of cosmology and 2 themes related to these categories, 6 categories belonging to the concepts of star and black hole and 2 themes related to these categories, 5 categories belonging to the concepts of galaxy and universe and 2 themes related to these categories were revealed. In the students' expressions related to their drawings, it is seen that they explained the concept of cosmology by emphasising the concept of investigation-research, the concept of star by emphasising the shape and colour of the star, the concept of black hole by emphasising the feature of being absorbed, the concept of galaxy by emphasising the feature of being big and the concept of universe by emphasising the feature of being infinite. In the individual interviews,

misconceptions about cosmology and basic astronomy concepts were identified in many students. Another interesting result was that aesthetic concerns were more important than scientific accuracy in students' drawings. When the students' drawings were compared with the actual visuals of the concepts, some similarities and inconsistencies were found. The students expressed the concepts of cosmology, star, galaxy, black hole and universe not by themselves but by associating them with other concepts. The fact that they associated the concept of cosmology with tools such as telescopes, binoculars and glasses can be explained by the fact that they perceived this concept as the study and research of space. The presence of sky, sun, star and planet drawings in the drawings of the concept of cosmology shows that they associate this concept with celestial bodies. The fact that students expressed the concept of cosmology by associating it with other concepts and basing it on non-scientific knowledge can be explained by the fact that this concept is not directly included in the 7th grade science textbook. When the students' drawings of the concept of star were evaluated, it was noteworthy that most of them used the five-pointed star symbol. This result can be attributed to the fact that the students were inspired by the star symbol in our official flag and frequently encounter it in their daily lives. Similarly, Çakır (2020) found that the symbol on our official flag was effective in the formation of 3rd and 4th grade students' mental perceptions of the Sun and the Moon. Another point that draws attention in the drawings is that the Sun is represented as spherical, large and bright by colouring with a highlighter, while other stars are shown small with a five-pointed symbol. When the students' drawings and individual interviews were compared, it was observed that although they knew scientifically that the star shape was spherical, they used the five-pointed star symbol while drawing. In his study, Direkci (2014) included the views of students who stated that the Sun is spherical and in yellow-orange-red tones. In the written explanations of the students' drawings related to the star, it is seen that the expression sky is frequently mentioned. This situation can be associated with the fact that they see the Sun during the day and distant stars at night in the day and night cycle that occurs as a result of the daily movement of the Earth. Another point that emerged as a result of the interviews was that the students described the property of stars as heat and light sources as ‘emitting heat’ and that they had misconceptions about the concepts of heat and temperature. In addition, students associated comets and meteorites with stars. One student thought that the rings of Saturn were formed by stars. The most important finding that emerged from the analysis of the students' drawings related to the concept of galaxy was that they used galaxy and solar system interchangeably and reflected the solar system instead of the galaxy in their drawings. In the drawings of the solar system, it was observed that the planets were drawn one after the other and orbital lines were included. In the interviews, students stated that they had seen this representation in science textbooks and videos used as educational materials. This finding coincides with the finding of Çoramık and Özdemir (2021) that the examples in the students' drawings are in parallel with those in the textbooks. In their study, Görecek Baybars and Çil (2019) stated that very few students stated that the expression of the solar system can be considered scientifically correct, and that students mostly drew planets in order. This situation shows that visual tools used as educational materials can cause misconceptions in students and misplacing concepts in their minds. Students did not include the term galaxy when defining the concept of galaxy. Although the concept of galaxy is also included as galaxy in the 7th grade science textbook taught in state secondary schools in the 2023-2024 academic year, the concept of galaxy was not encountered in the students' statements. It is seen that the students only knew the Milky Way galaxy as an example of a galaxy and did not express any opinion about galaxy types. While spiral galaxy was included in student expressions, elliptical and irregular galaxy types were not used by the students. The use, size and selection of the visuals in the textbook (MoNE, 7th grade science textbook, pages 37, 38) may be effective in this situation. Another one of the students' ideas about the concept of galaxy is that galaxies have borders. The galaxy was drawn as a cluster including celestial bodies by most of the students. It is noteworthy that many students drew the size of galaxies and stars equal, and even drew stars larger than galaxies. This situation can be attributed to the incorrect ordering of the order from the smallest astronomical structure, the earth, to the largest structure, the universe,

in the students' minds. When the students' drawings related to the concept of black hole were evaluated, the most common expressions were that the black hole was really a hole and that it sucked everything into it. Some of the students expressed black holes as scary. This can be explained by the fact that it is not known what happens to the objects entering the black hole after they pass the event horizon. In their study, Sadıkoğlu et al. (2022) stated that students had ideas about the strong gravitational effect of black holes. In individual interviews, there were also students who made scientific explanations such as black hole is a phase of the stellar life process. When the students' drawings related to the universe are analysed, it is seen that they tried to draw the universe by associating it with space. While they expressed the space as a frame with clear boundaries, they expressed the universe as unlimited. It is noteworthy that the students drew on a very large area by using the whole page. This shows that students think of the universe as very large, very wide and unlimited in their minds. The emergence of the words 'infinity' and 'everything' in the students' explanations about the concept of universe can be attributed to this. In the findings obtained from individual interviews, it is seen that there are students who think that there can be more than one universe. Science fiction films can be shown as the source of this situation. The fact that only two students included the information that the universe is expanding shows that the students' knowledge about the universe is incomplete and their thoughts about this concept are far from scientific. With the acceptance of astronomy as a popular science, the presence of sources containing correct and incorrect information may have led to the emergence of unscientific thoughts in students. When all of the cosmology concepts are evaluated, it is seen that they are tried to be explained by using drawings of the Earth, Moon and Sun. The reason for this may be the students' existing knowledge of the "Sun-Earth-Moon" unit in the 5th grade "World and Universe" subject area. It is surprising that students mostly preferred Earth and Saturn when drawing planets despite the increasing studies and interest in Mars in recent years. In addition, the fact that they called Saturn as Jupiter in individual interviews shows that they misunderstood the names of the planets. The reason for this may be that both planets are gaseous and large planets.

Although it was observed that the students frequently preferred the five-pointed star symbol in their star drawings, they were able to identify the star correctly when compared with the real image. The shape and colour feature in the visual enabled them to identify the star correctly. Although they have scientifically correct knowledge, it is thought that the misconceptions that students acquire in childhood continue in later ages. This situation shows that the fixed concepts developed by the students during their past experiences continue at later ages (Çakıcı, 2010). It was observed that the students made incorrect matching when comparing their own drawings with galaxy and black hole visuals, confused galaxy and black hole, and had great difficulty in associating their own drawings of the concept of cosmology with real visuals. This situation can be explained by the fact that cosmology is not a concept included in the science textbook.

5. Recommendations

The findings and conclusions obtained in this study revealed that misconceptions about cosmology concepts are common among students and that students have problems in making sense of concepts based on scientific knowledge. In this direction, various suggestions were developed for science teachers, educators and policy makers.

Science teachers can use teaching approaches such as multiple representation, modelling and conceptual change texts in their teaching processes by taking into account the difficulties experienced by students in making sense of astronomy-based concepts and the misconceptions and inconsistencies identified in the "Earth and Universe" subject area. They can conduct their lessons by supporting them with techniques (e.g. concept map, word association technique, conceptual change text) to eliminate misconceptions. In addition, digital simulations, interactive software and applications, out-of-school environments (e.g. planetariums) can be included in the teaching process in order for students to

establish correct relationships with concepts. In this way, they can support students' observation, reasoning and inference skills in line with the scientific process skills emphasised in the Turkish Century Education Model. Teachers can place the course content in a pedagogical context through interdisciplinary activities and increase critical thinking and scientific awareness. Policy makers, on the other hand, can increase the scientific consistency of the visuals and content in textbooks and make structural arrangements to prevent misconceptions. In addition, pedagogical control of the visuals in textbooks in terms of size, content and meaning can be provided. It is thought that these methods can help students construct concepts more effectively and eliminate misconceptions.

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Article Information Form

Author Notes: The author would like to thank the editors and anonymous reviewers for their helpful comments and suggestions that contributed to the improvement of this paper.

Conflict of Interest Disclosure: No potential conflict of interest was declared by authors.

Ethical approval: During the preparation process of this study, it was declared that scientific and ethical principles were complied with and all the studies used were indicated in the bibliography. For this study, approval was obtained from Sakarya University Educational Research and Publication Ethics Committee dated 10.05.2024 and numbered E-61923333-050.99-360105.

Artificial Intelligence Statement: In this study, ChatGPT-4, an artificial intelligence tool developed by OpenAI, was used as a supporting tool to increase the fluency of the language during the writing process, improve the comprehensibility of the text, and minimize punctuation and spelling errors. The suggestions provided by the tool were reviewed in detail by the author and the necessary adjustments were made before finalizing the text.

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Appendix. A. Drawing form prepared to examine middle school 7th grade students' drawings of cosmology concepts in the subject area of 'Earth and Universe' in the science course

Instruction: Dear students, I am conducting a study in which I aim to reveal middle school 7th grade students' conceptions and misconceptions about the concepts of cosmology in the subject area of 'Earth and Universe' in the science course. Within the scope of this subject, I will ask you to reflect your thoughts about five concepts with drawings and explain your drawings. I want you to make sure that your drawings *are related to the subject*. Your drawings are important in terms of *content, not artistic*. You can color your drawings as you wish. Your answers will be kept completely confidential and will not be used for any purpose other than scientific research. Your participation in the study is voluntary. Thank you for your contributions.

1. What does the concept of cosmology mean to you? Can you show it by drawing it in the space below?
   a. What is the reason for painting such a picture of the concept of cosmology?
   b. So what do you think the concept of cosmology is? Can you explain why you think this way?
2. What does the concept of star mean to you? Can you show it by drawing it in the space below?
   a. What is the reason for drawing such a picture of the concept of a star?
   b. So what do you think the concept of a star is? Can you explain why you think this way?
3. What does the concept of black hole mean to you? Can you show it by drawing it in the space below?
   a. What is the reason for painting such a picture of the concept of a black hole?
   b. So what do you think the concept of a black hole is? Can you explain why you think this way?
4. What does the concept of galaxy mean to you? Can you draw it in the space below?
   a. What is the reason for painting such a picture of the galaxy concept?
   b. So what do you think the concept of a galaxy is? Can you explain why you think this way?
5. What does the concept of universe mean to you? Can you show it by drawing it in the space below?
   a. What is the reason for drawing such a picture of the universe?
   b. So what do you think the concept of the universe is? Can you explain why you think this way?

Appendix. B. Poster prepared for middle school 7th grade students to compare their drawings of cosmology concepts in the subject area of 'Earth and Universe' in the science course.