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Investigation of Prospective Science Teachers' Answers to Multiple Choice Questions about Star: Analysis Wrong Answers as well as Corrects

Fen Bilgisi Öğretmen Adaylarının Yıldız ile İlgili Çoktan Seçmeli Sorulara Verdikleri Cevapların İncelenmesi: Doğru Cevapların Yanında Yanlış Cevapların da Analizi

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ÖZ

Araştırmanın amacı, fen bilgisi öğretmen adaylarının yıldız ile ilgili çoktan seçmeli sorulara verdikleri cevapların yoğunlaşma analizini yaparak ilgili fen konusuna ilişkin modelleme durumları hakkında bilgi elde etmektir. Bu çalışmada nicel araştırma yöntemi kullanılmıştır. Araştırmanın çalışma grubunu Batı Karadeniz Bölgesinde bir üniversitenin fen bilgisi öğretmenliği programı son sınıfta öğrenim gören 73 öğretmen adayı oluşturmaktadır. Veri toplama aracı olarak "Yıldız Konusu Kavram Testi (YKKT)" kullanılmıştır. Verilerin çözümlenmesinde yoğunlaşma analizinden yararlanılmıştır. Bu anlamda yoğunlaşma puanı, yoğunlaşma faktörü ve yoğunluk sapması formülleri kullanılmıştır. Elde edilen bulgular doğrultusunda öğretmen adaylarında ön-testte DD (Düşük-Düşük) tipi modellemenin olduğu, son-testte ise sorularda YY (Yüksek-Yüksek) modeline yaygın olarak yer verildiği belirlenmiştir. Elde edilen sonuçlar ışığında, bu durumun öğretim öncesi değerlendirilmesi ve farklı öğretim yöntemlerinin etkililiğinin analiz edilmesi konularına yönelik önerilerde bulunulmuştur.

Anahtar kelimeler
Yoğunlaşma faktörü, astronomi eğitimi, yıldız, fen bilgisi öğretmeni adayı.

ABSTRACT

The aim of the research is to obtain information about the modeling status of the related science subject by making a concentration analysis of the answers given by the prospective science teachers to the multiple choice questions about the star. The quantitative research method was used in this study. The study group of the research consists of 73 prospective teachers studying at the senior year of the science education department of a university in the Western Black Sea Region. Data collection tool "Star Subject Concept Test (SSCT)" was used. Concentration analysis was used to analyze the data. In this sense, concentration score, concentration factor and concentration deviation formulas are used. In line with the findings obtained, it was determined that there was LL (Low-Low) type modeling in the pre-test in prospective teachers, and post-test showed that HH (High-High) modeling was common in the questions. In the light of the results obtained, suggestions were made to evaluate this situation before teaching and to analyze the effectiveness of different teaching methods.

Keywords
Concentration factor, astronomy education, star, prospective science teacher.

INTRODUCTION

The concept of the star is a concept that is frequently encountered at every stage of education, from science lessons and textbooks to undergraduate astronomy lessons. Since this concept is an indirect part of daily life, as in many other astronomy concepts, it attracts the attention of people, and different meanings can be attributed to this concept. In this sense, the teaching of astronomy concepts such as the star is indicated as an important factor for the change in students' conceptual structures (Trumper, 2006).

When the studies in the literature are examined, there are studies that take the Sun or the Solar System as a subject, or examine the star within the concepts of astronomy (eg. Emrahoğlu & Öztürk, Kaplan & Çiftçi Tekinarslan, 2013), but studies that focus only on the concept of 'star' in education are limited (eg. Agan, 2004; Kurnaz, 2012; Ezberci Çevik & Kurnaz, 2016). Similarly, when the literature is examined, it is stated that the answers are given to the question "What is a star?" are not at a sufficient level, and there are serious alternative ideas in individuals regarding their characteristics and life process (Agan, 2004; Bailey, 2006; Emrahoğlu & Öztürk, 2009). In his book (Heavenly Errors), Neil F. Comins (2001) presented some examples of alternative ideas that undergraduates have about stars and cited them specifically as "the most common false astronomical beliefs":

- The North Star Polaris is the brightest star in the sky.
- Shooting star is actually the falling of a star from the sky.
- The sun is not a star.
- The Sun / Stars will live forever.
- The sun glows from burning gas or molten lava.
- The sun is solid.
- All stars are yellow in color.
- There is more than one star in the Solar System.

When the relevant literature is examined, it is seen that the studies on the conceptual understanding of the students about the star generally used multiple-choice tests (Bektaşlı, 2014; Göncü & Korur, 2012; Kalkan, Ustabaş & Kalkan, 2007; Küçüközer, Küçüközer & Yürümezoğlu, 2010; Şensoy, 2012; Türkoğlu, Örnek, Gökdere, Süleymanoğlu & Orbay, 2009), and secondary open-ended questions are used (Bolat & Altınbaş, 2014; Kurnaz, 2012; Küçüközer et.al., 2010). Besides, while only a score-based statistic is used for multiple-choice items, descriptive and/or content analysis is used for open-ended questions. In the thematic research conducted by Ezberci Çevik and Kurnaz (2016) on studies about stars, it is stated that stars are generally included under the subject of astronomy, and that multiple-choice success tests are used as data collection tools, and descriptive statistics are mostly used as analysis methods. Also, it was stated that the findings frequently obtained in the studies examined by Ezberci Çevik and Kurnaz (2016) were presented as alternative ideas about the star.

Within the scope of studies focusing on descriptive statistics as an analysis method, Dinçer and Aktan's (2017) study can be shown as an up-to-date example of the subject area. Based on the number and rates of answering the options in the inventory used in the relevant study, some alternative opinions of the participants about the star and the stars were determined. "A newly forming star is called a nebula. Stars reflect the light received from the Sun or other energy

sources. Statements such as "The sun is the highest temperature among the red giant, and white dwarf celestial bodies" are among these ideas determined by Dinçer and Aktan (2017). Similarly, Kaptan and Çiftçi Tekinarslan (2013), who presented an analysis, stated that as a result of the analysis of the data they obtained with the Basic Astronomy Knowledge Test (TABT), the success of the inclusive students with intellectual disabilities in the TABT was significantly lower than the students without mental disability. The striking situation in these two studies is that the studies in the relevant literature often focus on statistical meaning with the number and rates of correct answers. It is noteworthy that this analysis approach is frequently used, almost like a general/traditional perspective. The particular emphasis here is that the traditional way of analyzing scores does not provide very useful information on students' real perceptions (Bao, 1999). As stated above, in the relevant literature, student performance is often determined by the score obtained from the test. When the student has a low score (usually in pre-test situations or sometimes in a post-test after ineffective intervention), why the majority of them answered the item incorrectly cannot be determined by examinations based on the total score. However, the status of choosing the wrong options in an achievement test can also provide meaningful information to test developers.

The concentration factor, which is the first part of the analysis, developed by Bao (1999), was used in the present study. A concentration factor is a statistical approach that provides information about how student responses are distributed/spread, rather than measuring student performance, which is characteristic of multiple-choice tests, usually based on correct answers. For example, the knowledge of the distribution of the results among different options due to the students giving the same answer concentrating on a certain option or random predictions is revealed with this analysis approach. In the literature, it is seen that this analysis method was used over measuring tools that include different subjects, for example, on force-motion by Bao and Redish (2001), on electricity and magnetism by Philippi (2010), on electric potential and energy and electromagnetic induction by Dega (2012), and on energy and momentum by Dega and Govender (2016). As a result of the literature review, it is considered that concentration analysis will be much more comprehensive and informative than traditional analysis methods. For this reason, it is inevitable to reach more descriptive information on the learning situation of the students with the help of a detailed analysis of a multiple-choice test on the star subject.

Purpose of the Research

Multiple-choice tests are widely used as data collection tools in education (Temizkan & Sallabaş, 2011). While such tests can be highly misleading regarding the nature of information when not well structured and used in inappropriate situations, it is possible to say that it can be very effective when well prepared and appropriately evaluated. The model analysis is needed for proper evaluation. In this analysis, the concentration factor determination was used to obtain detailed information about the distribution of student responses (quantitative evaluation of student model situations). In addition, this analysis gives information about the distribution of wrong answers as well as the distribution of all answers, which will be an important clue for the educators in evaluating the lesson and measuring the change in the students' performance before and after the instruction. At the same time, the distractors in the items are an indication that the concept test is suitable. Thanks to this feature, it is possible to reveal the knowledge that has taken place in the cognitive structures of the students before.

In this sense, the study aims to conduct a concentration analysis based on the answers given by senior prospective science teachers to the multiple-choice questions about the star as a result of the usual teaching practices process and to obtain information about the modeling situations related to the relevant subject. The reason why especially prospective science teachers were selected is that the prospective science teachers of the science education program in Education Faculties in Turkey are taking the 'astronomy' course in the last year of the education program before 2018. In order to find solutions to the research problem, answers will be sought for the following sub-problems:

1. What is the distribution of all the answers given by prospective science teachers to the star subject concept test before and after the instruction?
2. What is the distribution of wrong answers given by prospective science teachers to the star subject concept test before and after the instruction?

METHOD

Research Design

The study was based on a single group pre-test post-test experimental design among quantitative research methods. Experimental research designs are designs that are used in a study to both measure variables and reveal the relationships between these variables (Çepni, 2012). The most important feature that distinguishes experimental research from all other types of research is that the researcher(s) can manipulate the independent variable (Fraenkel & Wallen, 2006).

In a single group pre-test post-test experimental design, an instruction is made to the group, and measurements take place before and after the procedure (Balcı, 2013). Although factors affecting internal validity such as the characteristics of the data collector and prejudices are not completely controlled in this design in order to explain the findings obtained from the posttest (Fraenkel & Wallen, 2006), it can be said that internal validity is taken under control since the research conducted is the current teaching and the targeted element is the analysis of the pre-service teachers' modeling situations.

Participants

The study group consists of 73 prospective science teachers studying at the senior year of the Science Education Department of a university in the Western Black Sea Region. A purposeful sampling method was used in forming the study group. Purposeful sampling is the sampling that involves the researcher using their judgment in order to conduct in-depth research depending on the purpose of the study and in which information-rich situations are selected (Fraenkel & Wallen, 2006). In this context, criterion sampling and convenience sampling types of purposeful sampling were used. As the criterion sampling, fourth grade pre-service science teachers who took the astronomy course for the first time at the undergraduate level were taken as the basis; As convenience sampling, in order to provide convenience in terms of transportation and cost, fourth grade prospective teachers from the institution where the researcher worked were included in the study group.

Data Collection Tool

In the study, Star Subject Concept Test (SSCT) developed by Ezberci Çevik (2018) was used as a data collection tool. The test, which was developed to examine the prospective science teachers' modeling for the star subject, consists of 26 questions with five options. There are three groups of questions in the test: 'Identity of the Star' (nine items), 'The Structure of the Star' (11 items), and 'The Life Cycle of the Star' (six items). It was observed that these groups of questions were determined through a detailed literature review and creating an indicator table. The mean item difficulty and discrimination indices of the test were 0.37 and 0.39, respectively; Cronbach α reliability coefficient was calculated as 0.748. An example question is given below. (Ezberci Çevik, 2018):

The stars begin their life

a. as part of another star or planet.

b. as a white dwarf.

c. as a substance in the Earth's atmosphere.

d. as a black hole.

e. as dust and gas clouds.

Procedure

Within the scope of the research, prospective teachers enrolled in the astronomy course were given a three-week course, two hours a week. Lessons were conducted by the course's own lecturer. Within the scope of the astronomy lesson, the subject of the star is covered as the definition, properties and life cycle of the star in accordance with the content. In this context, lessons were conducted on the smart board with question-answer technique (see. Table 1).

Table 1. *Teaching Process and Subjects*

Week	Period	Star Subject
1st week	1 lesson	Definition, shape, feature
	1 lesson	Size, diameter, distance
2nd week	1 lesson	Gases in its structure and density, temperature
	1 lesson	Color, brightness, energy production
3rd week	1 lesson	Periods, birth, formation
	1 lesson	Formation (continued), death

Data Analyses

In the analysis of the data, 'score', 'concentration factor', and 'concentration deviation' of the model analysis elements were used. Firstly, student answers obtained with the optical reader were computerized as an excel file. Concentration (C) and concentration deviation (Γ) of each question were calculated using a paper-pencil study using the concentration factor and concentration deviation formulas, and the scores (S) were calculated with a statistical program. Tables and graphics were created over the excel file. The explanations of the formulas for model analysis in the order of use are given below.

Concentration Score (S)

Concentration score (S) are measures that provide information about the scores students received from the test and take a value between 0-1. It is expressed as:

$$S = {}^{n_c}/_{N}$$

In the equation, n_c stands for the number of correct answers to an item and N is the total number of student responses.

Concentration Factor (C)

The analysis factor that gives information about the distribution of student responses is called the 'concentration factor' (Bao, 1999). C, which is defined as the concentration factor, takes a value between 0-1. A value of zero indicates low concentration, and a value of one indicates high concentration. In this context, a higher value means answers with more concentration. The concentration factor is defined as

$$C = \frac{\sqrt{m}}{\sqrt{m}-1} \times \left(\frac{\sqrt{\sum_{i=1}^{m} n_i^2}}{N} - \frac{1}{\sqrt{m}} \right)$$

where *m* represents the number of choices for a particular question, *N* is the number of student responses, and *ni* is the number of students who select choice *i* of the question.

Concentration Deviation (┌)

For the details of the distribution of incorrect answers, the absolute distance should be removed by scores. To do this, the concentration on wrong answers needs to be calculated. This is called the concentration deviation and is represented by (┌).

$$\Gamma = \frac{\sqrt{m-1}}{\sqrt{m-1}-1} \times \left(\frac{\sqrt{\sum_{i=1}^{m} n_i^2 - S^2}}{(N-S)} - \frac{1}{\sqrt{m-1}} \right)$$

In the formula, (m) represents the number of options, (ni) the total number of students choosing option I, (N) the total student response, (S) points/scores. ┌ and S are independent of each other and ┌ can have any value between 0-1. In this sense, the answers given by prospective teachers to SSCT were analyzed using the formulas mentioned first. In the second stage of the analysis, the model situations of the students were categorized by using the values obtained in the first stage. Bao's three-level coding was used to categorize students' answer status first (see. Table 2).

Table 2. *Three-level coding*

S	C	┌	Level
0~0,4	0~0,2	0~0.2	L
0,4~0,7	0,2~0,5	0.2~0.4	M
0,7~1,0	0,5~1,0	0.4~1.0	H

*L: Low, M: Medium, H: High

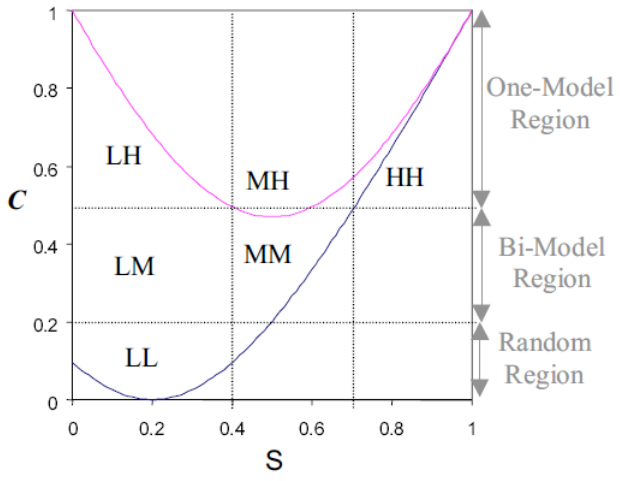
As seen in Table 2, there are three levels in the analysis as Low (L), Medium (M) and High (H). The meanings of the model states obtained from these coding levels are given in Table 3 below.

Table 3. *Students' possible model states categorization (Bao, 1999)*

	Model State	Description
1	**LL**	Students' answers are often the result of random guesses.
2	**LH**	The majority of students chose the same distractor.
	HH	The students showed good results regarding the concept.
3	**LM**	The answers are focused on two options, and both are wrong answers.
	MH	There are two non-popular models.
	MM	The answers are focused on two options, one of which is the correct answer. (Two popular models available)
	ML	There are two non-popular models.

Among the categories specified in Table 3, the 'null model' expressed as '1,' those expressed as '2' indicate that there is a single model, and those expressed as '3' indicate that there are two existing models. In addition, the information obtained about both the concentration factor and the scores within the scope of the study, the answers, and their categorization is also presented in a two-dimensional graph.

Graph 1. *Allowed region of the S-C Plot (Bao & Redish, 2001)*



As can be seen in Graph 1, the concentration scores are shown on the horizontal axis, and the concentration factor is shown on the vertical axis in the S-C chart. Then the answer to each question is shown in the graph in the form of dots. That is, each dot gives the mean result on a question from all students. However, the point to note here is that due to the limitation created by the relationship between scores and concentration, data points will not fall into all regions in the S-C chart. Accordingly, the classifications and graphs obtained by the analysis of the SSCT data are presented in the findings section.

Validity and Reliability

Measures taken in the study in order to minimize or completely eliminate the factors that threaten validity and reliability in the study are presented in Table 4.

Table 4. *Validity and Reliability Measures Taken in the Study*

Validity	**Internal validity**	Expert opinions
	External validity	Using purposeful sampling Explanation of the reason for the method used Explanation of the characteristics of the study group Explanation of the procedure Explanation of the data analysis process
Reliability	**Internal reliability**	Presenting the findings without comment
	External reliability	Detailed discussion of the data in the conclusion

The concept test prepared for use in the study was presented to expert opinions before the instruction to ensure the internal validity of the current study. The opinions of three faculty members were taken regarding the prepared test, and then a reader who was not related to the subject was asked to evaluate in terms of expression/understandability. In accordance with the data obtained from the relevant opinions, the test was re-examined in terms of clarity and suitability of the questions, and necessary corrections were made. In this sense, the internal validity of the research has been tried to be provided. In order to ensure external validity, which is defined as the generalizability of the research results (Yıldırım & Şimşek, 2011), the participants of the study consist of suitable individuals to contribute to the purpose of the study. In this sense, purposeful sampling was used. In addition, the research model, the study group, the implementation process including data collection, and data analysis, were described in detail.

In order to provide internal reliability regarding whether different researchers can reach the same results using the same data (Yıldırım & Şimşek, 2011), all of the findings of the study were presented to the reader without comment. All of the findings of the study were presented to the reader without comment in order to provide internal reliability regarding whether different researchers can reach the same results using the same data (Yıldırım & Şimşek, 2011). In this way, the external reliability of the study was tried to be increased.

FINDINGS

The Distribution of the Answers that the Prospective Science Teachers gave to SSCT before and after the Instruction

The concentration analysis results of the answers given by the prospective teachers in the pre-test SSCT are presented in Table 5 in terms of C and S.

Table 5. *The Model Situation of Prospective Teachers' Including pre-test Scores and Concentration Factor*

Question	S	C	Model (S&C)*
1	0,07	0,10	LL
2	0,27	0,02	LL
3	0,22	0,18	LL
4	0,05	0,40	LM
5	0,18	0,19	LL
6	0,53	0,29	MM

7	0,03	0,11	LL
8	0,33	0,13	LL
9	0,22	0,38	LM
10	0,36	0,08	LL
11	0,32	0,27	LM
12	0,60	0,37	MM
13	0,36	0,15	LL
14	0,16	0,21	LM
15	0,23	0,16	LL
16	0,44	0,17	ML
17	0,07	0,24	LM
18	0,18	0,06	LL
19	0,49	0,25	MM
20	0,33	0,09	LL
21	0,10	0,18	LL
22	0,22	0,15	LL
23	0,07	0,28	LM
24	0,08	0,13	LL
25	0,21	0,10	LL
26	0,48	0,23	MM

*L: Low, M: Medium, H: High

Table 5 shows the coding list of the pre-test created for all 26 questions in SSCT. When the S and C categorization is examined from the table, it can be seen that the answers of the prospective teachers are grouped into four categories. It is seen that there is Low-Low (LL) type modeling in prospective teachers in general of the questions, and Low-Medium (LM) type is common in six questions. The high number of LL types indicates that there is a tendency in favor of the common faulty model. It was determined that there was Medium-Medium (MM) type modeling in four questions in prospective teachers, that is, prospective teachers did these questions well, while it was determined that there was Medium-Low (ML) type modeling in one question. Which questions the pre-test S-C categorization covers and their percentages are given in Table 6.

Table 6. *Questions in Model Situations (pre-test S&C)*

Model (S&C)	Question(s)	%
LL	1, 2, 3, 5, 7, 8, 10, 13, 15, 18, 20, 21, 22, 24, 25	57,69
LH	-	0
HH	-	0
LM	4, 9, 11, 14, 17, 23	23,08
MH	-	0
MM	6, 12, 19, 26	15,38
ML	16	3,85

As can be seen in Table 6, approximately 58% of the answer models of prospective teachers in SSCT are in the null model state (LL), that is, close to the random response state. Approximately 23% of the answers indicated low scores with medium concentration (LM); 15.38% indicates medium concentration and medium score (MM). Regarding the 16th question, which reflects two unpopular models, it was observed that nearly half of the prospective teachers (n=32) chose the right option.

Concentration analysis results of the answers given by the prospective teachers in the post-test SSCT application are presented in Table 7 in terms of concentration factor and score.

Table 7. *The Model Situation of Prospective Teachers' Including post-test Scores and Concentration Factor*

Question	S	C	Model (S&C)
1	0,48	0,26	MM
2	0,99	0,97	HH
3	0,81	0,67	HH
4	0,16	0,26	LM
5	0,95	0,90	HH
6	0,96	0,93	HH
7	0,38	0,12	LL
8	0,58	0,36	MM
9	0,71	0,55	HH
10	0,96	0,93	HH
11	0,85	0,75	HH
12	0,86	0,76	HH
13	0,97	0,95	HH
14	0,78	0,63	HH
15	0,85	0,74	HH
16	0,74	0,60	HH
17	0,26	0,13	LL
18	0,53	0,28	MM
19	1,00	1,00	HH
20	0,62	0,38	MM
21	0,56	0,32	MM
22	0,78	0,63	HH
23	0,29	0,08	LL
24	0,18	0,05	LL
25	0,83	0,71	HH
26	0,78	0,62	HH

Table 7 shows the coding list of the post-test created for all 26 questions in the SSCT. When the S-C categorization is examined from the table, it can be seen that the answers of the prospective teachers are grouped into four categories. It was determined that prospective teachers showed High-High (HH) type modeling in the questions (in 16 questions). From here, it is understood that the candidates showed good results regarding the concept. In addition, it is seen that there is Medium-Medium (MM) type modeling in five questions (in 1., 8., 18., 20. and 21. questions) in prospective teachers, that is, two options are focused on (one of the options is the correct answer).

According to Table 7, it was determined that continued LL type modeling in four questions (in 7., 17., 23. and 24. questions). It is also seen that there is LM type modeling in one question (4. question). In this sense, it is understood that the answers are focused on two options and both are wrong answers. Which questions the post-test S-C categorization covers and their percentages are given in Table 8.

Table 8. *Questions in Model Situations (post-test S&C)*

Model (S&C)	Question(s)	%
LL	7, 17, 23, 24	15,38
LH	-	0
HH	2, 3, 5, 6, 9, 10, 11, 12, 13, 14, 15, 16, 19, 22, 25, 26	61,54
LM	4	3,85
MH	-	0
MM	1, 8, 18, 20, 21	19,23
ML	-	0

As can be seen in Table 8, approximately 62% of the pre-service teacher answer models in the post-test SSCT are in the correct model (HH). Approximately 19% of the answers indicate medium scores with medium concentration (MM), while 15.38% indicate low concentration and a low score (LL). It is seen that only 3.85% of the prospective teachers took part in the 4th question, where the answers were focused on two incorrect options. Regarding this question, it was determined that only a small portion of the prospective teachers (n=12) chose the right option.

The Distribution of the Wrong Answers that the Prospective Science Teachers gave to SSCT before and after the Instruction

The answers given by the prospective teachers in the pre-test SSCT are presented in Table 9 in terms of ┌ and S.

Table 9. *The Model Situation of Prospective Teachers' Including pre-test Scores and Concentration Deviation*

Question	S	┌	Model (S& ┌)
1	0,07	0,08	LL
2	0,27	0,03	LL
3	0,22	0,29	LM
4	0,05	0,42	LM
5	0,18	0,28	LM
6	0,53	0,25	MM
7	0,03	0,04	LL
8	0,33	0,19	LL
9	0,22	0,59	LH
10	0,36	0,04	LL
11	0,32	0,49	LM
12	0,60	0,26	MM
13	0,36	0,22	LM
14	0,16	0,29	LM
15	0,23	0,26	LM

16	0,44	0,13	ML
17	0,07	0,23	LM
18	0,18	0,09	LL
19	0,49	0,26	MM
20	0,33	0,12	LL
21	0,10	0,19	LL
22	0,22	0,23	LM
23	0,07	0,29	LM
24	0,08	0,11	LL
25	0,21	0,16	LL
26	0,48	0,18	ML

When the S-┌ categorization is examined in Table 9, it is noteworthy that the questions in high ┌ (in 4. and 9. questions) have significantly low scores (except question 11). It is seen that prospective teachers tend to choose the same distractor, as high ┌ indicates strong distractors. This is an indication that there are common faulty states.

When the categorization of the answers of the prospective teachers is examined, it is seen that 38.46% of them were in LL type modeling, and similarly, 38.46% have LM type modeling with low scores and concentration deviations. In addition, it was determined that there was an LH model type representing an alternative model situation in only one question (in 9. question) and the HH model case was not present in the pre-test results. Table 10 shows the choice distributions of the prospective teachers regarding the 4th and 9th items.

Table 10. *The Answers Given by the Prospective Teachers to the 4th and 9th Questions*

Question	a	b	c	d	e
4	4	46	3	16	4*
9	7	43	16*	3	2

*correct answer

As seen in Table 10, while the prospective teachers focused on similar distractors in the 4th question, they chose the same distractors in the 9th question. In addition, the answers to both questions were scattered over different options.

The analysis results of the answers given by the prospective teachers in the post-test SSCT in terms of scores and concentration deviation are presented in Table 11.

Table 11. *The Model Situation of Prospective Teachers' Including post-test Scores and Concentration Deviation*

Question	S	┌	Model (S& ┌)
1	0,48	0,32	MM
2	0,99	1,00	HH
3	0,81	0,26	HM
4	0,16	0,36	LM
5	0,95	0,58	HH
6	0,96	0,49	HM
7	0,38	0,11	LL
8	0,58	0,36	MM

9	0,71	0,66	HH
10	0,96	0,49	HM
11	0,85	1,00	HH
12	0,86	0,10	HL
13	0,97	0,41	HM
14	0,78	0,33	HM
15	0,85	0,49	HM
16	0,74	0,80	HH
17	0,26	0,22	LM
18	0,53	0,21	MM
19	1,00	-	-
20	0,62	0,21	MM
21	0,56	0,21	MM
22	0,78	0,31	HM
23	0,29	0,12	LL
24	0,18	0,08	LL
25	0,83	0,23	HM
26	0,78	0,21	HM

When the S-┌ categorization was examined in Table 11, there were high concentration deviations together with high scores in the 2nd, 5th, 9th, 11th, and 16th questions. When the data of these questions were examined (see Table 12), it was determined that most of the prospective teachers chose the right option, and the remaining part was distributed between one or at most two options. Staying on a single alternative option indicated a high concentration deviation.

Table 12. *The Answers Given by the Prospective Teachers to the 2nd, 5th, 9th, 11th, and 16th Questions*

Question	a	b	c	d	e
2	0	0	72*	0	1
5	1	0	69*	3	0
9	17	4	52*	0	0
11	0	62*	11	0	0
16	2	0	0	17	54*

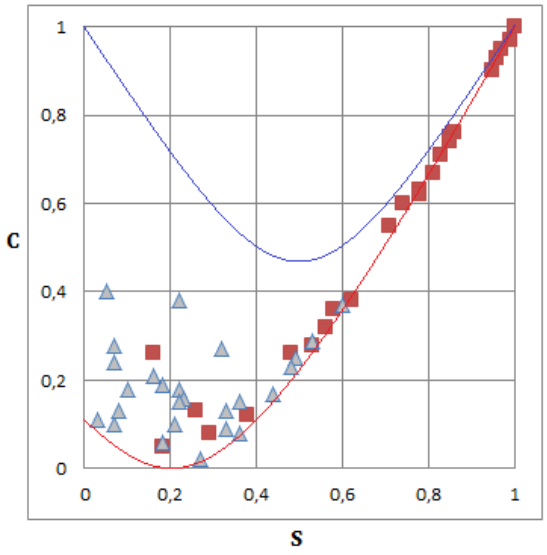
*correct answer

In addition, according to Table 12, it was determined that prospective teachers showed HM type modeling in nine questions, MM type in five questions, LL type in three questions, LM type in two questions, and HL type modeling in one question.

Graphic Presentations of the Answers Given by Prospective Teachers to SSCT

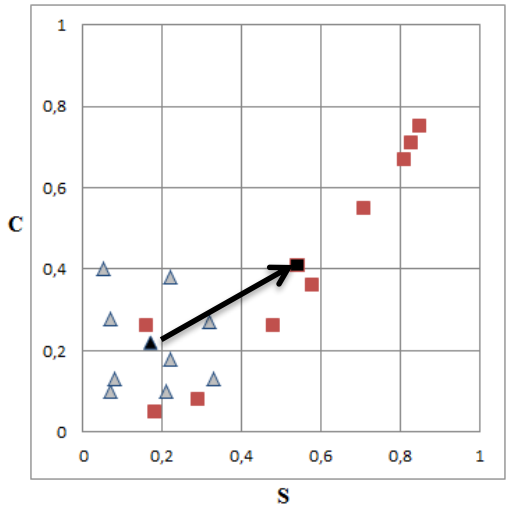
S-C and S-┌ graphics were used to present the obtained data in a visual format. These data obtained in line with the answers given to the SSCT are presented using symbols and signs on the graphics to show the pre-test, post-test, mean, and change. The graph showing the S-C change for the answers given by the prospective teachers in the pre-test and post-test SSCT application is given below.

Graph 2. *S-C Change Graph for 26 Questions in SSCT (△=pre-test, ■= post-test)*

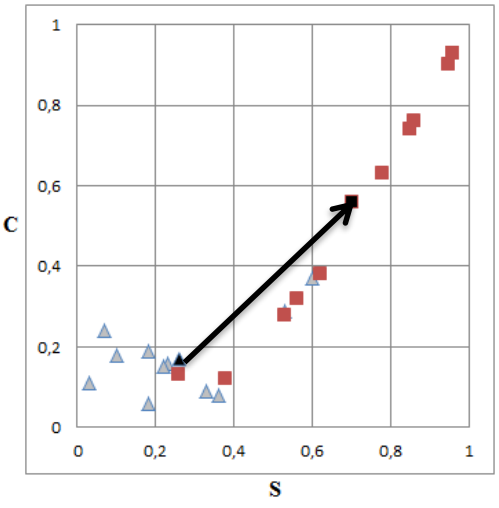


According to Graphic 2, while the prospective teachers showed intensity in the DD region in terms of their answers to the questions before teaching, it is seen that this situation shifted towards the HH region in the post-test. Also, it is understood that the concentration in the MM region continues in the pre-test and the post-test, and in this sense, the prospective teachers still concentrate on two options in some questions. Taking different concept groups into consideration, a detailed analysis of the questions in the groups on the prospective teachers' situations is presented in the graphs below.

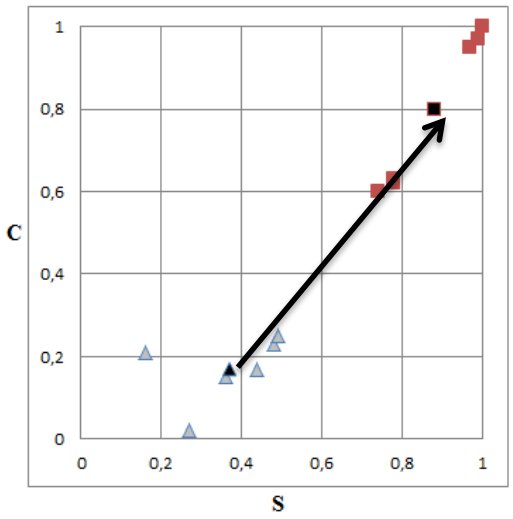
Graph 3. *S-C Graphs (△=pre-test, ■= post-test, ▲= pre-test average, ■= prost-test average) a) Identity of the Star Question Group; b) The Structure of the Star Question Group; c) The Life Cycle of the Star Question Group*



a)



b)

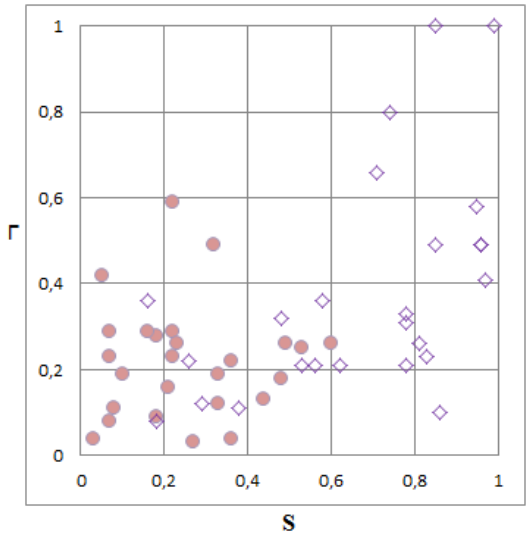


c)

As can be seen in Graph 3, prospective teachers were generally located in LL and LM regions in the pre-test for prospective teachers are quite low and they have strong alternative ideas. When the post-test status of prospective teachers after training is examined, it is seen that they were mostly located in the HH region, as well as in the MM and LM regions.

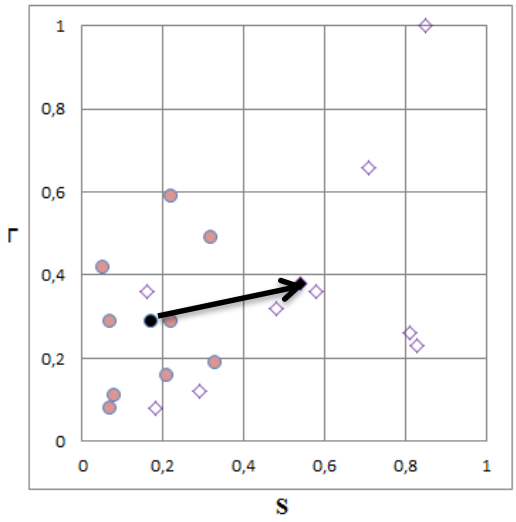
When looking at the changes in the pre-test and post-test means in Graphic 3 (indicated with an arrow in the graphic), while there was a shift towards the MM region in the 'identity of the star' question group; It is seen that there was a great change in the 'structure of the star' and the 'life cycle of the star' question groups, and in these question groups, there was more transition from LL type modeling to HH type modeling. The graph showing the S-┌ change for the answers given by the prospective teachers in the pre-test and post-test SSCT application is given below.

Graph 4. *S-┌ Change Graph for 26 Questions in SSCT (● =pre-test, ◇= post-test)*

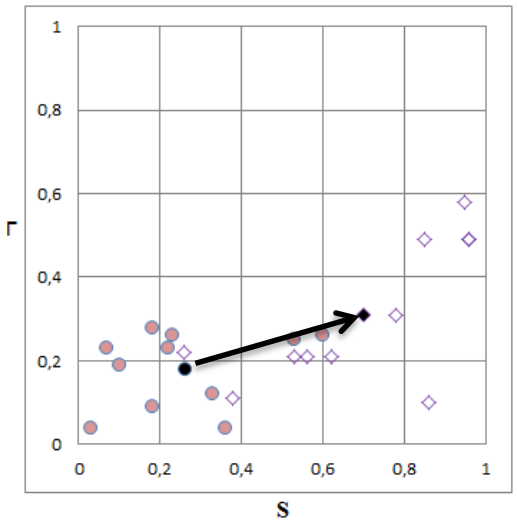


The S- ┌ draft in Graphic 4, in which the pre-test and post-test results are compared, is a good demonstration to examine the analysis of prospective teachers' behavior on incorrect answers. As can be seen in Graphic 4, it was determined that the pre-test and post-test ┌'s of prospective teachers were scattered, and in this sense, prospective teachers displayed quite similar false answers in their pre-test and post-test applications. When the groups of questions are considered, which questions are in favor of this situation are detailed in the graphics below.

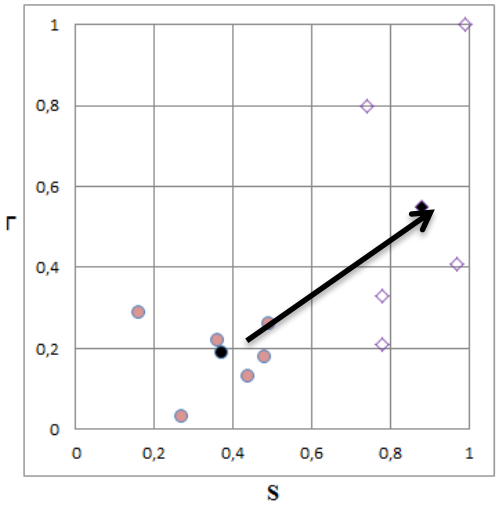
Graph 5. *S- ┌ Graphs (● =pre-test, ◇= post-test, (● = pre-test average, ◆= prost-test average) a) Identity of the Star Question Group; b) The Structure of the Star Question Group; c) The Life Cycle of the Star Question Group*



a)



b)



c)

As can be seen in Graph 5, in the pre-test for the 'identity of the star' question group, prospective teachers were generally found in LL and LM regions in terms of score and concentration

deviation. The pre-test scores of the prospective teachers were quite low and there was a tendency in favor of the erroneous dominant model. When the post-test situations of prospective teachers after teaching were examined, there was a scattered differentiation rather than a specific area. However, when looking at the change in mean (indicated by an arrow), there was a significant increase in post-test scores. To show this situation in more detail, the choice distribution for the third item in the test is presented in Table 13.

Table 13. *The Answers Given by Pre-Service Teachers to the Third Question*

	3rd Question					
Options	a	b*	c	d	e	Γ
pre-test	8	16	10	5	34	0,29
post-test	1	59	5	1	7	0,26

*correct answer

As can be seen in Table 13, the wrong answers of the prospective teachers, in other words, the alternative ideas they have in this sense, decreased significantly after the training. In other words, there was a significant change in the main distractors (the stars do not have a specific shape; the stars are in the form of a five-point star), while there was a tremendous increase in the correct choice. Similarly, in Graph 5, it is seen that prospective teachers in terms of score and concentration deviation were mostly at LL and then at LM region in the pre-test for the 'structure of a star' question group. It is seen that the pre-test scores of the prospective teachers were quite low, and they chose the answers containing different alternative ideas. When the post-test situations of the prospective teachers were examined, it was determined that they were concentrated in HM and MM regions. Also, there was a significant increase in the post-test scores of the 'structure of the star' question group.

In Graphic 5, it is seen that there was a distribution to different regions in the pre-test of the 'life cycle of the star' question group in terms of score and concentration deviation. Also, it was determined that the pre-test scores of the prospective teachers were low and medium, and they had low and the medium Γ's in terms of concentration deviation. When the post-test situations of prospective teachers after training were examined, it was determined that they were concentrated in HM and HH regions. The high level of all posttest scores for the 'life cycle of the star' question group indicates that there was a greater tendency towards correct answers for this question group. When Graph 5 is analyzed in terms of mean, it was determined that there was a change in terms of both score and concentration deviation, and the arrow has shown significant progress towards higher scores.

CONCLUSION, DISCUSSION AND RECOMMENDATION

With this study, it was aimed to obtain information about the modeling situations of the relevant subject by conducting the concentration analysis of the answers given by the science teaching senior students to the multiple-choice questions about the star. The results of the concentration analysis of the pre-test and post-test SSCT answers were first examined in terms of concentration factor (C) and score (S), and as a result, it was determined that the prospective teachers had LL type modeling throughout the questions in the pre-test. It was determined that MM type and ML type modeling is also present, while the excess of LL type modeling indicates that there was a tendency in favor of the common faulty model. In the post-test, it was determined that the

prospective teachers showed HH type modeling in the questions. After the teaching process, although some prospective teachers had MM type modeling, HH type modeling was predominant; therefore, it can be stated that the candidates showed good results for the star concept.

When the change in pre-test and post-test means was examined, it was seen that there was a significant change, but it was concentrated in the MM region. Besides, in the 23rd and 24th questions, staying in LL type modeling in the posttest affected the mean. Items 23 and 24 of the test are given below.

23. Which of the following is the most important characteristic of a star's existence and determines its future events?

a. Surface temperature

b. Size (diameter)

c. Color

d. Composition (type of atoms)

e. Mass

24. Which of the following is one of the features that determine the remaining life of the star?

a. Brightness

b. Temperature

c. Color

d. Mass

e. Chemical structure

In both questions, prospective teachers' focusing on the composition and chemical structure of the star caused their scores to be low; The distribution of other options also caused the concentration to be low. Similarly, it was seen that the prospective teachers were generally located in the LL region in the pre-test for the 'structure of the star' question group (see Graph 3). From here, it can be concluded that pre-test scores and concentration of prospective teachers are low and the answers contain randomness. Considering the post-test status of prospective teachers after training, it was determined that although they were mostly in the HH region, they were also in the MM region and stayed in the LL region in only two questions. When considering the change in pre-test and post-test means in the same graph (indicated by an arrow in the graph), it was determined that there was a significant change, and there was more transition from LL-type modeling to HH-type modeling in this question group (compared to the 'identity of the star' question group).

It was determined that prospective teachers were generally located in LL and MM regions in the pre-test regarding the 'life cycle of the star' question group (see Graph 3). In this sense, it was understood that prospective teachers were between two or more options, and these are generally options with alternative ideas. In addition, prospective teachers' indecision between different options caused the concentration factor to be low and medium. When the post-test situations of

prospective teachers after training were examined, it was concluded that all of them were in the HH region and that the prospective teachers showed good results regarding the specified concept group. When considering the change in pre-test and post-test means in the same graph (indicated by an arrow in the graph), it was determined that there was a significant change, and there was a greater transition from LL-type modeling to HH-type modeling in this question group compared to the other two question groups. In the study conducted by Bao (1999), when all the student answers to all 29 questions in the FCI test were categorized, it was seen that the student answers were grouped into seven categories in the pre-test, and modeling was present in HH, MH, MH, LM, and LH types. In the post-test, it was determined that there was a tendency towards high scores with high concentration. In this sense, the study supports that the concentration factor emphasized in the current study gives detailed information about the students. Dega (2012) determined that 90% of the student responses in the pre-test were in the LL model state or close to the random model state, in line with the results he obtained by using the concentration factor in his study on the concepts of electric potential and energy and electromagnetic induction. Also, it was stated that only 10% of the answers indicated the MC and MM status, and the students were in the medium-level model. Dega and Govender (2016), on the other hand, as a result of the study in which Ethiopian students' scientific and alternative concepts of energy and momentum was analyzed with the concentration factor, it was seen that the distribution of students' answers was generally of the LL model type, while 80% of Ethiopian students and 52% of US students represent the null model or random situation. Also, it was determined that 20% of Ethiopian students and 48% of US students represented a model situation, and none of these items were completely correct or as an alternative model. Previous studies and the present study show that the concentration factor goes beyond qualifying the prospective teachers' scores as low or high. The information about how the prospective teachers answered the question incorrectly cannot be reflected only by using scores (Bao & Redish, 2001). However, this information can be helpful clues to educators while planning the teaching.

When the responses of the prospective teachers in the pre-test and post-test SSCT application were examined in terms of score and concentration deviation, it was found that the questions in high ┌ had significantly low scores, and in this sense, prospective teachers tended to choose the same strong distractor. In the post-test, it was determined that most of the prospective teachers chose the right option; besides, there were also candidates with a distribution over one or two alternative options, which indicates a high concentration deviation. In this sense, the concentration deviation provides an important clue to get an idea about the distribution of prospective teachers' wrong responses. Distractors, described here as wrong answers, are not just a simple use of a word or a phrase but are designed to reflect the results of the candidates applying their own modeling (Bao & Redish, 2006). Concerning the concentration deviation, Dega (2012) found that 83.3% of the students' responses were in the null model state with low scores and low concentration deviation (LL). It was found that only 16.7% of the responses were in the middle model situation (LM, MM and MH). Besides, it has been determined that there was no correct single model case (HH) and no alternative model case (DH). In this sense, it is considered that it is important to evaluate the concentration deviation in order to obtain in-depth information on the distractors, rather than reaching a brief conclusion that "the number of correct answers is increasing or decreasing. In this regard, Bao (1999) states that in order to see a

complete picture of the problem, there is a need to see the problem from all possible angles and find and examine the information that best fits the purpose.

In Unat's (2011) study, one of the studies in the literature, it was determined that the prospective teachers had insufficient knowledge of the subject area of the unit "From the Stars to the Quasi-Stellars" and that they had various misconceptions. İyibil and Sağlam Arslan (2010), on the other hand, determined the mental models of the prospective teachers and stated that the candidates generally had mental models that were not compatible with scientific knowledge. Regarding the concept of the star in her study, in which İyibil (2010) examined the mental models of prospective teachers for basic astronomy concepts, it was seen that a significant portion of the candidates gathered at the level of understanding in the question about the definition, and when the drawings made by the candidates for the shape were examined, it was seen that the candidates were at the level of understanding. In addition, when the responses given to the question about the movement of the stars were examined, it was found that the pre-school and physics prospective teachers were at the level of not understanding, and the classroom and science prospective teachers were at the level of partial understanding; Candidates' responses to the question requiring an explanation of the reason for shining were generally at the level of partial understanding; regarding responses to the question about the atmosphere of the stars, the candidates were more likely to be unable to answer; It was determined that almost all of the candidates were at the level of not being able to answer the question about the structure of the star. As a result, it was determined that the candidates did not have scientific knowledge about stars, and there was no significant difference between the programs they studied for their level of understanding. It can be stated that these results are compatible with the current study result. The difference of the current study from other studies is that it is not a descriptive analysis but an analysis that includes concentration factor and concentration deviation.

As another finding, the presentation of the obtained score and concentration factors in two-dimensional graphs provides the opportunity to better examine the results of the model analysis. This situation, as stated by Ainsworth (2006), increases the comprehensibility of the information by presenting a situation/process in two or more ways, that is, its multiple representations. In the present study, the findings obtained from the score and concentration factor were presented with graphics, and it was determined that the prospective teachers showed concentration in the LL model in terms of their responses to all questions before the training. This situation shows that the responses given by the prospective teachers to the questions about the star were in the region of randomness where no dominant model was included. In the post-test, it was determined that this situation shifted towards the HH states, and the concentrations in the MM states continued in some questions. In this sense, it was found that after the training, the majority of prospective teachers were in an a-model zone representing a possible dominant model, while some prospective teachers were in a two-model zone where there were two possible popular models. When the questions were examined on the basis of question groups in order to examine this situation in detail, it was observed that the prospective teachers' pre-test responses in the life cycle question group of the star were in the region containing randomness; in this sense, the knowledge of the candidates on this subject has one or more alternative ideas before the training, and it is understood that no dominant model was included. However, in the post-test, it was noted that this situation completely shifted to a model region where a dominant model was located and that the candidates had sufficient post-teaching knowledge about the life cycle of

the star. In other words, prospective teachers showed good results in the post-test for the specified concept group. In the 'identity of the star' and 'structure of the star' question groups, it was determined that the pre-test answers of the prospective teachers were mostly in the random region with strong alternative ideas, but also in two dominant model regions. In the post-test, although there was a positive shift regarding the concept groups, it was determined that the mean of the 'structure of the star' question group was better than the mean of the 'identity of the star' question group. In this sense, prospective teachers' post-test modeling situations have been seen best in the 'life cycle of the star' question group (One-model region), then in the 'structure of the star' question group (One-model region), and finally in the 'identity of the star' question group (Two-model region). In the study by Bozdemir et al. (2018), it was determined that the posttest scores and concentrations of the answers given by the teacher candidates for some astronomy concepts increased to medium and high levels. In this sense, the results of the study on astronomy concepts are similar to the current study.

In order to obtain information about the wrong responses given by the prospective teachers, the S- ┌ draft was created and analyzed. As a result, it was determined that the ┌ showed a rather scattered spread in the pre-test; low scores were found together with low and middle ┌, while three questions had high ┌. In the post-test, it was determined that the ┌ spread quite scattered as in the pre-test. However, it has been determined that the post-test includes high scores with low and middle ┌, and in this sense, prospective teachers show a change in favor of the correct answer. In addition, it was observed that there were high ┌ in eight questions. In this context, it can be stated that prospective teachers tend to choose the same distractor, as high ┌ indicate strong distractors. This situation may also be a reflection of the answers generated by erroneous student models (Bao, 1999).

When the S- ┌ draft was examined in terms of question groups, it was determined that the ┌ showed a scattered spread despite the increase in the post-test scores of the 'identity of the star' question group compared to the pre-test scores. In the 'structure of the star' question group, based on the ┌'s, it was observed that the prospective teachers were not inclined to choose strong distractors in most of the questions and concentrated on more than one distractor. In addition, it was determined that there were also candidates in three questions who showed a distribution over one or two alternative options, and this situation indicated a high concentration deviation. In the 'life cycle of the star' question group, the answers to the post-test showed a significant change in terms of both score and concentration deviation according to the answers given to the pre-test, and with the increase of the scores in the post-test, since a few of the prospective teachers concentrated on a single distractor caused high ┌'s to be included in the graph together with low ┌'s. Redish (2001) stated that the most important advantage of the S- ┌ graphs is that the ┌s are not affected by the scores; since the concentration factor is greatly affected by the scores, more information can be obtained about the wrong answers from the S-C graph. Bao (1999) also created the S- ┌ graph of the pre and post data of 29 questions in the FCI in his study, and as a result, he stated that the final ┌ of the students was quite scattered as in the pre-application data; therefore, the students displayed quite similar wrong answer situations in the pre and post applications.

In general terms, it is seen that these calculations obtained in order to evaluate the modeling of the prospective teachers regarding the star concept and to interpret the distribution of the

answers in detail, based on the relations between the concentration factor, scores and concentration deviation, have important meanings. At the same time, this part of the model analysis provides a quantitative evaluation opportunity to evaluate the modeling of prospective teachers before the current teaching, to evaluate the effectiveness of the current teaching and to see the change in modeling situations, in this sense, the results of similar and different studies will be obtained with the same analysis method. It is possible to say that it will contribute to educators and researchers. Besides, researchers can examine the development of students/pre-service teachers by analyzing their modeling situations by using different teaching methods (for example, technology based education for the concept of star).

In this study, while analyzing multiple-choice questions, not only the right options but also the wrong options were analyzed, and it was seen that the wrong options provided important clues for the educators. In this sense, researchers should not forget that multiple-choice tests are no longer a simple test of success or concept, that only those who choose the right option know the right thing, and that distractors can be options that those who know the right way can turn to.

REFERENCES

Agan, L. (2004). Stellar ideas: exploring students' understanding of stars. *Astronomy Education Review 3*(1), 77-97.

Ainsworth, S., (2006). DeFT: A conceptual framework for considering learning with multiple representations. *Learning and Instruction, 16,* 183-198.

Bailey, J. M. (2006). *Development of a concept inventory to assess students' understanding and reasoning difficulties about the properties and formation of stars*. PhD dissertation, The University of Arizona, Tucson, AZ, USA.

Balcı, A. (2013). *Sosyal bilimlerde araştırma: Yöntem, teknik ve ilkeler* (10. Baskı). Pegem Akademi.

Bao, L. (1999). *Dynamics of student modeling: A theory, algorithms, and application to quantum mechanics.* PhD. Dissertation, University of Maryland, Maryland.

Bektaşlı, B. (2014). In-service science teachers' astronomy misconceptions. *Mediterranean Journal of Educational Research, 15*,1-10.

Bao, L., & Redish, E. F. (2001). Concentration analysis: A quantitative assessment of student states. *American Journal of Physics, 69*(7), 45-53.

Bao, L., & Redish, E. F. (2006). Model analysis: Representing and assessing the dynamics of student learning. *Physical Review Special Topics-Physics Education Research, 2*(1), 010103, 1-16.

Bolat, M., & Altınbaş, A. (2014). *Ben de astronomi öğreniyorum*. XI. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi'nde sunulmuş bildiri, Adana.

Bozdemir, H., Ezberci Çevik, E., Candan Helvacı, S., & Kurnaz, M. A. (2018). Fen bilgisi öğretmen adaylarinin bazi astronomi kavramlarina yönelik alternatif fikirlerinin incelenmesi. *Trakya Eğitim Dergisi*, *8*(4), 808-821.

Comins, N. F. (2001). *Heavenly errors: Misconceptions about the real nature of the universe.* Columbia University Press.

Çepni, S. (2012). *Araştırma ve proje çalışmalarına giriş* (6. Baskı). Celepler Matbaacılık.

Dega, B. G. (2012). *Conceptual change through cognitive perturbation using simulations in electricity and magnetism: a case study in ambo university, ethiopia.* Doctoral Thesis, University of South Africa, Africa.

Dega, B. G., & Govender, N. (2016). Assessment of students' scientific and alternative conceptions of energy and momentum using concentration analysis. *African Journal of Research in Mathematics, Science and Technology Education, 20,* 201-2013.

Emrahoğlu, N., & Öztürk, A. (2009). Fen bilgisi öğretmen adaylarının astronomi kavramlarını anlama seviyelerinin ve kavram yanılgılarının incelenmesi üzerine boylamsal bir araştırma. *Ç.Ü. Sosyal Bilimler Enstitüsü Dergisi, 18*(1), 165–180.

Ezberci Çevik, E. (2018). *Fen bilgisi öğretmen adaylarinin yıldız konusundaki temellendirilmiş zihinsel modellerinin matematiksel algoritmalar yoluyla incelenmesi.* Doktora Tezi, Kastamonu Üniversitesi, Kastamonu.

Ezberci Çevik, E., & Kurnaz, M. A. (2016), Türkiye'de yıldızlarla ilgili yapılan bazı çalışmaların tematik incelenmesi. *İlköğretim Online, 15*(2), 421-442.

Fraenkel, J. K., & Wallen, N. E. (2006). *How to design and evaluate research in education* (6th ed.). McGraw-Hill, Inc.

Göncü, Ö., & Korur, F. (2012*). İlköğretim öğrencilerinin astronomi temelli ünitelerdeki kavram yanılgılarının üç aşamalı test ile tespit edilmesi.* X. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi'nde sunulmuş bildiri, Niğde.

Harman, G. (2012). *Fen bilgisi öğretmen adaylarinin model ve modelleme ile ilgili bilgilerinin incelenmesi*. X. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, Niğde.

Heyer, I. (2012). *Establishing the Empirical relationship between non-science majoring undergraduate learners' spatial thinking skills and their conceptual astronomy knowledge.* Doctoral thesis, The University of Wyoming, USA.

İyibil, Ü.G. (2010). *Farklı programlarda öğrenim gören öğretmen adaylarının temel astronomi kavramlarını anlama düzeylerinin ve ilgili kavramlara ait zihinsel modellerinin analizi.* Yüksek Lisans Tezi, K.T.Ü. Fen Bilimleri Enstitüsü, Trabzon.

İyibil, Ü., & Sağlam Arslan, A. (2010). Fizik öğretmen adaylarının yıldız kavramına dair zihinsel modelleri. *NEF-EFMED, 4*(2), 25-46.

Kalkan, H., Ustabaş, R., & Kalkan, S. (2007). *İlk ve orta öğretim öğretmen adayı öğrencilerinin temel astronomi konularındaki kavram yanılgıları*. VII. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi Özetler Kitabı, s. 356.

Kaplan, G. & Çifçi Tekinarslan, İ. (2013). Zihinsel yetersizliği olan ve olmayan öğrencilerin astronomi kavramlarindaki bilgi düzeylerinin karşılaştırılması. *İlköğretim Online, 12*(2), 614-627.

Kurnaz, M. A. (2012). Yıldız, kuyruklu yıldız ve takımyıldız kavramlarıyla ilgili öğrenci algılamalarının belirlenmesi. *AİBÜ Eğitim Fakültesi Dergisi, 12*(1), 251-264.

Küçüközer, H., Küçüközer, A., Yüzümezoğlu, K., & Korkusuz, M., E. (2010). Elementary school students' conceptions regarding astronomical phenomena. *e-Journal of New World Sciences Academy, 5*(1), 521-537.

Philippi, K. H. (2010). *An examination of student understanding of the use of models in science and conceptual understanding of electricity and magnetism.* University of New Orleans Theses and Dissertations. 1114, USA.

Şensoy, A. (2012). *Temel astronomi kavramlarının çeşitli değişkenler açısından incelenmesi*. Yüksek Lisans Tezi, Ondokuz Mayıs Üniversitesi, Eğitim Bilimleri Enstitüsü, Samsun.

Temizkan, M. & Sallabaş, E. (2011). Okuduğunu anlama becerisinin değerlendirilmesinde çoktan seçmeli testlerle açik uçlu yazili yoklama sorularinin karşilaştirilmasi. *Dumlupınar Üniversitesi Sosyal Bilimler Dergisi, 30,* 207-220.

Trumper, R. (2006). Teaching future teachers basic astronomy concepts —seasonal change—at a time of reform in science education. *Journal of Research in Science Teaching, 43*(9), 879-906.

Türkoğlu, O., Örnek, F., Gökdere, M., Süleymanoğlu, N., & Orbay, M. (2009). On pre-service science teachers' preexisting knowledge levels about basic astronomy concepts. *International Journal of Physical Sciences, 4*(11), 734-739.

Unat, O. (2011). *Fizik öğretmen adaylarının yıldızlardan yıldızsılara ünitesine ilişkin pedagojik alan bilgilerinin değerlendirilmesi.* Yüksek Lisans Tezi, Marmara Üniversitesi, Eğitim Bilimleri Enstitüsü, İstanbul.

Yıldırım, A., & Şimşek, H. (2011). *Nitel araştırma yöntemleri* (18. Baskı). Seçkin Yayınevi.