Journal of Theoretical Educational Science, 15(4), 867-883, October 2022
Kuramsal Eğitimbilim Dergisi, 15(4), 867-883, Ekim 2022
[Online]: http://dergipark.org.tr/akukeg
DOI number: http://doi.org/10.30831/akukeg.1095368

Using Case-**Based Science Scenarios to Analyze Preservice Teachers'** Analytical Thinking Skills*

Vaka Temelli Fen Senaryoları Kullanılarak Öğretmen Adaylarının Analitik Düşünme Becerilerinin Analiz Edilmesi

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Received: 29 March 2022 **Research Article** **Accepted:** 19 August 2022

ABSTRACT: Any science teacher must first acquire analytical thinking skills in order to give their students the ability to think analytically. Therefore, the candidacy period is important for teachers to develop and transform this skill into professional knowledge. Based on this idea, the current research aims to determine the ability of third-grade preservice science teachers to use analytical thinking skills. An Analytical Thinking Test is used in the research conducted survey method. This test consists of twenty case-based science scenarios in total from four different learning fields. These scenarios are designed according to the analytical thinking skill dimensions of Marzano's Taxonomy. Preservice science teachers (*N*=158) from two public universities have participated in the study. It was determined that the majority of preservice science teachers weakly used their analytical thinking skills. It was revealed that preservice science teachers had difficulties respectively in classification - specification - error analysis - generalization – comparison according to Marzano's taxonomy from most to least while solving scenarios. It is recommended that the science educators develop the designs to improve the analytical thinking skills of the candidates in the courses they conduct on the basis of the results of the research. In addition, science educators should pay attention to development in the dimensions of classification and specification by considering the alternative conceptions of the preservice science teachers.

Keywords: The case-based science scenarios, thinking skills, analytical thinking, Marzano's taxonomy.

ÖZ: Bir fen bilgisi öğretmeninin öğrencilerine analitik düşünme becerisini kazandırabilmesi için ilk olarak kendilerinin bu beceriyi kazanmış olmaları gerekmektedir. Bu yüzden öğretmenlerin bu beceriyi kazanmaları ve mesleki bilgiye çevirmeleri için adaylık dönemi önemlidir. Bu fikirden yola çıkarak mevcut araştırma, üçüncü sınıf fen bilgisi öğretmen adaylarının analitik düşünme becerisini kullanabilme durumlarını tespit etmeyi amaçlanmaktadır. Alan taraması yöntemiyle yürütülen araştırmada analitik düşünme testi kullanılmıştır. Bu test, dört farklı öğrenme alanından toplam 20 vaka temelli fen senaryosundan oluşmaktadır. Bu senaryolar Marzano'nun Taksonomisinin analitik düşünme becerisi boyutlarına göre tasarlanmıştır. Araştırmaya iki devlet üniversitesinden fen bilimleri öğretmen adayları (*N*=158) katılmıştır. Fen bilimleri öğretmen adaylarının çoğunluğunun analitik düşünme becerisini zayıf düzeyde kullandıkları tespit edilmiştir. Fen bilgisi öğretmen adaylarının senaryoları çözerken Marzano'nun taksonomisine göre en çoktan aza doğru sırasıyla sınıflama – özelleştirme – hata analizi – genelleme - karşılaştırma boyutlarında zorlandıkları ortaya çıkmıştır. Araştırmanın sonucuna dayanarak fen bilgisi eğitimcilerine yürüttükleri derslerde adayların analitik düşünme becerilerini geliştirmeye yönelik tasarımlar geliştirmeleri önerilmektedir.

Anahtar kelimeler: Vaka temelli fen senaryoları, düşünme becerileri, analitik düşünme, Marzano'nun taksonomisi.

* This research paper is part of TUBITAK (The Scientific and Technological Research Council of Turkey) project named "Design, Implementation, and Evaluation of Life Skills Training Guide in Enriched Science with Context-Based Learning Practices".
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Citation Information
Kirman-Bilgin, A., & Kala, N. (2022). Using case-based science scenarios to analyze preservice teachers' analytical thinking skills. *Kuramsal Eğitimbilim Dergisi [Journal of Theoretical Educational Science], 15*(4), 867-883.

ISSN: 1308-1659

The type of people that the societies need termly varies. Therefore, the definition of qualified people varies according to the period. Especially, since the second half of the 19th century, it has been understood that skill is more important than knowledge in business circles (Inkeles, 1969). It is a necessity to raise individuals who can adapt to various jobs of this age and have high-level thinking skills in this century, in which we are experiencing the Industry 4.0 revolution (Ichsan et al., 2021). All the qualities sought in the current era are defined in the skills of the 21st century. Therefore, it is known that all developed countries, including Europe and USA, have revised their curricula in order to enable their students to gain 21st century skills for qualified work and qualified earnings (Green, 1986). According to the research report, which reveals the necessity of 21st century skills carried out with the participation of many institutions in the USA, it is determined that good education increases productivity in the workplace by 15-20 percent on average, while it increases the earnings of individuals by about 77 percent (Stuart, 1999). In general, these skills include collaboration, communication, digital literacy, citizenship, problem-solving, critical-analytical thinking, creativity, and productivity (Voogt & Roblin, 2012).

Having analytical thinking skills, one of the 21st century skills, is among the general competencies individuals should have (Prawita et al., 2019). Since the individuals with this skill do not have difficulty in solving the problems they encounter both in their daily life and their business life (Eckman & Frey, 2005), it is necessary to develop the analytical thinking skills of individuals who will just start their profession (Ratnaningsih, 2013). There is an important relationship between students' analytical thinking skills and their academic success (Bozkurt, 2022); therefore, analytical thinking affects students' success in many areas (Hyerle, 2008; Sebetci & Aksu, 2014). For example, analytical thinking skills are directly proportional to the development of scientific process skills (Irwanto et al., 2017) and creative thinking skills (Lestari et al., 2018; Lubart et al., 2013).

Due to the importance of the individual in school life, daily and business life, analytical thinking skills are among the skills expected to be acquired by secondary school students in the Science Curriculum in Turkey since 2013 (Ministry of National Education [MoNE], 2018). However, according to research, it has been determined that the level of analytical thinking skills of students at many levels, from secondary school students (Bozkurt, 2022; Mete, 2021) to university students (Akkuş-Çakır & Senemoğlu, 2016), is medium or low. Teachers have the most significant role in acquiring analytical thinking skills for students (Ennis, 1985). The fact that teachers do not give enough importance to such thinking skills in their classrooms causes low students' skill levels (Tanujaya, 2016). Teachers need to develop instructional designs more compatible with problem-solving teaching methods to gain this skill (Chinedu & Olabiyi, 2015; Ramdıah et al., 2018) and use such long-term designs (Siribunnam & Tayraukham, 2009). However, it is a well-known fact that a teacher who wants to teach or gain any skill must first have these skills. It has been determined that preservice teachers (Kala & Kirman-Bilgin, 2020) and even teachers (Anılan & Gezer, 2020) do not have professional competencies to teach their students analytical thinking skills. Knowing how much teachers use this skill during candidacy before starting the profession is essential. This is because preservice teachers gain most of their professional knowledge and skills during their candidacy. A candidate who does not

gain analytical thinking skills during the candidacy period may have difficulty acquiring this skill in his/her students in his/her career. Therefore, researching the analytical thinking skills of preservice science teachers is important in contributing to the relevant literature and structuring preservice teacher education programs. To examine preservice teachers' analytical thinking skills in-depth, first, the characteristics of this thinking skill should be well known.

Theoretical Background

Analytical thinking is a high-level thinking skill (Ichsan et al., 2021; Toledo & Dubas, 2016) and is in critical interaction with other thinking skills. Analytical thinking is associated with other thinking skills such as synthetic, systematic, and creative thinking (Amer, 2005). It is seen that analytical thinking is mostly done within the framework of the concept of analysis in the literature. Amer (2005) defines analytical thinking as dismantling the situation, thinking of an idea in a distinctive way, analyzing data to solve problems, and remembering and using information. Dewey (2007), on the other hand, thinks that analytical thinking is to first examine the parts that make up the objects separately and then reason how the parts interact with each other in order to make the system work. According to Sternberg (2002, 2006), analytical thinking is a) to break down a problem into parts and make sense of these parts, b) to explain the operation of a system, the reasons why something happens, or the steps to solve a problem, c) to compare two or more situations, d) to evaluate and criticize the properties of something. Although the general features of analytical thinking are seen in the current definitions, it is of foremost importance to know the systematic cognitive processes (indicators) of analytical thinking so that teachers can recognize this skill and integrate it into instructional designs.

One of the sources of cognitive processes of analytical thinking is chronologically the analysis phase of Bloom Taxonomy. According to Bloom et al. (1956), analytical thinking takes place in three interrelated cognitive processes: item analysis, relationship analysis, and organizational principles analysis. Behn and Vaupel (1976) have stated that analytical thinking takes place in five stages. These stages are thinking, subdividing, simplifying, specifying, and rethinking. An individual who implements these five stages in the thinking process has acquired the ability to think analytically. Anderson et al. (2001), who have revised the Bloom Taxonomy, state that the individual differentiates important parts of a message, organizes the ways in which parts of this message are edited, and characterizes the underlying purpose of the message in the process of analytical thinking. Therefore, the authors say that analytical thinking occurs in three cognitive processes: differentiating, organizing, and attributing. Marzano mentions five cognitive processes for analytical thinking: comparison, classification, error analysis, generalization, and specification. (Marzano, 2001; Marzano & Kendall, 2007). It is accepted that individuals who can systematically perform these five processes in their working memory think analytically. Analysis means more than just the illumination of the structure, unlike other taxonomies in Marzano's Taxonomy. The individual can also think analytically and produce new information that he does not already have in this taxonomy (Marzano & Kendall, 2007). It is decided that the analysis phase is in problem-solving and is put hierarchically under the creation immediately in the taxonomy proposed by Ichsan et al. (2021).

Analytical thinking is one of the high-level thinking skills as seen in the thinking taxonomies. One of the courses in which analytical thinking skills can be acquired most easily is the science course (Tsalapatas, 2015). Since science is a course intertwined with life, students' analytical thinking skills can be developed very easily in order to solve the problems in this course. However, the teachers must first have analytical thinking skills for students to overcome both science and daily life problems.

When the studies are examined, it is seen that the student's analytical thinking skills are low despite the significant importance of analytical thinking in our business and daily life (Gunawardena & Wilson, 2021; Husain et al., 2012; Irwanto et al., 2017; Thaneerananon et al., 2016). Although determining the level of thinking skill is particularly important, determining which element of the thinking process has a problem is more important in terms of developing instructional designs to eliminate existing problems. As mentioned in the top paragraph, some scientific studies examine the sub-cognitive processes of analytical thinking. In this study, data collection tools were developed based on Marzano's analytical thinking categories because the analysis category in Marzano's Taxonomy includes elements from at least three levels in Bloom's Taxonomy, namely "analysis, synthesis and evaluation" (Marzano & Kendall, 2007). In this respect, it is thought that Marzano's analytical thinking categories are more suitable for solving complex daily life problems. There are limited studies in the literature analyzing analytical thinking based on Marzano's Taxonomy (Fakhrurrazi et al., 2019; Yulina et al., 2019), but it is seen that multiple-choice test is used in these researches. In multiple-choice tests, since the student marks one of the derived information, it allows us to reach limited information about the individual's thinking processes. Case-based science scenarios were used in this research. A limited number of studies have been found in the literature in which case-based scenarios are used to improve students' inquiry skills (Cresswell & Loughlin, 2017) or to measure only their analytical thinking skills (Akkuş-Çakır & Senemoğlu, 2016; Olça, 2015). Case-based science scenarios were preferred in this study both because the student produces the knowledge directly and because it eliminates the chance factor in multiple-choice questions. In addition, since these scenarios are remarkably similar to the cases that the individual may encounter in his/her daily or business life, it is thought that results that are more reliable will be obtained on whether he/she can solve a complex case by thinking analytically in real life. In this context, the aim of the study is to determine the proficiency of third grade preservice science teachers in analytical thinking skills first and then to analyze their analytical thinking. Accordingly, it will also be possible to determine which element is executive for preservice science teachers in analytical thinking or why they cannot think analytically.

Method

This research is carried out by survey method. Survey studies are a type of research carried out to determine the current situation. The ability of preservice science teachers to use analytical thinking skills is investigated in this study. The survey method prepares the necessary infrastructure for special case studies and provides the environment for the creation of the problem that will be investigated (Ruel et al., 2015). It is thought that the results of this research will form the basis of many studies that will be conducted.

Participants

The third year preservice science teachers (*N*=158) studying at two state universities in Turkey participated in this research. The reason for working with these participants is that the same teacher training program is implemented in all education faculties in our country. The preservice science teachers go through the same education process except for a few elective courses, even if they are in different universities. Related research is a product that emerges from an ongoing project. The researchers involved in this project work at two different universities. Therefore, the researchers preferred convenience and convenience sampling while determining the participants. Sixty-nine preservice teachers from one of these universities and eighty-nine preservice teachers from the other have participated in the research. Since the research aims not to compare the competencies of universities to provide preservice teachers with analytical thinking skills, the data obtained from the participants are not presented separately. It is decided to conduct the research with third-year preservice science teachers since they have taken all the field courses in the first three years in the Science Teacher Training Program at universities and have the necessary field knowledge to analyze a scenario. Participants have not taken any analytical thinking training courses before the research.

Data Collection Tools

The researchers of this study develop the Analytical Thinking Test (ATT) as part of the research to reveal the analytical thinking skills of preservice science teachers. Since the solution of the scenarios in ATT takes time and cannot be solved once in practice, it has been transformed into four worksheets. The scenarios in these worksheets are developed by considering the achievements in four different learning fields in the secondary school Science Curriculum (SC). Therefore, the scenarios are designed to cover four different learning fields (Living Beings and Life, Physical Events, Matter and Change, Earth and Universe) and Marzano's five analytical thinking skills (comparison, classification, error analysis, specification, and generalization). Each worksheet contains five scenarios, one of which is from Marzano's entire analytical thinking category. Therefore, preservice science teachers have solved twenty case-based analytical scenarios within the scope of this research. The features of the developed scenarios are shown in Table 1.

Table 1

The Distribution of ATT Questions according to Learning Fields and Dimensions of Analytical Thinking Skills

Learning Fields	The Dimensions of Analytical Thinking Skills				
	Comparison	Classification	Error Analysis	Specification	Generalization
Living beings and Life	6	8	7	9	10
Physical Events	12	11	15	13	14
Matter and Change	3	2	5	1	4
Earth and Universe	19	17	16	18	20

The developed case-based science scenario examples and considerations while developing these scenarios are shown in Table 2.

Table 2

The Developed Case-Based Science Scenario Examples and Considerations while Developing These Scenarios

<table>
<tr><th>The Examples of Case-Based Science Scenarios</th><th>Related learning outcomes in SC</th><th>Learning Domains</th><th>The Dimensions of Analytical Thinking Skills</th></tr>
<tr><td>Ufuk teacher makes his students work in groups. The groups studying the solar system model have noticed that the Earth follows an elliptical orbit as it goes around the Sun, and the Earth's axis in this orbit is also oblique. One of the questions stuck in the minds of the students is, "What would happen if the Earth did not have axial tilt?" Answer the question considering the seasons.</td><td>It makes predictions about the formation of the seasons.</td><td>Earth and The Universe</td><td>Error analysis</td></tr>
<tr><td>The teacher draws the following table about recycling on the board, the students in this process;
<table><tr><td>Domestic Solid Waste</td><td>Energy saving (GJ/ton)</td></tr><tr><td>Aluminum</td><td>222</td></tr><tr><td>Plastics(recycling by burning)</td><td>32.6</td></tr><tr><td>Plastics</td><td>0</td></tr><tr><td>Steel</td><td>12.6</td></tr><tr><td>Paper and cardboard</td><td>7</td></tr><tr><td>Glass</td><td>6</td></tr></table>**Ali:** We should definitely obtain aluminum from waste materials. Thus, we protect our resources and make a huge energy saving.
Betül: I agree. But we should not recycle plastics or we can just burn them for energy...
According to these conversations, if there is no profit in the process of obtaining plastic from waste plastics, what is/are the benefit/s of recycling this material? Explain the reasons.</td><td>It questions recycling in terms of the effective use of resources. The contribution of recycling facilities to the economy is emphasized.</td><td>Matter and Change</td><td>Comparison</td></tr>
<tr><td>Mert's family has orchards with many types of fruits. Mert said to his mother one day, "Mom, we have many kinds of fruit trees. Only our goats and we eat these fruits. My cat does not want to eat." How do you explain the situation that Mert has identified? Explain the reasons.</td><td>It gives examples of producers, consumers, and decomposers in the food chain.</td><td>Living Beings and Life</td><td>Classification</td></tr>
</table>

The scenarios developed within the scope of Table 2 are designed by the researchers and are subjected to validity studies by two science educators. The revised questions are applied to twenty preservice science teachers within the feedback framework. The reliability studies are completed within the framework of the data obtained from the senior preservice science teachers, and the ATT is finalized. Since the ATT consisted of open-ended questions, the reliability coefficient was not calculated. However, the researchers of this study examined the answers given by the preservice science teachers and checked how many of the expected answers were given.

Data Collection Process

The data are applied at separate times. The questions with two learning fields are applied one day, the questions with other learning fields are applied the next day, and the data are collected. There is no time limitation for the preservice science teachers while they are solving scenarios in the worksheets. The preservice science teachers who gave the data collection tool the earliest completed the questions in 45 minutes. The preservice science teachers who gave the data collection tool the latest completed the questions in 61 minutes.

Data Analysis

The data obtained from the ATT is analyzed on the basis of the criteria in Table 3 obtained by adapting the classification used by Marek (1986).

Table 3

The Analysis of the Data That Is Obtained from the ATT

Categories	Contents	Score
Complete Analytical Thinking	The answer that includes scientifically correct analytical thinking in particle size: To be able to detect the data related to the given problem, to divide the data into elements, to be able to process and solve the problem by using the dimensions of the ability to think analytically about the elements	3
Partial Analytical Thinking	The answer that indicates some of the ways you can think analytically at a macroscopic level or think correctly	2
Analytical Thinking with Alternative Concepts	Analytical thinking with alternative concepts that are not consistent with scientific knowledge	1
Inability to Think Analytically	The answers like “I don’t know” and meaningless answer	0
No answer	No respond	0

The categories are scored in Table 3 to calculate the participants’ average scores according to the dimensions of the participants’ analytical thinking skills and learning fields and to interpret more deeply how much the candidates can use their analytical thinking skills. When the data obtained from the ATT are scored within the scope of Table 3, a candidate receives a maximum of “60” points and a minimum of “0” point from the aforementioned test. According to the answers given by the preservice science

teachers to the ATT, it is based on the evaluation style proposed by Kala (2019) to interpret how much they use this skill in general. This form of evaluation is shown in Table 4.

Table 4

The classification that is used in the analysis of data that will be obtained from ATT

Score Interval	Analytical Thinking Level	Code
0 - 19	Analytical thinking skills are at a level that needs to be improved.	A
20 - 39	Analytical thinking skills are weakly acceptable.	B
40 - 51	Analytical thinking skills are moderately acceptable.	C
52 - 60	Analytical thinking skills are well acceptable.	D

According to Kala (2019), an individual's analytical thinking level is in the A (analytical thinking skills are at a level that needs to be improved) code between 0-0.99 points, B (analytical thinking skills are weakly acceptable) between 1-1.99 points, C (analytical thinking skills are moderately acceptable) between 2-2.59 points, and D (analytical thinking skills are well acceptable) between 2.6-3 points out of 1 question. ATT has twenty scenarios. When the coefficients proposed by Kala (2019) are multiplied by twenty, the score intervals in Table 4 and the analytical thinking levels that correspond to these score intervals appear.

Ethical Procedures

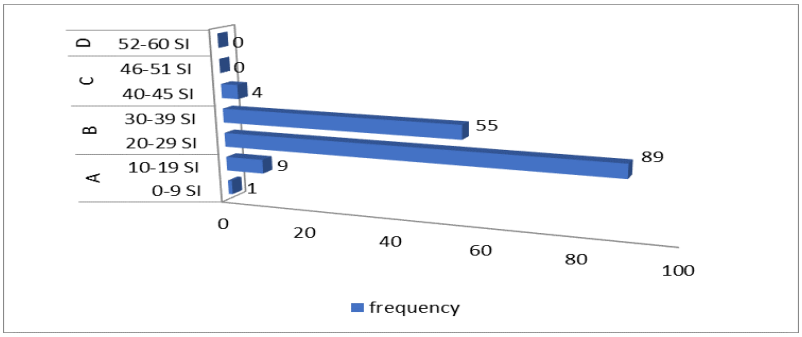
Ethical approval and written permission were obtained from Kafkas University Social and Human Sciences Ethics Committee with the decision dated 06.09.2017 and numbered 05/01. The research was carried out following ethical rules at every stage. Participation of the candidates in the research took place on a voluntary basis.

Results

The findings obtained from the ATT used to reveal the preservice science teachers' use of analytical thinking skills are demonstrated in Figure 1.

Figure 1

The Findings of Preservice Science Teachers' Use of Analytical Thinking Skills

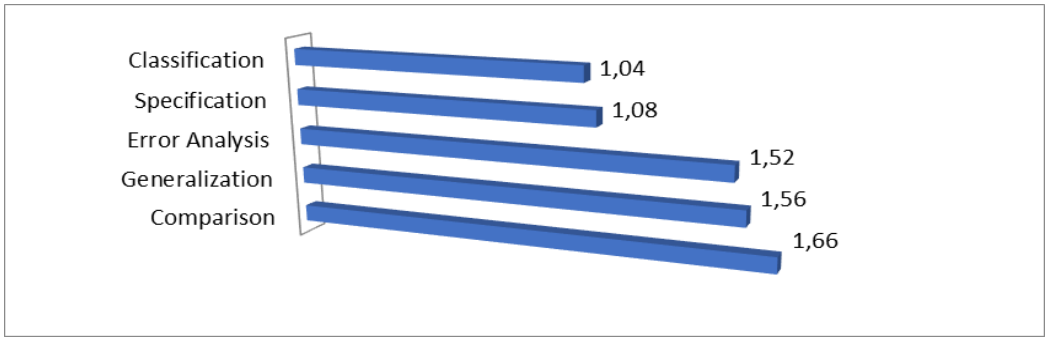


A: Analytical thinking skills are at a level that needs to be improved. B: Analytical thinking skills are weakly acceptable. C: Analytical thinking skills are moderately acceptable. D: Analytical thinking skills are well acceptable. SI: Score Interval

When Figure 1 is examined, it is noteworthy that the ability of ten preservice science teachers to use the relevant skill within the scope of the ATT is at a level that needs to be improved. It is seen that there are 144 preservice science teachers who can use analytical thinking skills at a poorly acceptable level and four who can use them at a moderately acceptable level. It is noteworthy that there is no preservice science teacher who can use it at a well acceptable level. The general test averages of the candidates according to the dimensions of analytical thinking are as in Figure 2.

Figure 2

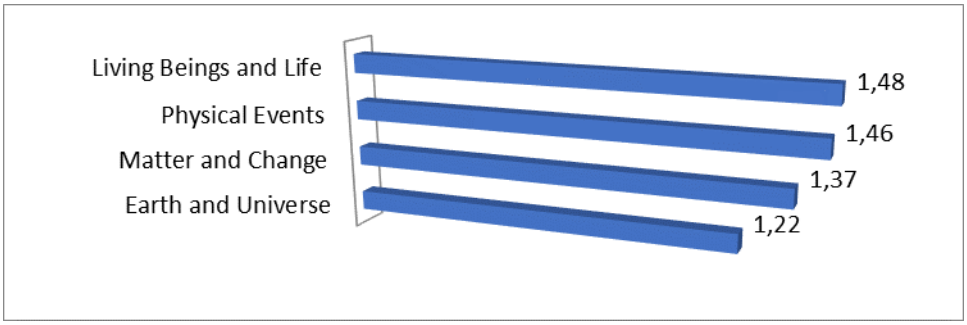
The Findings of General Test Averages According to the Dimensions of Analytical Thinking



When Figure 2 is examined, it is seen that the test average (1.66) obtained from the questions belonging to the comparison dimension of the ATT of all preservice science teachers participating in the research is higher than the other dimensions. It is noteworthy that the test averages obtained from the classification (1.04) and specification (1.08) dimensions are lower than the other dimensions. The overall test averages obtained according to the learning fields of the candidates are shown in Figure 3.

Figure 3

The Findings of General Test Averages According to Learning Fields



When Figure 3 is examined, it is seen that the ATT of preservice science teachers is lower than the test average (1.22) obtained from the Earth and Universe learning field compared to other dimensions. It is noted that the test average (1.48) obtained from the Living Beings and Life learning field is higher than other dimensions. The alternative concepts that emerged within the framework of the ATT of preservice science teachers are stated in Table 5.

Table 5

The Findings of Alternative Concepts Obtained from the ATT

Question No	Alternative Concepts	*f*
1	Since the density of the water is high, the upper surface is frozen, since the density of the olive oil is low, it freezes from the bottom.	33
	The water is frozen because it is pure.	2
	Dense substances are more difficultly frozen.	2
	The surface of the water is frozen because of the specific heat difference.	1
4	The water droplets in the laundry freeze and separate from the laundry, so the laundry dries.	9
8	Cats cannot eat fruit.	1
	Cats do not need vitamins in fruit.	1
9	Horses may have died of exhaustion because they have too much muscle.	4
	The horses may have died because of carbon dioxide in their bodies.	3
	Horses die of exhaustion because they do not convert lactic acid into glucose.	1
10	The deep cut may have devastated the veins.	4
	In the first case, it reduces pain as the blood clots.	1
12	The distance the laser beam takes in the space is too high.	2
	The laser beam is at the speed of light, the lantern light is slower.	1
16	If there were no axial tilt, the seasons would be reversed.	1

When Table 5 is examined, it is seen that preservice science teachers mostly have alternative concepts in the fields of matter and change, living beings, and life learning. It is noted that more alternative concepts have been identified in the field of matter and change learning field than other questions within the scope of question 1 on the specification dimension.

Discussion and Conclusion

The way that secondary school students can use or acquire analytical thinking skills in science lessons is related to how much science teachers include activities that will enable students to think analytically in their learning environments (Ichsan et al., 2021; Tanujaya, 2016). A science teacher is expected to have analytical thinking skills in order to design such learning environments (Ennis, 1985). They need to gain this skill in the process of preservice training, which they must combine with teaching professional knowledge and skills and improve themselves with supportive training while performing their professions. Based on this idea, the current research aims to reveal the situations in which preservice science teachers use analytical thinking skills. The data obtained from the ATT used within the research scope shows that most preservice science teachers can weakly use their analytical thinking skills (Figure 1). This may be because preservice science teachers have not been trained to develop these skills in their learning life until the research. This is because analytical thinking skills have been added to our country's curriculum only to be developed at the secondary school level since 2013. It is thought that since the students do not receive an education

aimed at gaining analytical thinking skills, it causes them to have problems while interpreting a non-routine problem or a socioscientific situation. It has been determined that the students have more difficulty solving conceptual problems based on interpretation than operational problems in many studies conducted in our country (Bekdemir et al., 2010; Kaya & Keşan, 2012). Preservice science teachers could not both think analytically and had difficulties interpreting conceptual questions. As a result of this situation, their test averages were low. To sum up, the preservice science teachers participating in the research have not gone through a training process focused on improving their analytical thinking skills. The fact that they have not taken a vocational course for this skill during the candidacy process can also be seen as one of the reasons for the results of this research. However, higher education institutions are required to produce graduates with analytical thinking skills (Kwok, 2018).

Another research result obtained from the ATT is that the test averages of preservice science teachers are low according to the dimensions of analytical thinking skills. It is revealed that the preservice science teachers have more difficulty in classifying and specifying the data compared to other dimensions within the framework of the dimensions of analytical thinking skills. It is seen that they have less difficulty in making comparisons compared to other dimensions. Yulina et al. (2019) find that they are able to think analytically at a low level in their study with fifteen preservice chemistry teachers. Yulina et al. (2019) find that the candidates have already been struggling in the dimensions of error analysis, generalization, specification, comparison, and classification from most to least in terms of the dimensions of analytical thinking skills. Fakhrurrazi et al. (2019) state that they have difficulties matching, generalizing, classifying, analyzing errors, and specifying categories in biology subjects from most to least in their study. Preservice science teachers have difficulties respectively in classification, specification, error analysis, generalization, and comparison from most to least in the current study. As can be seen, the results of these three studies are quite different from each other. This may be due to the differences in the contents of the questions used in the three studies. This study revealed that preservice science teachers have more difficulties in solving problems related to the learning fields of Earth and Universe, Matter, and Change by using analytical thinking skills in the current study and they have less difficulty in solving problems related to physical events, living beings, and life learning fields by using their analytical thinking skills compared to other dimensions. The reason for this situation is that it is necessary to have conceptual learning in the field of knowledge learning to gain analytical thinking skills (Hyerle, 2008).

It was determined that preservice science teachers had the greatest number of alternative concepts in the field of Matter and Change and the least in the field of Earth and the Universe within the scope of ATT. The emerging alternative concepts were seen as density, dietary patterns, fermentation, digestive system, nervous system, light, and Earth. However, the subject in which the preservice science teachers had the greatest number of alternative concepts is density. The reason for the emergence of alternative concepts within the scope of the concept of density may be due to the insufficient conceptual knowledge of the candidates about the particulate structure of matter (Barker & Millar, 1999; Kirman-Bilgin & Yiğit, 2017). From a general perspective, both the high level of misconceptions and low understanding of Matter and Change, and Earth

and Universe areas can be explained by the fact that preservice science teachers have received less education in these areas until now. For example, when the number of achievements in the four areas of the Science Curriculum is listed, there is a ranking similar to Figure 3 (MoNE, 2018). It can be said that the courses related to Matter and Change, and Earth and Universe in high school and Science Teacher Training programs in our country are fewer than the courses in the other two fields. Furthermore, considering that the overall test averages of the problems related to these two fields are low (Figure 3), it can be said that the lack of conceptual knowledge of preservice science teachers negatively affects analytical thinking processes. This is because it is necessary to have theoretical knowledge about that case as well as analytical thinking skills in order to be able to analyze a science-based scenario or case. Bozkurt (2022) determined that content knowledge has a profound effect on the solution of a science-based scenario.

When the findings obtained from the research are evaluated in general, the following main conclusions are reached. It is found that the majority of preservice science teachers use analytical thinking skills at a poorly acceptable level, and the candidates have difficulties respectively in classification - specification - error analysis - generalization – comparison from most to least while solving problems. This research is found that preservice science teachers have difficulties in learning fields, respectively the Earth and Universe - matter and change - physical events - living beings and life from most to least while solving problems. Finally, it was determined that the preservice science teachers had alternative conceptions for each learning area, but mostly about density.

Implications

This research revealed the status of preservice science teachers' analytical thinking skills according to their learning areas. The result of the research provides the opportunity for science educators to design their learning environments according to the needs of the preservice science teachers. It can be suggested to science educators to conduct the critical and analytical thinking course, which is among the vocational elective courses in the undergraduate course content of science teaching on the basis of the results of the relevant research. Moreover, science educators may be advised to use this skill by comparing them with case-based science scenarios based on problem-solving in their courses. The learning environment to improve the analytical thinking skills of preservice science teachers can be designed using the current research results, and its effectiveness can be investigated. Science educators should pay attention to development in the dimensions of classification and specification by considering the alternative conceptions of the preservice science teachers. In addition, science educators should strive to develop more analytical thinking skills in the learning areas of matter and change and the Earth and Universe.

Acknowledgments

This research paper is part of TUBITAK (The Scientific and Technological Research Council of Turkey) Project coded 117K993 "Design, Implementation, and Evaluation of Life Skills Training Guide in Enriched Science with Context-Based Learning Practices."

Statement of Responsibility

Arzu Kirman-Bilgin and Nesli Kala contributed equally to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

Conflicts of Interest

The authors declare that there is no conflict of interest.

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