Examining pre-service science teachers' diagnostic question preparation skills on Seasons, climate, and weather movements

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Abstract

For meaningful learning to take place and to eliminate misconceptions, it is necessary to identify the process of conceptual change on any given topic. The research aims to examine the skills of science teacher candidates to prepare two-stage diagnostic questions on 'Seasons, Climate and Weather Movements'. For this purpose, the research was carried out in 4 weeks with 40 (39 females, 1 male) second-grade science teacher candidates in the fall semester of the 2019-2020 academic year, using the holistic single-case study pattern of the 'Observation-Based Case Study'. Tests prepared by pre-service teachers were applied to eighth-grade students. The 'Diagnostic Test Preparation Rubric' was collected using "Concept maps", "Open-ended two-stage tests" and "Multiple choice two-stage tests". As a result of the descriptive and content analysis, it was noticed that teacher candidates are usually at an intermediate and good level in determining the propositions of knowledge about the subject, developing a concept map, and a two-stage diagnostic test related to the subject content.

Keywords: Diagnostic questions; science teacher candidates; seasons; climate; weather movements

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1. Introduction

A concept is "the expression of the properties of similar or different objects or events that have common characteristics in a single word" (Çaycı, 2007). In other words, "they are the names given to this class as a result of the classification of any events, objects, and thoughts". The way to access information healthily is possible with the correct acquisition of the concepts that form the basis of the information (Çaycı, 2007). Therefore, it is important to find out what information students come to classes within order to gain new information from the information they have gained from their previous experiences (Lemerise & Arsenio, 2000).

In recent years, many studies have been conducted focusing on the identification and correction of different concepts that occur outside of scientific information (Caleon & Subramaniam, 2010; Çardak, 2009). These non-scientific concepts can be called prejudices, naive theories, alternative concepts, and misconceptions, and students develop these concepts as a result of their own lives (Çardak, 2009). These misconceptions are a serious obstacle to the correct learning of concepts whose accuracy has been scientifically proven. In particular, the fact that science courses contain abstract concepts leads to the formation of misconceptions in students (Akgun, Gönen & Yılmaz, 2005).

Defining misconceptions is the first step for better science teaching and learning (Yip, 1998). Students may have had an idea about some concepts before coming to science classes (Amir and Tamir, 1994). One of the most challenging situations for teachers is that students have difficulty portraying abstract concepts in their minds (Şenel & Güngör, 2009). At this point, one of the most important goals of science education is to provide permanent and meaningful learning by associating scientific concepts with the concepts existing in students (Bozdag, 2017). So, the student's concepts to the students with concepts should not be a conflict between the desired. When there is a contradiction between these concepts, there will be a conflict in the cognitive structure of the student. For meaningful learning to take place and to eliminate misconceptions, it is necessary to identify and replace false information, that is, to experience a process called the process of conceptual change (Smith and Seda, 2007).

The most important step in eliminating misconceptions in science is for teachers to determine the correct teaching method that will correct the misconception (Güneş et al., 2010). Various teaching methods and tools have been developed that will best reveal the mental structure of students. Of these, multiple-choice tests have the most widespread use as an assessment tool. Other evaluation tools are used to determine alternative concepts; concept maps (Novak and Govin, 1993), interviews (Osborne and Gilbert, 1980), prediction-observation-explanation (Liew driver, 1998), V diagrams (Novak & Gowin, 1993), word association (Gussarsky, & Gorodetsky, 1990), multiple-choice tests (Kopp, 1989) is listed as.

1.1. Literature review

1.1.1. Multiple Choice Tests

Multiple-choice tests are tests with high validity because they allow a large number of questions to be asked in a short time (Karataş, Kose and Coştu, 2003). It is accepted that there are limitations in determining whether a student gives a correct answer consciously or by chance in multiple-choice exams (Duit and Treagust 1998; Çetin-Dindar and Geban, 2011; Anam, Widodo, Sopandi and Wu, 2019). This limitation interviews that can be done to reduce students ' alternative concepts and to understand how they provide more detailed information about determining a particular concept, even if a large number of people applying is time-consuming (Montfort, Brown and Findley, 2007). Therefore, to

strengthen the advantages of multiple-choice tests, which are the most convenient way for a large number of students to practice, progressive tests have been proposed (Caleon and Subramaniam, 2010).

Progressive Tests: To reduce the disadvantages of multiple-choice questions, two-stage tests were first developed, and then three-, four-, five- and six-stage tests.

Two-stage tests: Although they are similar to multiple-choice exams in terms of structure, the reason for choosing such tests is that they allow students to explain the reasons for their answers (Uyulgan, Akkuzu, and Alpat, 2014). In this tool, the first layer of each item consists of a content question consisting of several options. The second part of each item contains the reasons for the answers given to the first part and this part is the part that distinguishes two-stage tests from multiple-choice tests (Karataş, Köse, and Coştu, 2003). In this context, two-stage tests provide researchers with an opportunity to make sense of whether an incorrect response to the first layer of an item is due to a misunderstanding and whether a correct response to the first layer is due to students understanding the scientific concept (Peshman and Eryilmaz, 2010). That is, the student must have fairly clear (far from misunderstandings) information to get the right answer (Uyulgan, Akkuzu, and Alpat, 2014). The second stage of the test can be created as an open-ended or multiple-choice test based on open-ended questions, misconceptions stated in the literature on the subject, and student misconceptions identified as a result of interviews. The two-stage test types are given in Table 1 (Karataş, Köse, and Coştu, 2003).

Table 1

Types of two-step tests

Types of two-step tests	1. Stage I	2. Stage II
1. Multiple choice two-step tests	3. Multiple choice	4. Multiple choice (+ Open-ended)
2. Two-step tests that require classification	5. Right- False	6. Multiple choice (+ Open-ended)
3. Open-ended two-step tests	7. Multiple choice	8. Open-ended

In addition, the validity and reliability of two-stage tests are higher in terms of reducing the chance success factor in multiple-choice tests (Özbayrak and Kartal, 2012). Treagust (1988), who proposed the development of two-stage tests, has collected these stages under 3 headings and sorted them into ten digits. These titles are; (Karataş, Köse, and Coştu, 2003) are given in Table 2.

Table 2

Two-step test development stages

Determination of Content	Learning About Students' Misconceptions	Development of Diagnostic Testing
1)Determination of information propositions	5) Examination of the relevant literature	8) Developing a two-step diagnostic test
2)Development of the concept map	6)Realisation of unstructured student interviewsRealisation of unstructured student interviews	9) Creation of the token table
3)Associating and including information propositions in concept maps	7) Development of multiple-choice test materials with open-ended justification	10)Maintaining regulations maintaining regulations
4)Ensuring scope validity		

Three-Stage Tests: The weakness of the two-stage tests mentioned above can be significantly remedied by including a third level in the confidence rating questions, which measures the level of confidence participants have in their answers in the first two levels (Caleon and Subramaniam, 2010). Through the third layer, a misunderstanding and a lack of information can be distinguished (Peshman

and Eryilmaz, 2010). Although the method followed in the development of three-stage tests is the same as the development of two-stage tests, in addition, students are asked how confident they are in the answers they have given. As a result, a three-layer test is only a two-layer test, except for an October layer that asks students if they are confident in their responses to the first two layers (Peshman and Eryilmaz, 2010).

Four-Stage Test: Although it is believed that technical errors and errors, as well as a lack of knowledge, have passed three-level tests, there are still some limits (Kaniawati, et al., 2019). In this context emerged the four-step test; experiment, the second tier, the first tier ba trust the answer; the first layer, the third layer ISE justify your answer on whether the attempt; and the fourth phase of the trial, the third (reasoning) in the stage of trust, the answer is ba (Caleon & Subramania 2010a; Kaltakci-Gurel, Eryilmaz, and McDermott, 2017; Anam, Widodo, Sopandi and Wu, 2019).

Five-Stage and Six-Stage Tests: Four-layer tests include a "drawing" layer that allows students to provide more detailed information about a phenomenon or concept, although they can more clearly identify misconceptions and support students' progress in learning (Anam et al. 2019). The researcher can conclude intuitively from the drawings drawn by the students, but since he cannot predict the degree to which the student believes in this information, the last layer represents the students' beliefs in this regard.

1.2. Related studies

When the literature is examined, with the teacher candidates the ability to ask questions according to bloom's taxonomy often work toward evaluation' were on (Koray, Altuncekic and Yaman, 2005; Aydemir and Farmer, 2008; Ozcan and Akcan, 2010; Karaman, 2018). Studies often test for identifying a specific topic (article, acid-base, cellular respiration, ecological footprint, electricity, wave mechanics, force, and motion). Test is understood to be aimed at developing (Pesman and Eryılmaz, 2009; Caleon & Subramania, 2010; Cetin-Dindar and Geban, 2011; Parker et al., 2012; Kirbulut and the geban, 2014; Gürel and Eryilmaz, 2015; Özden and Yenice, 2017; Kaltakci-Gurel, Eryilmaz, and McDermott, 2017; Liampa et al., 2019; Hunter et al., 2018; Anam et al., 2019).

In addition, the seasons (Atwood and Atwood, 1997; Doğar and Başıbüyük, 2005; Salierno, Edelson and Sherin, 2005; Alkış, 2006; Küçüközer, 2008; Küçüközer and Bostan, 2010) were used by Atwood and Atwood, 1997, Dogar and Başıbüyüközer, 2010, Boesdorfer, Lorsbach, and Morey, 2011, Gooding and Metz, 2011, Bloody, 2014, and Bolat, 2018. Climate and air movements were studied by Alkis, 2006, Demirkaya, and Tokcan, 2007, Harrington, 2008, Kelleci, 2014, Malleus, and Kruus, 2016. It is understood that studies are available to determine misconceptions (Emli & Afacan, 2017).

This study is important both for determining the diagnostic question preparation skills of prospective teachers and for providing an idea about misconceptions about 'Seasons, Climate and Weather Movements.' Since no similar study has been found in the literature, it is thought that this study will contribute to filling the gap in the literature.

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1.3. Purpose of the study

This study aims to examine in detail the skills of pre-service science teachers to prepare two-stage diagnostic questions. The problem of the research is 'How are the skills of science teacher candidates to prepare two-stage diagnostic questions? it has been determined as 'and in this direction, the answers to the following sub-problems have been sought:

1. What is the situation of pre-service teachers when creating diagnostic test content, determining the propositions on the subject, and preparing a concept map?

2. 8th grade of pre-service teachers. how are the situations of developing an open-ended two-stage test item by investigating the misconceptions and misconceptions of students in the classroom?

3.8th grade of pre-service teachers. how are the situations of developing multiple-choice two-stage test items from them, using the misconceptions and misconceptions of classmates?

2. Materials and Method

2.1. Data collection method

A case study, one of the qualitative approaches, was used in the research. The case study is a qualitative approach based on the collection of detailed data on specific situations in real life with multiple sources of information such as documents, interviews, and observations, and aims to present themes for the situation by describing the current situation (Creswell, 2013). Case studies can be classified as Observation-Based Case Study, Life History, Documents, Case Studies Examining the Past of Organizations, Case Analysis, Microethnography, Multi-Case Studies, and Comparative Case Studies (Bogdan & Biklen, 1998; Aytaçlı, 2012). In this study, 'Observation-Based Case Study' was used because it allows participant observation, which is accepted as a primary data collection tool and provided by document analysis, to be used in school environments. The situation examined in the research; two-stage diagnostic test preparation skills of prospective science teachers. The unit of analysis is science teacher candidates.

2.2. Research Design

A research pattern is an action plan used to correlate questions, data, and findings of a study. Its main task is to be able to create answers to questions without deviating from the roadmap when searching for answers to research questions . In general, a case study can have one of four types of patterns: a holistic single state, a nested single state, a holistic multiple states, and a nested multiple state pattern . In this study, a single analysis unit (individual, school, program, etc.) that can be used to test a method or theory is used.) a holistic single-state study pattern was used that allowed working on it. Eight stages can be followed when conducting a case study. In this study, the analysis unit and the situation to be studied were determined by developing research questions and sub-problems primarily, and after determining the individuals to participate in the research, the data were collected and related to the sub-problems. After data analysis and interpretation, the case study was reported. The research pattern is given in Figure 1.

Figure 1

Research Pattern
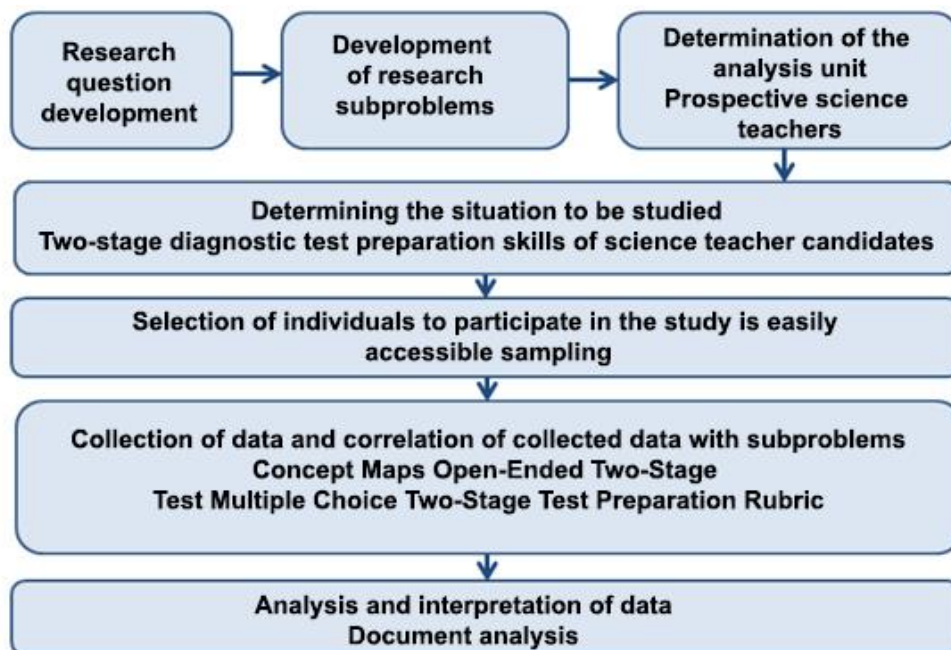
2.3. Participants

It was carried out with 40 (39 girls, 1 boy) second-year science teacher candidates in the 2019-2020 academic year. In the first stage of the test development process, the "test questions" consisting of the stages consisting of people from the "one-stage" exams should be chosen from 40 eighth grade courses, and "two-choice exam questions" from 60 eighth grade.

2.4. Data Collection Tools

Data collection tools used in the study; concept maps are multiple-choice test questions with an open-ended justification, two-step diagnostic test questions, and diagnostic test preparation.

2.4.1.   Diagnostic Test Preparation Rubric

There are 7 evaluation criteria in the rubric created by the researchers to evaluate the test preparation stages of the teacher candidates. The evaluation criteria are based on the ten-digit method proposed by Treagust (1988) for the development of two-stage tests. It is given in Rubric Figure 2.

Figure 2

 Diagnostic Test Preparation Rubric

Main stages	Lower stages	Good	Middle	Weak
Development of content	1. Determination of information propositions on the subject			
	2. Development of a concept map related to the subject content			
	3. Associating information propositions with concept maps and including them in the			
	4. Ensuring the validity of the scope			
Obtaining information about students' misinterpretations	5. Examination of the relevant literature			
	6. Development of multiple-choice test items, the justification part of which is open-ended			
Development of diagnostic testing	7. development of a two-stage diagnostic test			

2.4.2. Concept maps

Teacher candidates' 'Seasons' (Group 6) and 'climate and air movements' (Group 4) topics in the concepts given to them in groups with (Group 10) prepared from the premise that the concept maps are created and then prepared together has been incorporated in all the groups.

2.4.3. The open-ended two-stage test questions

Approximately 3 open-ended multiple-choice questions have been prepared using Teacher candidates' issues as part of the justification of propositions and concepts given in the literature misconceptions prepared from individual 'Seasons' and 'climate and air movements'. Then, the questions were reviewed by the researchers, and a 17-question multiple-choice test consisting of open-ended questions with justification was created under the guidance of the researchers.

2.4.4. Multiple Choice Two-Stage Test Questions

Eight (8) of the open-ended two-stage multiple-choice test questions were created for use by teacher candidates in the second stages of the tests, by determining the misconceptions obtained as a result of their application to grade students (n=40). The questions were examined by the researchers and 1 question was removed from the test and the 16-question two-stage test was completed. It was applied to eighth-grade students (n=60).

2.5. Procedure

2.5.1. Development of Content

In the content development section; 8. the topics of the class 'Seasons' and 'Climate and Weather Movements' were selected, and the content limit was determined. When the achievements of the current Science Education Program were examined, it was seen that there were three achievements related to them and there were eight related topics and concepts. After the literature review, 27 concepts related to the topic of 'Seasons' and 70 concepts related to the topic of 'Climate and Weather Movements' were included in the study. The subject propositions written by pre-service teachers were related to these concepts and concept maps were created.

### 2.5.2. Obtaining Information About Students' Misconceptions

By examining the misconceptions in the literature by the groups, the first draft of the test was developed with open-ended two-stage questions. The test studied by experts is 8. it was applied to grade students (n=40).

2.5.3. Development of Diagnostic Testing

The answers received from the students were examined by the pre-service teachers and the teachers were determined for the second stage of the test. The final version of the given test is 8. it was applied to grade students (n=60). The application steps of the study conducted with pre-service teachers are given in Figure 3.

Figure 3

Application Steps
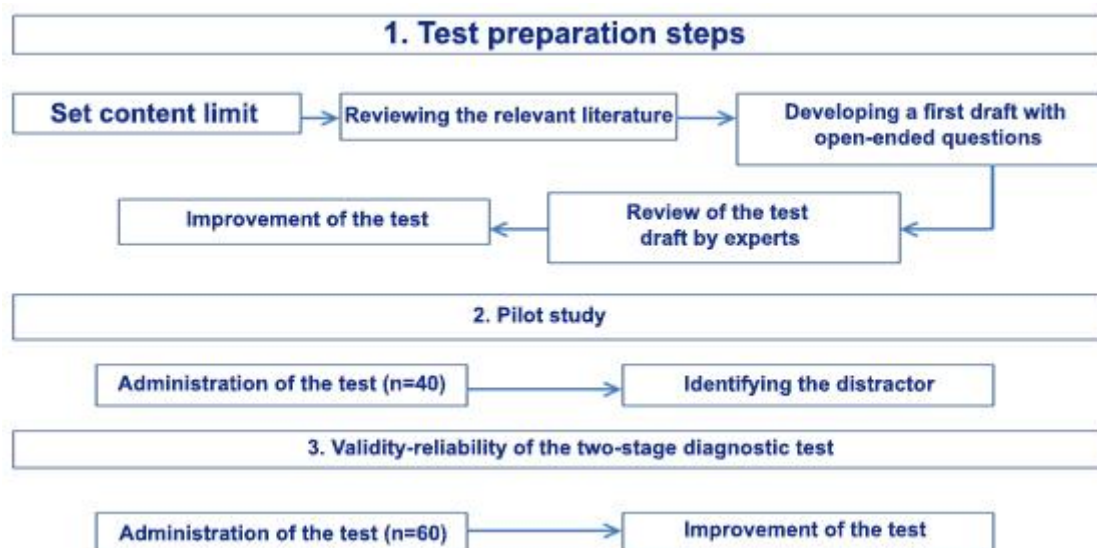
2.6. Data Analysis

In the case study, the analysis can be done with a detailed description of the situation (Creswell, 2013). For this reason, the data obtained from the participant observations and documents were analyzed using descriptive and content analysis. Diagnostic Test Preparation Rubric scoring criteria from data collection tools are given in Table 3.

Table 3

Diagnostic Test Preparation Rubric and Scoring Criteria

Diagnostic Test Preparation Rubric Scoring Criteria				
Main stages	**Lower stages**	**Good**	**Middle**	**Slim**

	1. Determination of information recommendations on the subject	Correct spelling of propositions	The partial spelling of propositions	-The premise that two concepts are bound by one judgment -Inaccurate proposition -Proposition with missing information -The premise that binds the two judgments
Development of content	**2.** Development of the concept map related to subject content	Concept map score (67 points for groups working on 'Seasons'; 121 points) for groups working on 'Climate and Weather Movements'	Concept map score (57-67 points for groups working on 'Seasons'; 112-121 for groups working on 'Climate and Weather Movements'puanarası) medium	57 points for groups that work on the concept map score(Seasons); Low 112 points for groups working on 'Climate and Weather Movements'
	3. Associating and including information propositions in concept maps	Inclusion of all information propositions in the concept map	Partial inclusion of information propositions in the concept map	Information propositions are inaccurate or under-included in the concept map
	4. Ensuring scope validity	From 20 concepts on seasons, Making more than 35 concepts of 'Climate and Weather Movements'	Seasons' 15-20 concepts, Associating between 30-35 concepts on 'Climate and Weather Movements'	'From 15 concepts on the 'seasons', Less than 25 concepts of 'Climate and Weather Movements'
	5. Examination of the relevant literature	The number of multiple-choice questions prepared in the second stage with an open end is more than 3	Prepare three second-stage open-ended multiple-choice questions	The number of multiple-choice questions prepared in the second stage with an open end is less than 3
Learning about students' misunderstandings	**6.** Development of multiple-choice test materials with open-ended justification	Allow explaining why you selected the option	Partially explain why you selected the option	Do not allow explanation because the proposition is incorrect when developing the option
Development of diagnostic testing	**7.** Development of two-stage diagnostic testing	Strong temptation	Moderate level of stirs	Weak temptations

Concept maps, on the other hand, were read using the structural scoring method created by Novak and Gowin (1984). Propositions, concepts, hierarchies, cross-relations, and examples in a total of ten concept maps have been identified. Maps were read and the total score was calculated by giving 1 point for each correct concept, proposition, and example, 5 points for each correct hierarchy, and 10 points for each correct cross-relationship. An average score was determined separately between the groups working on the topic of 'Seasons' and the topic of 'Climate and Weather Movements' and a dec rating was made. When determining the rating score, +/- 5 points of the average score were taken into account above and below. The average concept map score (sum of concept, proposition, hierarchy, cross-relationship, and the number of examples points) for 'seasons' is 62. a score of 67 or higher was

determined as good, a dec of 57-67 was determined as a medium, and a score of 57 was determined as poor. As for the 'Climate and Weather Movements', the average concept map score is 117. 112 points were rated as poor, 112-121 points were rated as dec, and 121 points were rated as good.

3. Results

The findings of the research were examined under three headings: the development of content for child problems, the acquisition of information about students' misunderstandings, and the development of a diagnostic test.

3.1. Findings on the Development of Content

How is the situation of determining the propositions related to the subject and preparing a concept map when creating the diagnostic test content of prospective teachers, which is the first subproblem of the research? The propositions and concept maps prepared by the groups for the 'question' were examined. The sub-themes, codes, and examples of the theme of determining information propositions related to the topic at the stage of content development are presented in Table 4.

Table 4

The Sub-themes, codes, and examples of the theme of determining information propositions related to the topic

Theme	Bottom his	At	Example
Determination of information proposals on the subject	Good		• The branch of science that studies weather events is called meteorology (G10).
		Correct proposition	• The sun's rays never fall at a right angle outside the area between Capricorn and Crab spinning (G3).
			• As the Earth approaches the Sun, the weather warms up (G1).
		Misrepresentation	• The reason for the formation of the seasons is that the orbit the Earth follows as it rotates around the Sun is in the form of an ellipse (G2).
			• Solstice dates are the longest daytime dates in both hemispheres (G6).
	Middle	Partially accurate proposition	• The earth stands obliquely at about 23 degrees Celsius (G1).
		The premise that two concepts are bound by one judgment	• Climate and weather events can be known for sure (G7).
	Poor	Inconclusive proposition	• Winds have a beneficial effect on Earth (G10).
		A proposition with two bound judgments	• The Earth has only daily movement, resulting in seasons (G8)
		A proposition with missing information	• Climate weather (G9).

According to Table 4; It has been observed that the groups that are at a good level in terms of determining the propositions of knowledge about the subject express the true and false propositions correctly, while the groups that are at a moderate level write partially true propositions. It is understood that the groups at a weak level write propositions that connect two concepts with a single judgment, give two judgments in one sentence, do not declare certainty, and contain incomplete information.

The data obtained by structural scoring of concept maps belonging to a total of ten groups are given in Table 5. The groups are numbered and coded with the letter 'G'.

Table 5

Data obtained by scoring concept maps

Group	Concept (x1)	Proposition (x1)	Hierarchy (x5)	Cross-Relationship (x10)	Total points	Degree
G1	8x1=8	8x1=8	4x5=20	1x10=10	46	Poor
G2	18x1=18	19x1=19	5x5=25	2x10=20	82	Good
G3	21x1=21	23x1=23	4x6=24	0	68	Good
G4	18x1=18	20x1=20	4x5=20	1x10=10	68	Good
G5	15x1=15	14x1=14	4x5=20	1x10=10	59	Middle
G6	18x1=18	15x1=15	5x5=25	0	58	Middle
G7	36x1=36	36x1=36	6x5=30	1x10=10	112	Middle
G8	48x1=48	44x1=44	7x5=35	0	127	Good
G9	41x1=41	40x1=40	4x5=20	1x10=10	121	Middle
G10	52x1=52	52x1=52	6x5=30	0	134	Good

According to the data in Table 5, it is seen that 1 group (G1) is weak, 4 groups (G5, G6, G7, G9) are medium and 5 groups (G2, G3, G4, G8, G10) are good at developing a concept map related to the subject content. Examples of good, medium and weak concept maps prepared by the study groups are given in Figure 4 (Good), Figure 5 (medium), and Figure 6 (weak)

Figure 4

Example of a concept map of Group 10

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Figure 5

Example of a concept map for Group 5

Figure 6

Example of a concept map for Group 1

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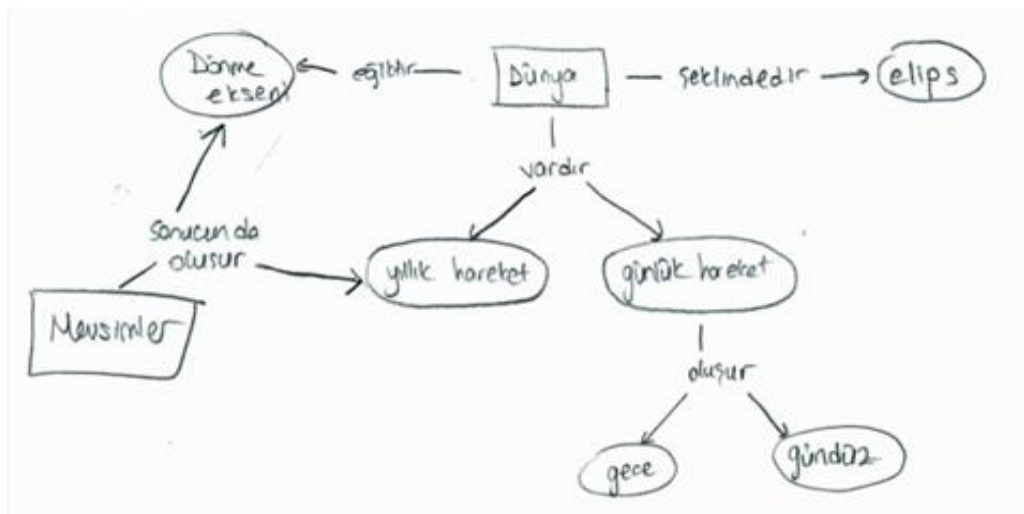
3.2. Findings on Obtaining Information About Students' Misconceptions

The second sub-problem of the research is "8th grade of teacher candidates. How is the development of a multiple-choice test item, the second stage of which is open-ended, by investigating the misconceptions and misconceptions of students in the classroom?" open-ended test questions prepared by teacher candidates to answer the question " and 8. The answers of the students to these questions were examined.

In the two-stage tests, the student is asked to explain why he/she chose the option he/she chose in the first stage. In this study, the second stage of the test was organized in an open-ended structure to determine whether the students have alternative concepts different from the misconceptions determined depending on the findings obtained from the literature review (Karataş, Köse, and Coştu, 2003). The candidates have prepared the first stage following their requests in such a way that it is multiple choice or true-false. The sub-themes, codes, examples, and percentage values for the open-ended two-stage tests prepared for obtaining information about students' misconceptions are given in Table 6.

Table 6

The sub-theme, code, examples, and percentage values of the theme of obtaining information about students' misunderstandings

Theme	Bottom his	Code	Example	Percent
Learning About Students' Misunderstandings	Good	Write a test item that allows explanation	**Today, there was a conversation between Ali and Pinar, who learned about the seasons in science class. How do you think Ali should respond to Pinar?** **Pınar:** As the Earth approaches the Sun, the air warms up, and as it moves away from the Sun, the air gets colder. **Ali:** I agree/disagree because;	%30
	Medium	Write a test item that partially allows the description	**.................... and it is always summer.** **A)** Ecuador **B)** Poles **C)** Equinox **D)** Desert **The reason I chose this option is that I am not going to be able to**	%30

Poor	Write a test item that does not allow an explanation	**Climatology is a branch of science that studies weather conditions.** **A)** True **B)** False **Explain why you chose this option.**	%40

According to Table 6; It is seen that 30% of the groups write a test item that allows explanation, 30% have a test item that partially allows explanation, and 40% have written a test item that does not allow explanation. When the conceptual misconceptions obtained from the open-ended questions prepared were examined, it was seen that there were different misconceptions than the conceptual misconceptions found in the literature. The misconceptions obtained as a result of the test applied to 40 eighth graders are given in Table 7.

Table 7

Student conceptual misconceptions about seasons, climate, and movements

Theme	Bottom his	Misconceptions
Seasons	Day and night formation	• Since the Earth revolves around the Sun, daytime occurs when it comes in front of the Sun, and night occurs when it comes behind it. • It occurs due to the Earth's axial tilt day and night. • The formation of day and night depends on the annual movement of the Earth.
	Elliptical orbit	• As the Earth approaches the Sun, the rays from the Sun fall into a narrower area, and the heat increases, the further away it falls, the lower the heat. • When the sun approaches Earth, summer becomes winter when it moves away. • The Earth's distance from the Sun is effective in the formation of seasons.
	Formation of seasons	• The seasons are the result of the daily movement of the Earth. • Seasons occur even if the Earth does not have an axis tilt.
	Equinox	• On March 21 and September 23, the sun's rays fall at a right angle to the spinners. • On March 21 and September 23, the daytime is longer than the night. • On December 21st and June 21st, the sun's rays fall at a right angle to the equator. • On March 21st and September 23rd, there is day-night equality.
	SolsticeSolstice	• There is always winter on December 21st and summer on June 21st. • On June 21st, the daytime is longer than the night. • On December 21st, the nights begin to grow longer. • On June 21, the sun's rays fall at a right angle as the Capricorn rotates.
	Tropic	• The sun's rays fall at a right angle in summer, crabs in winter, Capricorns in winter. • There's winter in Capricorn spinning, summer in crab spinning.
	Equator	• The equator is closer to the Sun. • The equator always receives the sun's rays at a right angle.
	Measuring instruments	• Pressure measurement is not required when determining the weather.
	Wind formation	• The wind is formed from low pressure to high pressure. • The high-pressure area is hot because the particles are dense. • The low-pressure area is cold because low means the temperature is low.
	Pressure fields	• Cloud formation at high pressure is high because the humidity in the air rises, forming clouds.

Climate and Weather Movements		
		• Since the high pressure is cold, the air is closed and there is a high probability of precipitation.
		• Degrading air movements are observed in the low-pressure area.
		• Amplifier air movements are seen in the high-pressure area.
		• Depending on the seasons, the climate may change.
	Climate	• Seasons are climate types.
		• Climatic is interested in climate, not weather events.
	Weather events	• Weather events vary only by the air temperature.

When the misconceptions given in Table 7 are examined; It is seen that the sub-themes of the seasons' theme are the formation of day-night, elliptical orbit, formation of the seasons, equinox, solstice, tropic, and the equator. The most misconceptions were encountered in the concepts of day-night formation, the formation of the seasons, and the solstice. The sub-themes that emerged in the theme of climate and air movements; measuring instruments, wind formation, pressure fields, climate, and weather events. It is understood that students have more misconceptions about the concept of pressure fields and climate.

3.3. Findings for the Development of the Diagnostic Test

The third sub-problem of the research is "How are the pre-service teachers' development of multiple-choice test items using the misconceptions and misunderstandings of 8th-grade students?" To answer the question, the multiple-choice two-stage test questions prepared by the pre-service teachers and the Diagnostic Test Preparation Rubric data were examined. The sub-theme, code, sample, and group percentage values for the theme of Diagnostic Test Development are given in Table 8.

Table 8

*The sub-theme, code, sample, and frequency values of the Diagnostic Test Development theme*

Theme	Bottom his	Code	Example	Percent
	Good	Strong temptation	**Today, there was a conversation between Ali and Pinar, who learned about the seasons in science class. How do you think Ali should respond to Pinar?** **Spring:** As the Earth approaches the Sun, the air warms up, and as it moves away from the Sun, the air gets colder. **Ali: I agree/disagree** because; **A)** There is no relationship between the Earth's distance from the Sun and the air temperature. **B)** As the Earth approaches the Sun, the rays from the Sun fall into a narrower area, and the heat increases, the further it moves, the lower the space, and the lower the heat. **C)** The side of the Earth that sees the sun in summer, the other side is winter. **D)** When the sun approaches the Earth, it is summer when it is farther away, it's winter.	%50
Development of Diagnostic Testing	Middle	Moderate level of stirs	**Which of the following is closed and is likely to see precipitation?** **A)** In the low-pressure area **B)** In the area of high pressure **C)** In the area affected by cold weather	%50

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		D) In the area of very high pressure	
		The reason I chose this option is because I am not going to be able to	
		A) The humidity in the air descends and causes precipitation.	
		B) The temperature of the airdrops.	
		C) Humidity in the air rises and cloud formation is observed.	
		D) Humidity in the air is intensified by the pressure effect and cloud formation is observed.	
Slim	Weak temptations	**Global warming** is unstoppable. **A)** True **B)** False **Because I do not know if I** **A)** Problems caused by global warming are unstoppable. **B)**Thermal insulation, dissemination of recycling, energy saving can stop global warming.	%0

According to Table 8; It is seen that half of the 10 groups prepared questions at a good level using strong distractors, and half of them at a moderate level. Percentage values were determined by taking into account the questions that they wanted to take place in the test, out of three questions prepared by each group. The frequency distribution of the diagnostic test preparation rubric criteria according to the groups is shown in Graph 1, which is prepared according to the data obtained from the Diagnostic Test Preparation Rubric.

Figure 1

Frequency Distribution of Diagnostic Test Preparation Rubric Criteria by Groups
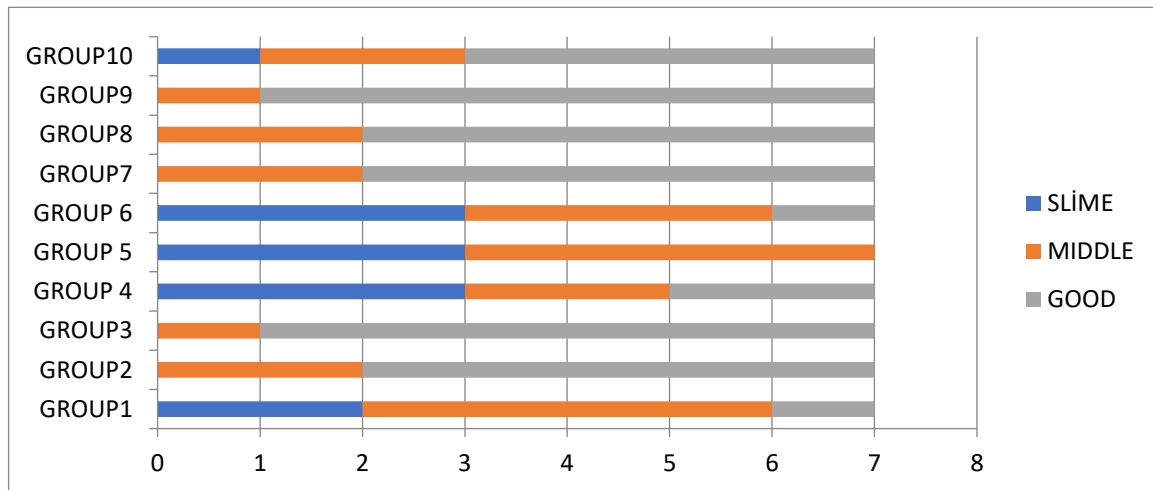
When Graph 1 is examined, it is seen that the groups met at most 3 criteria at a weak level (G4, G5, and G6), and at least 4 criteria at a moderate and good level. It is understood that the rate of meeting the criteria in 5 groups (G2, G3, G7, G8, and G9) at a good level is over 70%.

Table 9

Frequency Distribution of Diagnostic Test Preparation Rubric Criteria by Evaluation Criteria

Category measures	Weak (f and %)	Medium (f and %)	Good (f and %)

Identifying information propositions on the subject	1 (G1) %10	4 (G4, G5, G6, G7) %40	5 (G2, G3, G8, G9, G10) %50
Developing a concept map related to the subject content	1 (G1) %10	4 (G5,G6,G7,G9) %40	5 (G2, G3, G4, G8, G10) %50
Linking information propositions to concept maps and including them in the map	2 (G4, G6) %20	2 (G1, G5) %20	6 (G2, G3, G7, G8, G9, G10) %60
Ensuring content validity	2 (G5,G6) %20	2 (G1,G4) %20	6 (G2 ,G3, G7, G8, G9, G10) %60
Reviewing the relevant literature	3 (G4, G5, G6) %30	3 (G1, G2, G10) %30	4 (G3, G7, G8, G9) %40
Developing multiple-choice test items with an open-ended rationale	4 (G4, G5, G6, G10) %40	3 (G1, G3, G8) %30	3 (G2, G7, G9) %30
Development of a two-stage diagnostic test	-	5 (G2, G5, G6, G8, G10) %50	5 (G1, G3, G4, G7, G9) %50

According to Table 9; It is seen that 50% of the groups are at a good level in identifying information propositions related to the subject and developing a concept map related to the subject content, and 60% in associating information propositions with concept maps and including them in the map and providing content validity. In the development of multiple-choice test items with an open-ended rationale, it is understood that although 40% of the groups were weak, 60% of them were at a moderate and good level. When the two-stage diagnostic test development status of the groups is examined, it is noticed that all groups (100%) are at a moderate and good level.

4. Discussion

In line with the findings for the development of the content; In addition to the groups that express information propositions correctly or partially, some groups connect two concepts with a single judgment, give two judgments in one sentence, and write propositions that do not express certainty and contain incomplete information (Table 4). It is thought that the deficiency here is since the pre-service teachers have little/incomplete knowledge or misconceptions about the subject. Bolat and Altınbaş (2018), in their study to determine the content knowledge of pre-service science teachers on seasons, stated that the success of the candidates was low and that there was not enough education for teaching these subjects in their programs.

He thinks that it is due to the absence of the course. Likewise, Bolat, Türk, and İskeleli (2018) concluded that the mental model of pre-service teachers about the change of day length is mostly primitive and they concluded that they could not transfer knowledge. He stated that this was due to the lack of training with the built model. In the study of Eroğlu and Aydoğdu (2016), it was revealed that although the knowledge level of science teacher candidates on global warming is above the average, their knowledge on some subjects is lacking. Evrim, Ercan, and Bilen (2017) also revealed that pre-

service science teachers have conflicting and scientifically incorrect ideas about global warming, and they have many misconceptions about the subject.

Content related to the subject in developing the concept map, concept maps drawn by the teacher candidates as a result of the structural scoring; from the front group of five (G2, G3, G4, G8, G10) at a good level of four (G5, G6, G7, G9) and a moderate level of One (G1) can create a concept map, it is understood that weak level (Table 5). It is thought that the information provided by the researchers to the pre-service teachers about the subject and about creating a concept map contributes to the candidates' creation of a map. In their study, Tekin, Inci, Aslan, and Yağız (2013) emphasized that pre-service teachers who think they have received enough information about concept maps have a higher ability to prepare a concept map than pre-service teachers who think they have not received enough information. Despite this, in this study, it was observed that some pre-service teachers had difficulty in general in the process of creating a concept map. Smith & Aydoğdu, (2016) stated that the reason teacher candidates have difficulty in establishing hierarchies and lateral relationships is that they do not have domain knowledge about the subject and cannot make sufficient use of resources.

Teacher candidates, students ' misconceptions prepared to gain knowledge about open-ended two-stage test substances examined groups of 30%, which allows explaining the test item, 30% partially explain which allows you to test the item and 40% while allowing you to explain that he wrote the test article, it was observed (Table 6). While developing an open-ended two-stage test, in the first stage, multiple-choice questions on the subject are created by placing a part of the proposition in each question to reveal the common misconceptions (Karataş, Köse, and Coştu). In this direction, it was understood that the test questions prepared by teacher candidates on erroneous propositions do not allow for an explanation.

When the student answers to the questions that allow explanation were examined, it was seen that the students had the most misconceptions about the subject of 'Seasons' in the concepts of day-night formation, seasons formation, and solstice (Table 7). It has been noticed that these misconceptions, which are often seen in students, are caused by October not knowing the results of the daily/annual movements of the Earth and the tilt of the axis (Küçüközer and Bostan, 2010; Boesdorfer, Lorsbach, and Morey, 2011). In addition, it is thought that erroneous drawings in various sources may be effective in the formation of these misconceptions in students (Alkış, 2006). It has been noticed that there are more misconceptions about the concept of pressure fields and climate in terms of 'Climate and Air Movements' (Table 7). It is thought that these misconceptions that students have in the concept of climate are based on their daily life experiences (Akbaş, Koca, and Cin, 2008). In the same way, it has been observed that qualifying adjectives such as 'high' and 'low' affect students' learning by causing connotations in the learning of pressure areas. An example is that students think that the temperature will also be 'low' in the ' low-pressure area'.

5. Conclusion

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It has been observed that the multiple-choice two-stage test questions prepared by pre-service teachers at the development stage of the test have strong and medium level learners and that the groups are good and medium level in terms of preparing these questions (Table 8). It has been observed that pre-service teachers use their experiences obtained at the stages of developing content and obtaining information about students' misconceptions at this stage. The information obtained from the Diagnostic Test Preparation Rubric also confirmed this finding (Chart 1 and Table 9). As a result, it was understood that the diagnostic question preparation skills of pre-service teachers can improve with progressive progression. This result shows how important the field knowledge training that will be given to prospective teachers is in developing their skills as well.

Activities aimed at eliminating misconceptions in field courses and preventing misconceptions that may be found in prospective teachers can be provided. To strengthen the pedagogical knowledge of prospective teachers, studies related to creating questions can be included in the measurement /evaluation courses of educational programs. Two-stage tests are amazingly effective in detecting misconceptions in students. For this reason, it can be used for the detection of misconceptions about the preliminary information obtained before the concept teaching and the information obtained during the evaluation process after the concept teaching. It is preferable to identify misconceptions with valid and reliable paper and pencil tests, such as two-stage tests because they can help teachers develop and use appropriate teaching and learning approaches in their lessons.

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