Gifted Students’ Perceptions on Basic Astronomy Concepts

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Abstract
In order for the human beings to perceive themselves and the events taking place around them, they must perceive the universe first. Understanding and interpreting the functioning of the universe is the purpose of astronomy, which is in one another with all sciences. For this purpose the aim in this study is to determine the perceptions of gifted students on the basic concepts of astronomy. The phenomenological method, which is one of the quantitative research designs aiming to reveal the perceptions of people on a certain concept or phenomenon, has been used in the study. An interview form which is semi-structured with 14 open-ended questions has been used in the study. The interviews were made with 4 gifted students who have been diagnosed with being gifted and who are attending to Bilsem (Center of Science and Art). In the analysis of the data, the descriptive analysis has been performed in the study by using pre-determined categories. The results revealed that gifted students have a perception at “Understanding Category” on basic concepts of astronomy at a rate of 78%; and also revealed that they did not have perceptions on “Not Understanding Level”. Furthermore, it has been observed that gifted students have upper level thinking skills like analytical, hypothetical and associative skills.

Keywords: gifted students, students’ perceptions, basic astronomy concepts, science education, phenomenological method

INTRODUCTION
Gifted students who are different from their peers in terms of physical, mental and social aspects have a natural and innate interest in physical sciences. Because physical sciences trigger and activate their curiosity and imagination. When their potential and interests are considered, gifted students are accepted as privileged individuals who will integrate science with their lives and contribute to it (Camci Erdogan, 2014). The increase in the need for human resources who will help to solve the modern problems by using sciences and arts rather than producing information is one of the main objectives of the education given to gifted individuals. Gifted individuals are good problems solvers who can think analytically and produce creative, practical solutions (Renzulli, 1986); they are also sensitive to social problems and the solutions for them (Sak, 2014, p.58).

Gifted individuals, who are 15% more talented than their peers in one or more areas like mental, creativity, etc., are interested in problem solving, and science and technology. Efficient programs must be used in order to reveal the talents of these students or to improve their existing talents. Astronomy, which enables students encounter big problems and help them develop their skills such as problem solving, mathematics, computer technology, scientific literacy, etc. may be given as an example for these programs (Hollow, 2005, p.27-28-29).

Astronomy is a subject which makes it possible for people to learn the universe, the physical laws that govern it and the changes in the universe by using the observation skill and thus contributes greatly to the structure of the thought of people. Astronomy is the greatest practice laboratory where the laws of the universe are presented and tested in visual form (Kececi, 2012). Although it is the oldest science that ensures that people perceive themselves and the events happening around them, it is deep inside other sciences (Trumper, 2006). Because the natural practice area of many laws used in many classes at schools is the universe. Understanding and interpreting the functioning of this laboratory is the duty of Astronomy. In addition to this, it has some other purposes like thinking in 3-dimensional form, creativity, scientific thinking skills, gaining scientific research habits and interpreting the results. For example, as an answer to the question “How much is the eternity?”, we use the latest point in the universe with a space craft that is traveling through the space also as an answer to another question “Where is the eternity?” (Kececi, 2012).
Learning basic subjects helps to learn the further subjects better in the future (Ekiz & Akbas, 2005). However, the knowledge of the students and their interests cause them to develop alternative ideas instead of increasing the knowledge on Astronomy. For this reason, there have been conducted many studies on students’ perception of basic astronomy concepts (Pena, Quilez & Ciencas, 2001; Kurnaz & Degermenci, 2012; Ekiz & Akbas, 2005; Emrahoglu & Ozturk, 2009; Kurnaz & Degermenci, 2011; Trumper, 2006; Plummer, 2008; Miller & Brewer, 2010; Blown & Bryce, 2006).

In studies in which the aim was determining the mis-perceptions of students in understanding the concepts (Ekiz & Akbas, 2005; Kececi, 2012), it was determined that students did not understand the basic concepts and had many misconceptions. Kurnaz & Degermenci (2011) studied the perception of students and the levels of this perception according to the class levels on basic astronomy concepts and found out that students could not match the concepts and their properties accurately and that the examples on concepts were insufficient. Emrahoglu & Ozturk (2009) conducted a longitudinal study on Science Teacher Candidates and determined that the teacher candidates could eliminate their alternative ideas in the first and second grades; however, in third and fourth grades, it increased again. Trumper (2006) aimed to determine and compare the misconceptions of high-school teachers on basic astronomy concepts by using constructivist activities, and observed that there was an important change in the study group at the end of the process. Plummer (2008) wanted to develop the perceptions of preschool students on the Earth, the Moon and the stars by using the Planetarium Program. At the end of the application, he determined that there was a significant increase in the perception levels of the students. Miller & Brewer (2010) conducted a study on university students and found out that students estimated the distance between the Earth and the Moon more than the actual distance, and estimated the distance between the Earth and the Sun less than the actual distance. Pena et al. (2001) conducted a study with 78 teacher candidates and found out that the candidates did not have clear thoughts on the Earth, the Moon and the Sun models, and had difficulties in explaining these elements with diagrams.

Gifted individuals have a learning capacity that is at a further level when compared to that of normal students. For this reason, using further level thinking skills (analysis, synthesis, evaluation) in their educations will increase the quality and sustainability of the teaching. However, activities that will ensure that students learn with various learning and thinking styles, logical approaches to the topics, reasoning, and discovering (Sak, 2014).

The purpose in this study is determining the perception styles of gifted students, who have a natural and innate interest in science and a deep capacity to understand scientific concepts, on basic astronomy concepts (the universe, the solar system, the planets, the stars, the orbits, the Sun).

**METHOD**

**The Method of the Study**

In this qualitative study, the phenomenological research method has been used. The phenomenological research method tries to define what the experiences of many individuals on certain concepts or phenomena are (Guler, Halicioglu & Taspin, 2013, p. 234). Phenomenon is the name given to the subjective life of an individual who perceives himself/herself and the outer world according to his/her own perception (Yildirim & Simsek, 2005, p.72). Phenomenology is the research design that is suitable for this study. Because the concepts which represent the common changeable properties of different objects and phenomena that become meaningful in the minds of people (Ulugen, 2001, p.27) have been taken as the basic criteria throughout the study. By using concepts, the focus in the study has been on explaining and describing the understandings of the gifted students on basic astronomy concepts.

**The Study Group**

In the study, individual interviews were made with 4 gifted students whose intelligence levels were determined in advance with the WISC-R test (the students whose intelligence level points were over 130). These gifted students were selected from among the students who attended to Bilsem (Center of Science and Art) by using the Criterion Sampling Method. The Criterion Sampling Method is the study of all situations that cover a series of criteria formed by the researchers (Yildirim & Simsek, 2005, p.112). The researcher did not know the students who were included in the exemplification of the study before. In determining the exemplification, the criteria were the students’ interests in space and Astronomy, being at least 7th Graders, and the viewpoints of the science and technology teachers at Bilsem. The purpose in determining these criteria was to ensure that the researcher does not know the students before the study, the topic of the study being included in the curriculum of the 7th Grade, and the desire of the researcher to obtain rich and deep data.

**Table 1. Information of the Participants**

<table>
<thead>
<tr>
<th>Nickname</th>
<th>Gender</th>
<th>Duration of attending Bilsem (years)</th>
<th>Type of the School except Bilsem</th>
<th>Age</th>
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<tbody>
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<td>State School</td>
<td>13</td>
</tr>
<tr>
<td>O2</td>
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<td>3</td>
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<td>13</td>
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<td>4</td>
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<td>12</td>
</tr>
<tr>
<td>O4</td>
<td>Male</td>
<td>4</td>
<td>State School</td>
<td>13</td>
</tr>
</tbody>
</table>
THE STATUS OF THE RESEARCHER
In qualitative research, the researcher is one of the data collection tools. S/he observes the case and phenomena closely and develops a participative approach, and may reflect his/her viewpoint onto the case and phenomena (Yıldırım & Simsek, 2005, p.255-256). The researcher must be able to consider himself/herself and his/her activities throughout the study in a critical manner. S/he must clearly state his/her prejudices, inclinations and assumptions about the study (Merriam, 2013, p.210). The reasons of selecting the participants from among those whom the researcher does not know is to decrease the biased manner in a study. In addition, the researcher has paid attention not to ask directive questions and not to influence the attitudes of the participants in the study. The researcher transcribed the interviews before much time passed, determined and corrected the failing points and worked with a different researcher during the analyses of the data in order to ensure the reliability.

DATA COLLECTING TOOL
In phenomenology, which is one of the qualitative study designs, the phenomenon is examined in all aspects by working with a group of individuals who have experienced the phenomenon. Interviews are generally used in order to reveal the understandings on the phenomenon. Sometimes, these interviews may be repeated more than once (Creswell, 201, p.78-79). For these reasons, the interview form has been used in the study as the data collection tool.

The Results of the Interviews: The Interview Form consists of 14 open-ended questions. The interview questions were formed by taking into consideration the interviews with three students on the Solar System and Beyond in 7th Grade Science and Technology classes: The Unit of Space Puzzle. In preparing the questions, one main question and sub-questions on each concept were formed. Firstly, the concepts were evaluated among themselves and the questions were directed, and then questions were asked among the related concepts. By doing so, the purpose was to reveal the understandings on the concepts and establishing relations among them. The interview questions were asked under 4 categories about the concepts like the universe, the solar system, the stars and the orbits. Except these categories formed, 2 more questions were added related with why there is life on the Earth and the relation between the concepts of star and planet. In the first category, the structure of the universe and its definition were asked. In the second category, the structure of the solar system, the planets in it, the concept of planet, the movements of the planets and the reasons of this movement are dealt with. In the third category, the concept of star, and the category of the Sun among heavenly bodies and the reason for this are investigated. In the fourth category, the answers for the questions like concept of orbit, whether all the heavenly bodies have orbits or not, and what would happen if the orbits did not exist are sought. After these categories, the relation between the concepts of star and planet is asked and the students are enabled to establish relation between the second and third categories. As the last item, the students are asked to explain why there is life on the earth. The interview questions were sent to a science and technology teacher, and to two lecturers to receive their viewpoints. The interview form was used in 1 pilot interview. With the help of the pilot interview, the average duration of the questions and answers in the interview, the possible answers, and the probes that may be used in the answers were estimated. According to the data obtained in the pilot application, some questions were changed with better ones and some were eliminated and the final shapes of the questions are given as follows.

THE COLLECTION OF THE DATA
The interview method has been used as the data collection tool. Each of the participants were interviewed in the most proper times for them. All of the individual interviews were made in Bilsem, where the students are attending, in the rooms that were chosen by the students. The duration of the interviews varied between 13 minutes and 30 minutes. The interviews were recorded with sound recorder from the beginning until the end. By taking the desires of the students into consideration, the interview of one of the students was recorded as video. Because the interviews are a data collection tool in which the richest symbolic interaction takes place. All the questions were asked in the same order given in the interview form, and sometimes the researcher asked extra questions according to the flow of the interview or confirmed the answers of the participants to ensure better understanding.

THE ANALYSIS OF THE DATA
The data obtained in the interviews were analyzed with the descriptive analysis method, which is one of the qualitative analysis methods. The data obtained with the descriptive analysis method are summarized and interpreted according to pre-defined themes. The aim is interpreting the data that are described systematically and clearly, investigating them with cause-effect relations and presenting them to the reader (Yıldırım & Simsek, 2005, p.224).

The steps followed in the analysis of the data are as follows:
Figure 1: The categories formed by Ekiz & Akbas (2005) were used in the analysis of the data.

1- Understanding: It includes all the sides of the scientific answer about the question.
2- Limited Understanding: It covers the answers that include one or more parts of the valid scientific answer but not all aspects of it.
3- Not Understanding: The answers that are given like repeating the question in the same form or irrelevant or ambiguous are in this category.
4- Misunderstanding: The student answers that are alternative to the valid scientific answers are classified under this category. The answers of the students in this category may be very different and generally contain students’ understandings that are inconsistent with scientific facts.
5- Not answering the question: The answers given as leaving blank, “I do not know” or “I have forgotten” were classified under this category.

The interviews were examined according to the categories given above. The answers that may be considered as the samples for each category were presented to the reader as direct quotations without changing any part of them. The identities of the participants were hidden for ethical purposes and the students were given nicknames. The data transcribed were encoded by more than one researcher and the consistency between the code lists was considered before making any comparisons. When the comparisons were made, at least 70% rate was obtained and this rate shows that the two encodings were consistent (Creswell, 2013, p. 253-254).

FINDINGS
In the study, in which the aim was to reveal and describe the understandings of the gifted students on basic astronomy concepts, questions on the concepts like the universe, the solar system, the stars and orbits were asked to the students in the interview form.

Students’ Perceptions on the Concept of Universe
What crosses your mind when the universe is mentioned? (What do you understand from the universe concept?)

The 4 students to whom the first question was asked answered in the understanding category. The following dialogues may be considered as examples for this:

R: What crosses your mind when the universe is mentioned?
S1: A medium in which all the materials and energies in the third dimension exist which is considered infinite.

R: Can you explain the materials and energies in the third dimension a little bit?
S1: What I mean with the word “material” is all the creatures dead or alive. And the energy is the heat, light energy and similar other ones....

Students’ Perceptions on the Solar System
The students were asked “What crosses your mind when the solar system is mentioned? And “How many planets are there in the solar system?”, the 4 students answered in the understanding category. The following dialogues may be considered as examples for this:

R: What crosses your mind when the solar system is mentioned?
S3: The Sun in the center, the planets turning around it and the satellites turning around the planets.
R: How many planets are there in the solar system?
S3: Formerly there were 9 planets, but later Pluto was included in the dwarf planets. The science says that there are 8 planets now.

In the question “What crosses your mind when planet is mentioned?”, the attention is focused on the properties of the planets. 2 of the students gave answers that were included in the understanding category. They gave the answer in this category, which is “Planets usually turn around a star and are the source of heat and light”. Moreover, one of the students stated that the planets existed either as gas or land. One student answered in limited understanding level and gave only one side of the scientific answer for a planet.

S2: They are big masses formed of gas or rocks and their forming a specific attraction.

A student in misunderstanding category gave an alternative answer to the valid scientific question.

S1: Planet. In my opinion a cooled down star or a mass which is surrounded by solidified gas layer, a medium. This is what I recall.

“How do the planets move in the solar system?” and the question following this “Why do they turn around the Sun?” were asked by the 4 students in understanding category.

R: How do the planets move in the solar system?
S4: They are turning around the orbit of Sun, they are turning around the Sun.
R: So, why do they turn around the Sun?
S4: Because of the attraction power stemming from the mass of the Sun.

An alternative answer of another student answers to this question: “They turn both around the Sun and around themselves in the orbits shaped like an ellipse at different speeds.” (S1)

The perceptions of the students in 5 questions in the solar system category were generally included in the understanding category. The differences were only in the planet perception categories.
**Students Perceptions on the Star Concept**

In this category the students were asked “What do you understand from the concept star?” 3 students answered in understanding category and 1 student answered in limited understanding category. In the understanding category answers were given like “They are energy sources that diffuse heat and light in great quantities, and are formed of compressed gas and dust clouds” and “They are heavenly bodies that can produce heat and light and mostly formed of gasses with surfaces or nuclei at higher degrees”. 1 student who answered in limited understanding category stated about the stars that “They are masses of gas or solid material with a certain lifetimes”. The student made scientific explanations about the stars but did not state some aspects.

After the star concept, and after the “Yes” or “No” answers given to the question “Is the sun a star?”, the probe “Why?” was used. The result which was obtained in the star concept was repeated in this question. Generally it was stated that the Sun was a star but the answers given to the question of “Why?” were limited in terms of understanding like in the 3 understanding and 1 limited understanding. The answers in the understating category “Yes. If you ask why, it is the source of heat and light and it is a star because the planets turn around it”. The only student in the limited understanding category answered like “…because the gasses in it burn… I mean because they burn” (S1).

**Students’ Perceptions on the Concepts of Orbit**

3 questions were asked to the students in this category. “What do you understand from the concept of orbit?” was the first question of the category. 2 students answered in the understanding level and 2 students answered in the misunderstanding category. The answer in the understanding category was “The route followed by a heavenly body while it is turning around another heavenly body” (S1).

In the misunderstanding category, the answer was like “I remember the attraction power formed around a heavenly body in the space and the pull or push of an object by another object in the space to suspend it” (S2).

The second question in the category was “Do all heavenly bodies have orbits?” and the “What would happen if there were no orbits?” as the last question. 2 questions were given in understanding and 2 were given in the misunderstanding category. The understanding category “They do not have it in the space. Definitely no. There are asteroids, meteors and similar objects wandering in the space” (S3); and “I think there are not. If you ask why, because meteors wander in the space and therefore they do not have orbits” (S4). In the misunderstanding category, the students gave answers that were alternative to the valid scientific answer. “Yes, actually they may be in an orbit. Because everything has a mass attraction… even now, the thing you are recording me with has an attraction power; however, their masses and sizes are small and therefore this cannot be noticed. But the objects in the space cannot be regarded as small objects and I think that they have orbits (S2)”; “Galaxies and other similar things are turning all the time and this shows that there is an orbit” (S1).

All the answers given to the question “What would happen if there were no orbits? Were in the understanding category. In the under stating category, “If there were no orbits now, I think the Moon would be released to the space or come nearer to us and break the earth into pieces. The orbits hold the objects in space at a certain distance and keep them in a balance without leaving them or attracting them too much. We wouldn’t be turning around the Sun now and left in the space and freeze. If there were no orbits, I think life wouldn’t exist” (S2).

**Students’ perceptions on the relation between star and planet**

The aim in this category was to reveal the student perceptions about the star and planet concepts which was asked to the students in previous categories. For this purpose, the question “Can there be any differences between the concept of star and planet?” was asked. There were 3 understanding and 1 limited understanding category. Some examples for the answers given to the question in understanding category are as follows: “Of course there is. Stars are big masses that produce their own energy and diffuse heat and light, but planets are heavenly bodies that are much smaller and cannot produce and diffuse their own energy” (S2). The answer in the limited understanding category was “As far as I know, there are no explosions in planets like in stars, I mean they do not diffuse a certain energy” (S1).

**Students’ perceptions on the issue of the only life form being in the Earth in the solar system**

4 students answered in understanding category. The following dialogues can be given as an example for this:

**R:** Now we have talked about the solar system. We talked about 8 planets in the solar system. One of these planets is our earth, but when we consider the solar system, the only place that has the life form is our earth. So, what can the reason be for our planet being the only planet having life form?

**S3:** Of course the clear reason for this is the atmosphere. Atmosphere does not exist in other planets, maybe there is as a thin layer and this is not enough or there is bot it is very thick and the rate of carbon dioxide is too much. For example Mars also has an atmosphere and very similar to Earth but it is deserted completely and the poisonous gasses around
are too much. I mean it is not possible to see on the surface of Mars.

R: You mean the only reason for the life on Earth is the atmosphere?

S3: Of course not. Not only the atmosphere but it is also far from the Sun and it is one of the clear reasons.

R: How does the distance to the Sun affect it?

S3: If it were nearer to the Sun, the Sun would burn it down, just like in Mercury and Venus. If they were farther they would freeze. The most suitable conditions for the life forms, I mean for human beings, are in the Earth. Neither one centimeter farther nor closer... human beings would not be able to live. And there is the issue of water of course.

RESULT AND DISCUSSION

In this study in which the perceptions of the students on the concepts of the universe, the solar system, stars and orbit were investigated and it was determined that the perceptions of the gifted students on the relevant concepts were in Understanding Level or Limited Understanding Level. The perceptions of the gifted students on astronomy issues were in the form of Not Answering and Not Understanding levels and this is understood from the individual interviews. When the answers of the students are considered, the perception level in Understanding category is at 78%; in Limited Understanding Category it is at 8% and in Misunderstanding Category it is at 14%. This study revealed that the gifted students can use their analytical and hypothetical thinking styles especially in issues related with astronomy.

When the concept of the universe is compared with the scientific definition, it is understood that the perceptions are at the Understanding level and defined the concepts accurately. It is understood that the students can understand all of the heavenly bodies in the solar system with scientific acceptations and they can think hypothetically and are aware of their thoughts in a meta-cognitive style. The perceptions of the students in the categories on orbits are various. The students made alternative scientific explanations on this issue but these are not at the understanding level. They explained their answers given in the “If the orbits did not exist” and gave examples for them. It is observed that they adopted the reasoning thinking style. It was determined that the question “Why is the Earth the only planet having the life form in the solar system?” which was not included in the categories was explained by the students by establishing connections among the concepts and these are at the understanding level.

In the studies conducted on astronomy about the basic concepts of the secondary school students, it was determined that the students had perceptions in Understanding, Limited Understanding, Not Understanding, Misunderstanding and Not being able to Answer categories (Ekiz & Akbas, 2005; Kececi, 2012). In this study, which was conducted on gifted secondary school students, the perception categories were Not being able to Answer and Not Understanding. When the answers given are considered, it is observed that the students have perceptions mostly in Understanding Category. The Misunderstanding Category exists mostly in the orbit category. This result coincides with the studies conducted by Ekiz & Akbas (2005) and Kececi (2012).

The gifted students have developed a scientific understanding on basic astronomy concepts and can use their analytical thinking skills at the top level. In the study conducted by Kurnaz & Degermenci (2012) on 7th Graders it was determined that almost all of the students had mental models that were not in accordance with scientific information at a sufficient level. Moreover, Kurnaz & Degermenci (2011) also determined that the student could not match the concepts and their properties accurately and that the examples given about the concepts were insufficient. The gifted students could make scientific explanations for concepts and their properties and could exemplify these in different forms.

It may be claimed in the present study that the gifted students are very interested in astronomy and can follow this science closely. The reason for this may be explained with the fact that they have a wide interest area, sharp observation and analytical thinking skills, and have an excessive interest and curiosity for the unknown one (Levent, 2013, p.16-17). The answers given to the question at the end of the interview may be shown as an example: “If you were a space traveler, where would you travel first? Why?”. Some sample dialogues are given as examples below:

R: So, let’s assume that you are a space traveler. Where would you go first in space?

S1: Now... If I were not afraid of the Black Holes, I would travel to them!

R: Why are you afraid of black holes?

S1: For the first thing, the pressure and time are extremely higher; and I wonder if a person can endure this?[Rounds his/her lips.] I do not know the chaos then [shrugs his/her shoulders and laughs].

R: You mean, the first place to travel to would be the Black Holes... Why Black holes, can you explain it a little bit?

S1: The Black Holes are more interesting than the other parts of the space, they have more mysterious sides. I am interested in such thinks, I mean, the unknown...

The answer of another student:

R: So, if you had a space traveler, what would the first place be for you to go?
S3: If I remember correctly, there is a planet called Kepler b16, and it is very similar to the Earth. I would travel there first to check if there is life there. To see if there are living creatures in other planets and if they are also looking for us too.

R: Do you believe that there is a living community there?
S3: Why not?... because the universe is infinite...

R: You mean, the place where you would like to travel first is Kepler b16 because it is very similar to the Earth. You want to check whether there is a life form similar to that in the Earth.

S3: Because it is more like the Earth. I would like to travel there and see if there is a life form, because there are white clouds as far as I can see. I wonder if it is a deep blue planet. But, except for this, let us assume that I had enough time, I would travel around in the infinite space before I travel back to the Earth.

Except for the abovementioned interview questions, by considering the speeches of the students, it is observed that the curiosity of the students is at the forefront, which is necessary for scientific research. In addition, the idea that there might be life in other planets based on the assumption of the infinity of the universe shows that the students are inclined to research and may find reasons at a further level for their planned research. In addition, the process in which the students observe the heavenly bodies they wonder on their own is the exploratory learning itself. According to Sak (2014), by using the exploratory learning, students both discover the information and produce it, and also observe the production process of the information (p.180).

In the light of the findings obtained in the study:
1. The reasons of the perceptions of the gifted students in Misunderstanding Category may be determined and corrected.
2. It may be suggested that the concepts on basic astronomy should be included in course books and curricula in a more comprehensive manner.
3. Moreover, the unit which is related with the topic is the last unit of 7th Grade. This unit is either not dealt with or dealt with at an insufficient level due to time restrictions and the number of the unites being more. For this reason, this topic may be emphasized in Science and Technology classes in Bilsem.

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