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# Investigation of pre-service science teachers' knowledge levels, practical experiences, and perceived competencies in teaching biodiversity

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**ABSTRACT**
This study aims to investigate pre-service science teachers' knowledge levels, practical experiences, and perceived competencies in teaching biodiversity at secondary school level. The study was conducted in Turkey with 151 pre-service science teachers, 50 of whom were first-year, 34 second year, 42 third year, and 25 fourth year during the fall semester of 2022-2023. An open-ended biodiversity concept test was applied to identify their knowledge levels, prior education experiences, and perceived competencies in teaching biodiversity. Descriptive statistics and content analysis results revealed that as the year level increased, the knowledge levels and experiences of the pre-service teachers increased as well, and in parallel, they perceived themselves as more competent in teaching the subject of biodiversity. When first and second year students were evaluated together, it was found that most of their answers were at a low level in terms of their knowledge about biodiversity. When the third and fourth grade teacher candidates' knowledge levels about biodiversity were examined, it was revealed that they were predominantly at a good level. As can be clearly seen, as year levels increased, the level of knowledge also increased. These results highlight the importance of theoretical and practical courses for content and pedagogical knowledge on the perceived competencies of the pre-service teachers in teaching biodiversity.

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## Introduction

The term biodiversity was first defined in 1992 in Rio de Janeiro and subsequently accepted by a total of 157 countries, including Turkey. It was initially used at the Earth Summit, where the Convention on Biological Diversity (CBD) was signed. The Convention defined biological diversity as "the diversity of all living organisms resulting from terrestrial, aquatic, and other ecosystem differences and intra-species and inter-species differences" (cited by Yüce & Önel, 2015 p.327). Biodiversity is commonly defined as

the variability among living organisms from all sources, including, inter alia, terrestrial, marine, and aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and within the ecosystems. Biodiversity is identified by the interaction of various factors that differ spatially and temporally. For instance, average climate and climate variability, resource availability and overall productivity of an area, biodiversity stock and diffusion opportunities or barriers, spatial heterogeneity habitats and intensity and interdependence of biotic interactions such as competition, predation, mutualism and symbiosis, and intensity and type of sexual reproduction and genetic recombination (Balcha & Dalle, 2007). DeLong (1996) stated that there was still no coherent definition of biodiversity; it was defined differently by different people and based on his own findings, he defined biodiversity as follows:

*Biodiversity is a state or attribute of a site or area and specifically refers to the variety within and among living organisms, assemblages of living organisms, biotic communities, and biotic processes, whether naturally occurring or modified by humans. Biodiversity can be measured in terms of genetic diversity and the identity and number of different types of species, assemblages of species, biotic communities, and biotic processes, and the amount (e.g., abundance, biomass, cover, rate) and structure of each. It can be observed and measured at any spatial scale ranging from microsites and habitat patches to the entire biosphere (DeLong, 1996, p. 745).*

He noted that a widely accepted fundamental definition of biodiversity was essential for effective communication and cooperation within and among different countries, government agencies, disciplines, organisations, and private landowners, and that the cooperation between these entities was essential for the conservation of biodiversity.

The concept of biodiversity has gained an important place in the scientific and political fields since the United Nations Conference on Environment and Development (Rio de Janeiro, 1992). This is an indication that the importance of Biodiversity is increasing day by day. Since biodiversity refers to the richness and diversity of living species, as well as the adaptation of living things to environmental changes and the continuity of living species (Babou et al., 2020). Therefore, it is a very valuable heritage that needs to be protected (Cesco et al., 2021; McDonald, 2015). As a normative conservation concept, biodiversity is an important component of education for sustainable development (ESD) as it very well reflects the interaction of ecological, economic, and social issues and requires the student to consider different perspectives to attain balanced perspectives (Barthes & Zwang, 2014; Lange, 2011; Lindemann-Matthies et al., 2011).

Biodiversity includes diversity at the genetic, species, ecosystem and habitat levels and is directly related to human well-being. Due to people's need for natural resources, protecting biodiversity is of great importance for people's survival and good quality of life (Piccolo, 2017). Specific species offers various benefits to people. These include tangible goods such as food, timber, medicine, and fibre; various services recognised to support the ecological functions such as flood control, climate regulation, nutrient cycling, maintenance of hydrological cycles, purification of water and air, soil formation and soil storage, added to the cultural, social, aesthetic and ethical values, pollination and pest control, carbon sequestration, and storage (Venuste et al., 2017). Unfortunately, many plant species worldwide are in danger of extinction due to the gradual disappearance of terrestrial natural ecosystems thanks to various human activities. Most often, this is due to clearing of native vegetation for agriculture and the consequent erosion, salination and invasion of alien species, but recently climate change has emerged as a major new threat (Reed et al., 2011). Some studies demonstrated a "diagnostic fingerprint" of climate effects on the species worldwide, characterized by the progression of spring events, range shifts, changes in local abundance, interactions between the trophic levels, and climate-related extinctions. In some cases, the entire ecosystems such as cloud forests and coral reefs, disappeared locally due to warming temperatures (Van Dyke & Lamb, (2020).

One of the factors affecting biodiversity is the climate change. The 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4; IPCC 2007) concluded that climate change would have some significant impacts on many aspects of biodiversity; on the ecosystems, species, genetic diversity within species and ecological interactions. The consequences of these effects were

important to the long-term stability of the natural world and to the many benefits and services that humans derive from it (Secretariat of the Convention on Biological Diversity, 2009). Worldwide, many plant species are in danger of extinction due to the gradual disappearance of terrestrial natural ecosystems for various human activities. Often, this was due to clearing of native vegetation for agriculture and the consequent erosion, salination and invasion of alien species, but recently climate change emerged as a major new threat (Reed et al., 2011).

Education for biodiversity conservation is an important factor in shaping individuals' behaviour towards biodiversity conservation and, in this context, should be part of the curriculum in both primary and secondary schools (Kideghesho et al., 2007). Providing biodiversity education to individuals is important in gaining personal knowledge as well as creating behavioural changes towards the environment (Børresen et al., 2023). Navarro-Perez and Tidball (2012) stated that there were 4 main challenges in biodiversity education in general. The first challenge requires defining the biodiversity education approach and understanding how the nature and strategies of both environmental education and ESD programmes can potentially affect biodiversity education. While some biodiversity education efforts claim to be a mix of activities and mechanisms from both environmental education and ESD, conceptual tensions over which perspective is best suited for education can pose problems when defining the approach to biodiversity. Secondly, the challenge for educators is to help students find personal value and meaning in a concept that doesn't come easily to their minds. Biodiversity is a difficult concept to learn as it remains abstract due to insufficient examples given (Kara et al., 2017). Many educational scholars agree that biodiversity should be integrated outside of the natural while encouraging students to critically explore the different meanings, uses, and values of biodiversity. The third challenge represents the importance of reaching diverse and broad audiences with a meaningful message. Survey and research results on public attitudes around the world illustrate that the message about the importance of halting biodiversity loss is not fully understood. This indicates that the public needs to be more involved. Therefore, it is critical to convey the right message through non-formal education and biodiversity communication strategies that can contribute to raising awareness and motivating all layers of society. Finally, the fourth main challenge for education is reconnecting people with nature. Given that most people live in urban areas where the effects of urbanisation have altered ecosystems and thus people's relationships with nature, it has been argued that education should focus on increasing contact with nature through a variety of species in childhood and youth. Studies revealed that this early contact predisposed people in a way to increase their interest in nature.

The subject of biodiversity is included in the secondary school science curriculum in Turkey within the scope of “living things and life” domain, specifically the unit on humans and the environment. For this purpose, students are expected to inquire the importance of biodiversity for natural life, give examples of plants and animals that are endangered or in danger of extinction in our country and in the world, and discuss the factors that threaten biodiversity based on the research data. Unfortunately, previous studies demonstrated that students had difficulties in balancing their economic, social and environmental interests to identify the priority areas for conservation, and most of them lacked knowledge about current concepts of biodiversity conservation (Miani et al., 2016). In particular, the combination of active, participatory, collaborative learning methods and experiences in outdoor field environments is effective in developing biodiversity knowledge and attitudes.

Turkey is among the countries with the richest biodiversity in Europe and the Middle East. A country's biodiversity is part of its national heritage (Uzun et al., 2010). In order for Turkey to continue its development without losing its biological richness, educating the society and especially the students in a way that will raise awareness of conservation is of great importance, especially for future generations. However, the lack of clarity and understanding of the biodiversity issue is also a part of the problems in education (Yüce & Önel, 2015). One of the worst aspects of the current global crisis is that biodiversity is adversely affected. Biodiversity loss affects both species and the functionality of ecosystems. This leads to a reduction or loss of ecosystem services, with devastating effects on all living things, including humans. In this sense, education should be another tool that contributes to the conservation of biodiversity (Robles-Moral et al., 2022). Biodiversity, like many other science concepts, is a difficult

subject to learn because it is abstract due to the insufficient examples given in science education. It is important to raise the biodiversity awareness of teacher candidates, both in terms of increasing their awareness of various species in our country and transferring these species to future generations. The people who desire to raise individuals with this awareness should have competence in these subjects (Tekin & Aslan, 2022). Educational activities are extremely critical in raising the level of awareness for the protection of this heritage. Environmental knowledge received through formal education on biodiversity helps individuals become aware of their actions towards the environment and develop environmentally responsible behaviour. (Kollmuss & Agyeman, 2002). Therefore, it is vital to identify and develop the field knowledge of future teachers, who play a very important role in the education of children on biodiversity. In order to teach biodiversity effectively, teachers need to make connections between biodiversity with their students' lives and interests by using more than one method (Schaal et al., 2012).

Various studies have been conducted in different countries to understand teachers' awareness levels about biodiversity, but most of them have not produced encouraging results. Studies conducted reveal that teachers do not understand the meaning of the concept of biodiversity and what it includes (Dikmenli, 2010; Dresner, 2002; Gayford, 2000). This demonstrates that education, outreach, and public awareness strategies have failed to generate the interest and motivation needed for people to act in favour of biodiversity conservation and that the message about the importance of maintaining biodiversity has not been fully understood This situation reveals the need to increase efforts to inform and empower future generations (Navarro-Perez & Tidball (2012). Lindemann-Matthies et al. (2011) conducted some multinational research studies at teacher education institutions in four different countries. Their study investigated the confidence and perceived competence of 690 primary school teacher candidates in providing biodiversity education at primary school level. The results revealed that teacher education programmes that focused solely on filling (biodiversity) knowledge gaps might fail to increase their students' confidence and proficiency in conducting biodiversity education in schools. The programmes that were more likely to achieve effectiveness in biodiversity education demonstrated that there must be a balance between developing background knowledge, and pedagogical content, and opportunities to enact meaningful sequences of activities during instructional practice and engage the students in holistic educational innovations, leading to some experiential gains. Similarly, Yli-Panula et al. (2018) examined a total of 317 international scientific articles published since 2000 describing the biodiversity and teaching methods related to teaching and/or learning, and investigated what types of teaching methods were used to promote biodiversity education and how the methods supported biodiversity learning. Each teacher candidate will educate a large number of learners and exchange ideas with colleagues as a leading part of the society. In this context, determining the competencies of teacher candidates is extremely important (Barker & Elliot, 2000). Barker and Elliott (2000) found that the most used teaching methods were hands-on teaching, experiential learning and teacher presentation. The least used ones were games, role-play, debates, service learning, study trips, and visits. Items related to the teaching methods that supported students' learning were active participation and interaction in all items, followed by the techniques of observation, experimental study, learning by experience, and increasing environmental awareness.

It is extremely important for future generations to prevent the loss of biodiversity, and to educate society, especially the students and the teachers who train them, in raising awareness of conservation. This situation has been particularly emphasized in previous research (Lindemann-Matthies, 2011). The education of teacher candidates is extremely important, especially for the dissemination and implementation of current environmental education courses (Käpylä & Wahlström 2000; Powers 2004; Van Petegem et al., 2005). For this reason, it is important to analyse prospective teachers' understanding of the concept of biodiversity (Palmberg et al., 2017; Tekin & Aslan, 2022). Investigating whether teacher candidates are competent in how to handle biodiversity in schools will make valuable contributions to teacher education. In this context, this study aimed to determine the knowledge, awareness and competence perceptions of teacher candidates on biodiversity according to their undergraduate levels,

based on the vital importance of biodiversity globally and nationally. The main research questions of this study are as follows:
(1) What are the existing knowledge levels of pre-service science teachers about biodiversity and environmental problems?
(2) What are the prior education experiences and perceived competencies of pre-service science teachers with regard to biodiversity teaching at middle schools?

## Studies on Biodiversity Education

Considering the importance of the concept of biodiversity for today's world, the importance of raising individuals with sufficient knowledge and skills regarding biodiversity is better understood. Knowledge and skills regarding the concept of biodiversity are conveyed by teachers. Individuals need to learn the ecological and economic value of biodiversity and have sufficient skills regarding biodiversity (Karabal, 2011). In this respect, it is extremely important for teacher candidates to have knowledge and skills about biodiversity before starting their job. Therefore, in order to conduct a needs analysis in teacher education, it is necessary to determine the biodiversity knowledge levels of teacher candidates. In this context, many studies have been carried out in our country and abroad
Uzun et al. (2010) found that 66 first-year social studies teacher candidates focused on the concepts of biodiversity, species diversity, ecosystem, and ecology, and their prior knowledge was limited. In addition, pre-service teachers stated that the biodiversity in our country was high and the reason for this was due to the geographical location and climate characteristics. On the other hand, Yüce and Önel (2015) found that 4th-year science teacher candidates associated species diversity, ecosystem diversity, genetic diversity, and ecological events (process) diversity, which were four elements of biodiversity in the literature, in their minds. Moreover, concepts such as systematic, biotechnology, ecology, genetics, and biodiversity conservation were also identified as other important concepts associated with biodiversity by the pre-service teachers as a result of the study. In the study conducted by Jiwa and Esa (2015) it was aimed to determine the understanding of prospective biology teachers on the concept of biodiversity. As a result of the study, it was stated that teacher candidates had sufficient knowledge about biodiversity. However, the study emphasized that teacher candidates do not have sufficient knowledge about biodiversity teaching methods and that studies to determine needs on this subject are needed. The important thing is not only to have knowledge about biodiversity but also to integrate this information into teaching. In the study conducted by Bilgin (2016), it was seen that teachers had a limited understanding of biodiversity. It was observed that teachers reduced the concept of biodiversity to the simple concept of species diversity without taking into account genetic and ecosystem components. Venuste et al. (2017) aimed to investigate the knowledge levels of teacher candidates regarding the protection of biodiversity. It was found that the knowledge levels of teacher candidates regarding biodiversity conservation were sufficient, but additional studies were needed to determine their teaching competencies. Turan and Yangın (2014) evaluated the cognitive interpretations of 585 pre-service teachers about biodiversity in their study. In general, it was found that the pre-service teachers answered very few statements correctly. The statements considered scientifically correct were that the total number of species on the earth's surface was on the decline; that many species in the world were practically beneficial to humanity; that more than half of the world's species lived in tropical forests; that the genetic makeup of each individual of a species differed very little; islands and high mountains had species not found elsewhere, and that the coral reefs were as rich as tropical forests in terms of biodiversity. On the other hand, when we look at the statements that are accepted as scientifically weak, it turned out that the creation of parks and zoos was the best way to protect, that there was more diversity in agricultural products today than in previous times, and that in order to increase the fish diversity in a natural lake, it was the best solution to bring different fish species to that environment, that the disease resistance feature given to the wheat plant by spraying could be passed on to the offspring, that most of the species on earth could tolerate change in their habitats, that an extinct species could reappear in the process of evolution, that the front legs of monkeys lengthened as

they moved to reach higher heights in previous generations, that many species in an ecosystem were independent of each other, wetlands could be dried up in order to provide a livelihood for the people living in that area in sectors such as agriculture and tourism, and finally the rainforest ecosystem had the same connotation as the rainforest community. Harman and Yenikalaycı (2011) found that 57 fourth-year science teacher candidates had insufficient awareness of biodiversity. Pre-service teachers defined biodiversity in terms of species, genetics, ecosystem and ecological function diversity. They defined the living things within the scope of biodiversity as mostly all living things, plants, and animals. They discussed the factors that affected biodiversity positively and negatively in terms of biological, physical and palaeogeographical aspects. They specified the benefits of biodiversity in terms of ecology and environmental health, food and gene supply, economy, medicine, and pharmacy. In the study conducted by Palmberg et al. (2019), Scandinavian teacher candidates' views on learning and teaching genres and the identification of genres were analysed. Learning to identify species and species as the practical part of biodiversity and sustainability education was emphasised as an integral part of teacher education programmes. In the study conducted by Wolff and Skarstein in 2020, it was observed that teacher candidates' interest in nature and nature was encouraged as a result of the study carried out on teaching biodiversity and species in the preschool teacher training program. Çavuş-Güngören and Özdemir (2020) examined the biodiversity literacy of third-year science teacher candidates. According to the results of the analysis, pre-service teachers stated that the loss of biodiversity was caused by reasons such as waste, pollution, lack of education, natural disasters, agricultural practices, and natural and human factors. For the protection of biodiversity, they stated that it should be done through various measures such as prohibitions, training, restriction of waste use, and taking precautions for protection. Hence, they stated that the pre-service teachers' literacy on biodiversity was high. A study examining the sustainable environmental awareness levels of science teacher candidates through biodiversity visuals was conducted by Tekin and Aslan (2022). It transpired that the teacher candidates had sustainable environmental awareness, but they lacked biodiversity components in their drawings. It has been stated that this situation may also be due to drawing skills. Studies have also been conducted on practising teachers. Babou et al. (2023) investigated teachers' presentations on the subject of biodiversity. The results of the study indicate that the majority of teachers perceive the concept of biodiversity as a whole with complex relationships. A study on teaching the concept of biodiversity was conducted by Araujo et al. (2023). Within the scope of the study, Brazilian teachers' opinions and experiences regarding teaching biodiversity with an evolutionary and phylogenetic approach were determined. As a result of the study, it was seen that teachers did not associate it with the concept of biodiversity while teaching the relationships between living things. The results of these studies also point to the deficiencies experienced by teachers in learning the concept of biodiversity during their university education.

When the studies on teacher candidates' views on biodiversity are examined, it is seen that in some of the studies, teacher candidates have insufficient knowledge about biodiversity, their awareness of biodiversity is not at the desired level, and they have difficulty in associating the components. The studies carried out revealed the fact that pre-service teachers had not received a holistic environmental education and that incomplete / scientifically inaccurate information might be effective on their inadequacies in biodiversity

## Methods

### Research Design

A survey model was used in order to identify the current state of affairs. In this study, a mixed research method was used with the integration of both quantitative and qualitative data to approach a research problem in depth (Greene, 2007). An open-ended test was developed and applied in order to measure our participants' conceptual understanding of biodiversity. The answers given were coded and scored quantitatively. The responses derived from the answers suitable for each category were specified qualitatively

**Participants and Context**

The study was conducted with the students studying in a science teacher training undergraduate programme. In this study, the prior education experiences and conceptual understanding levels of all pre-service teachers on the subject of biodiversity were examined. The students participating in the study consisted of a total of 151 students, 50 of whom were first year, 34 second year, 42 third year, and 25 fourth year students.

Table 1 summarizes the participants in terms of gender and age. Of all the participants, 85 % were female and 15% were male. Average ages ranged from 19.21 years to 21.62 years.

**Table 1**

*Participants in the Study by Gender and Age*

| | Mean Age (years) | Male | | Female | | |
|---|---|---|---|---|---|---|
| Grade | X̄ | N | N% | N | N% | N |
| 1 | 19.21 | 11 | 22 | 39 | 78 | 50 |
| 2 | 20.45 | 3 | 8.8 | 31 | 91.2 | 34 |
| 3 | 20.78 | 4 | 9.5 | 38 | 90.5 | 42 |
| 4 | 21.62 | 4 | 16 | 21 | 84 | 25 |
| Total | 20.51 | 22 | 14.57 | 129 | 85.43 | 151 |

In the 2nd to 4th semesters, teacher candidates take the theoretical and applied courses in biology such as Biology I, II, III. Students will also be able to take science teaching methods courses (i.e., learning and teaching approaches, research methods in education, teaching principles and methods, science teaching programmes, teaching technologies, science teaching I and II, science teaching Laboratory Practice I and II, measurement in education, starting from the 3rd semester and assessment, classroom management, interdisciplinary science teaching, environmental education, guidance in schools, out-of-school learning environments in science teaching). Science teacher candidates also have to take Teaching Practice I in the 7th semester and Teaching Practice II in the 8th semester.

Students can also take courses 3-8th semesters with biology content such as science and technology-related problems, human anatomy and physiology, and Turkey's biological richness. They can choose any period they want for those courses, including within the semester.

**Data Collection**

**Biodiversity Test**

The Biodiversity Test, which consists of thirteen open-ended questions, was developed to measure students' conceptual understanding of the subject. For this purpose, a literature review was conducted on the concept of biodiversity. As a result of the literature review, the scope of the test was determined with the data obtained about the meaning of the concept of biodiversity, its components and protection. After determining the scope, questions were created and a draft test form was prepared. Necessary arrangements were made in line with the feedback received and the preliminary application of the questions was carried out. It was concluded that the texts prepared in line with expert opinions and pre-application were suitable for the subject scope and student levels. The biodiversity conceptual test contains two parts; the first 8 questions, it was aimed to establish the level of knowledge about the environment and biodiversity; and the last 5 questions, it was aimed to establish the practical experiences and perceived competencies of the pre-service teachers in teaching biodiversity at school.

**Data Analysis**

To investigate the current knowledge levels of science teacher candidates regarding biodiversity and environmental problems open-ended responses were analysed using the content analysis approach. In this context, firstly, the concepts to be measured were researched by conducting a literature review. Then, the criteria, definitions and scoring levels related to the questions were determined, supported by

data obtained from the literature. After this stage, a draft rubric was created. Two of the researchers collaboratively evaluated the open-ended questions to ensure interrater reliability. A matrix was prepared to evaluate the results of open-ended questions. In developing the answer key, the process steps outlined by Andrade (2000) were followed. The draft answer key was applied to the student answers and the missing points and points that needed correction were identified. Then, the draft key was presented for expert opinion and feedback was received regarding its suitability in terms of conceptual criteria and scope. Each question was evaluated using a scale of weak, moderate, good, and very good. Then, the descriptive frequency and percentage values of the students in each category were calculated. Appendix 1 presents the grading rubric for student responses and a sample of student responses was presented in the findings section. In order to evaluate the previous educational experiences and perceived competencies of science teacher candidates regarding biodiversity teaching in secondary schools descriptive statistical methods i.e. frequency and percentages were used. The questions in the biodiversity conceptual test and the methods used in the analysis of the data are given in Table 2.

**Table 2**

*The Questions in the Biodiversity Conceptual Test and the Methods Used in the Analysis of the Data*

| Dimension | Questions | Data analysis method |
|---|---|---|
| Level of knowledge about the environment and biodiversity | What are the most important environmental problems, and how can they be prevented? | Content analysis |
| | What is biodiversity? What does biodiversity mean to you? | Content analysis |
| | What does the protection of biodiversity mean and what factors does it depend on? | Content analysis |
| | What are the positive and negative factors affecting biodiversity? | Content analysis |
| | Why is it important that we protect biodiversity? | Content analysis |
| | What does the number of living things and the number of species mean to you? | Content analysis |
| | What is the relationship between biodiversity and climate change? | Content analysis |
| | What do you think about biodiversity in Turkey? | Content analysis |
| Practical experiences and perceived competencies | In which courses did you learn about biodiversity? | Descriptive statistics |
| | Have you ever taken any education on environment? | Descriptive statistics |
| | Please indicate your formal and informal education experiences on biodiversity out of school. | Descriptive statistics |
| | To what extent do you feel confident in teaching the subject of biodiversity? | Descriptive statistics |
| | When you become a teacher, which teaching methods and techniques would you consider using in teaching the subject of Biodiversity? | Descriptive statistics |

## Results

The answers given by the pre-service teachers to the question of 'what is biodiversity' evaluated by content analysis and their knowledge levels are given in Table 3.

**Table 3**

*Knowledge Levels of Pre-Service Teachers about the Biodiversity*

| Knowledge level | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | |
| | f | % | f | % | f | % | f | % |
| Weak | 22 | 44 | 24 | 70.6 | 1 | 20.4 | 2 | 8 |
| Moderate | 22 | 44 | 10 | 29.4 | 8 | 19.0 | 3 | 12.0 |
| Good | 6 | 12 | 0 | 0 | 26 | 61.9 | 17 | 68.0 |
| Very good | 0 | 0 | 0 | 0 | 7 | 16.7 | 3 | 12.0 |
| Total | 50 | 100 | 34 | 100 | 42 | 100 | 25 | 100 |

When Table 4 is examined, it is striking that the majority of the 1st year students were at a weak and moderate level, the 2nd year students at a weak level, and the 3rd and 4th tear students at a good level. Although there were no 1st and 2nd year students who defined biodiversity "very good", some of the 3rd and 4th grade students were able to offer an acceptable definition of the term. Below are some sample answers given according to these levels, along with the reasons for coding.

*Very good: Biodiversity is the whole encompassing ecosystem, species and genetic diversity and all life relationships in the biosphere. (3rd Class K17)*

The definition of biodiversity was coded as "very good" because it was made inclusively by referring to the types of biodiversity.

*Good: Biodiversity is the diversity of species and their genetic makeup in a particular region. (3rd Class K21)*

When defining biodiversity, it was coded as "good" because only two of the biodiversity types were mentioned.

*Moderate: Biodiversity is the diversity of living things. (2nd Class K8)*

This definition of biodiversity was coded as "moderate" because it did not refer to the types of biodiversity.

*Weak: They are living things that continue their lives in various living environments. (1st Class K12)*

This definition of biodiversity was coded as "weak" because it was misidentified

The answers given regarding what the protection of biodiversity meant and what factors it depended on are shown in Table 4.

**Table 4**

*Knowledge Levels of Pre-Service Teachers about Biodiversity Conservation*

| Knowledge level | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | |
| | f | % | f | % | f | % | f | % |
| Weak | 24 | 48.0 | 18 | 52.9 | 2 | 4.8 | 1 | 4 |
| Moderate | 23 | 46.0 | 15 | 44.1 | 12 | 28.6 | 4 | 16 |
| Good | 1 | 2.0 | 1 | 20.9 | 25 | 59.5 | 15 | 60 |
| Very good | 2 | 4.0 | 0 | 0 | 3 | 7.1 | 5 | 20 |
| Total | 50 | 100 | 34 | 100 | 42 | 100 | 25 | 100 |

When the level of knowledge about the protection of biodiversity is examined, it is possible to say that the 1st and 2nd year students were mostly weak, and the 3rd and 4th years were at a good level (see table 4). While it was clear that a small part of the first year students were at good and very good levels, the proportion of students with good levels in the second year was higher, and very good answers were

not given. It is notable that the rate of very good answers was higher in 3rd and 4th years than in 1st and 2nd years. Sample responses to these levels are given below along with the coding reasons.
*Very good: Conservation of biodiversity is the protection of living species, genetic diversity of living things, ecosystems and processes. Physical, paleogeographic and biological factors that affect the distribution of biodiversity all affect biodiversity conservation. (3rd Grade K8)*
(The concept of conservation of biodiversity was coded as "very good" because it was defined in terms of biodiversity components and factors affecting the distribution of biodiversity.)
*Good: Conservation of biodiversity is to ensure the continuation of all living things in a particular region. Conservation of biodiversity depends on human activities. (4th Grade K21)*
(The concept of biodiversity conservation was coded as "good" because it was correctly stated by referring to one of the factors on which biodiversity depended.)
*Moderate: Conservation of biodiversity means preserving and not decreasing biodiversity. It depends on the pollution level of the environment and the protection of the living environments of living things. (2nd Class K14)*
(The concept of conservation of biodiversity was coded at "moderate" level because it was only partially correctly defined by referring to the factors on which biodiversity depended.)
*Weak: Giving the necessary importance to the environment. (2nd Class K2)*
(The concept of conservation of biodiversity was coded as "weak" because it was misidentified.)

The knowledge levels of teacher candidates about the positive and negative factors affecting biodiversity are shown in Table 5.

**Table 5.**
*Knowledge Levels of Pre-Service Teachers about the Factors Affecting Biodiversity*

| Knowledge level | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | |
| | f | % | f | % | f | % | f | % |
| Weak | 25 | 50 | 15 | 55.9 | 0 | 0 | 1 | 4.0 |
| Moderate | 23 | 46 | 13 | 38.2 | 11 | 26.2 | 5 | 20.0 |
| Good | 2 | 4 | 2 | 5.9 | 25 | 59.5 | 16 | 64 |
| Very good | 0 | 0 | 0 | 0 | 6 | 14.3 | 3 | 12 |
| Total | 50 | 100 | 34 | 100 | 42 | 100 | 25 | 100 |

When the knowledge levels of the pre-service teachers about the factors affecting biodiversity are examined, it is seen that most of the 1st and 2nd year students were at the weak or moderate level, while the 3rd and 4th years were at a good level. While the 1st and 2nd grades could not answer this question very well, it is seen that some of the 3rd and 4th grade students answered them satisfactorily (see Table 5). Below are examples of the answers given by the pre-service teachers regarding these levels.
*Very Good: There are many factors affecting biodiversity. For example, if we need to explain this, we can say physical factors, paleogeographic factors and biological factors. Temperature, amount of light, protection of the natural environment, proper pH, soil structure and water distribution affect positively. The development of industry, global warming, overfishing, water consumption, forest fires and pollution adversely affect it. (4th Grade K5)*
(Biological factors, physical factors and paleogeographic factors, which were among the factors that affect biodiversity positively and negatively, were categorized as "very good".)
*Good: The factors that affect biodiversity positively or negatively are human influence, climate change and distribution of water resources. (3rd Class K9)*
(It was coded as "good" because it referred to physical and paleogeographic factors, which were the factors that affected biodiversity positively and negatively).
*Moderate: Human activities are at the forefront of the factors affecting biodiversity. We pollute the living spaces, air, seas and soil of living things. (1st Class K13)*
(It was coded as "moderate" level because only one of the factors affecting biodiversity positively or negatively was mentioned).

*Weak: Not considering the environment affects biodiversity. (1st Class K32)*
(Positive and negative factors affecting biodiversity were coded as "weak" because they were not mentioned at all, and the wrong answer was given).
The answers given by the pre-service teachers about the importance of protecting biodiversity were similarly evaluated with content analysis and their knowledge levels on this subject are shown in Table 6.

**Table 6.**
*Knowledge Levels of Pre-Service Teachers about the Importance of Conserving Biodiversity*

| Knowledge level | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | |
| | f | % | f | % | f | % | f | % |
| Weak | 29 | 58 | 19 | 55.9 | 1 | 2.4 | 1 | 4.0 |
| Moderate | 19 | 38 | 14 | 41.2 | 5 | 11.9 | 2 | 8.0 |
| Good | 2 | 4 | 1 | 2.9 | 23 | 54.8 | 13 | 52.0 |
| Very good | 0 | 0 | 0 | 0 | 13 | 31.0 | 9 | 36.0 |
| Total | 50 | 100 | 34 | 100 | 42 | 100 | 25 | 100 |

As is clear in Table 6, most of the 1st year students were weak, the 2nd years were at a moderate level, and the 3rd and 4th years were at a good level. While 3rd and 4th year students were mostly at a very good level, there were no 1st and 2nd year students at that level. Below are some sample statements according to these categories.
*Very good: Conservation of biodiversity is very important. Because the preservation of ecological balance and the continuity of life depend on it. In addition, many substances that increase the quality of life of people are produced thanks to nature. It also contributes to humanity economically. In other words, the protection of biodiversity is important both economically and ecologically. (4th Grade K6)*
(Coded as "very good" because the importance of biodiversity conservation was explained in terms of ecological and economic functions).
*Good: Conservation of biodiversity is necessary for living things to survive. For example, if we give an example from today, the extinction of bees caused the deterioration of the ecological chain. This situation endangers the lives of many living things. (4th Grade K15)*
(Coded as "good" because the importance of biodiversity conservation was explained only in terms of ecological functions).
*Moderate: Conservation of biodiversity is economically important. Because many drugs used in medicine are made from plants in nature. For example, if these plants become extinct, there may be a significant decline in the pharmaceutical industry. (1st Class K40)*
(As the importance of protecting biodiversity was explained through economic functions, it was coded as "moderate".)
*Weak: Nature has rules and people can get hurt if we don't follow them. (2nd Class K26)*
(Coded as "weak" because the importance of biodiversity conservation was misrepresented)
The answers given by the pre-service teachers about the number of living things and species were evaluated by content analysis and the frequencies and percentages of the knowledge levels of 1st to 4th grades according to these codes are shown in Table 7.

**Table 7**
*Knowledge Levels of Pre-Service Teachers about the Identification of Living Things and Species Numbers*

| Knowledge level | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | |
| | f | % | f | % | f | % | f | % |
| Weak | 10 | 20.4 | 10 | 29.4 | 1 | 2.4 | 1 | 4.0 |
| Moderate | 30 | 61.2 | 20 | 58.8 | 15 | 35.7 | 4 | 16.0 |
| Good | 5 | 10.2 | 3 | 8.8 | 19 | 42.2 | 12 | 48.0 |
| Very good | 4 | 8.2 | 1 | 2.9 | 7 | 16.7 | 8 | 32.0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total | 49 | 100 | 34 | 100 | 42 | 100 | 25 | 100 |

When Table 7 is examined, it is seen that most of the 1st and 2nd year students related to the identification of the number of living things and species were at a moderate level, while the 3rd and 4th years were at a good level. Below are the answers given according to these levels.

*Very good: The number of living things is the number of all living things on earth. The number of species, on the other hand, is the number of groups that show similar characteristics and can form fertile offspring when they mate. (3rd Grade K7)*

(It was coded as "very good" because the concepts of number of living things and number of species were expressed correctly)

*Good: The number of living things is a general concept. It is the number of living things possessed by all species in biodiversity. The number of species, on the other hand, is more specific and refers to living groups found in biodiversity. (3rd Class K25)*

(The difference between the concepts of number of living things and number of species was partially put aside. The concepts of number of living things and number of species were coded as "good" because they were answered partially correctly)

*Moderate: The number of organisms is the total number of individuals in a population. Species number is the number of different individuals present in the population. (2nd Class K10)*

(Only the number of living things was coded as "moderate" because it was expressed correctly)

*Weak: The number of living things and species indicates how many subspecies a living thing has. (2nd Class K6)*

(The number of living things and the number of species were coded as "weak" because the concepts were not expressed correctly)

The answers given by the pre-service teachers about the relationship between biodiversity and climate were evaluated by content analysis and the frequencies and percentages of the knowledge levels of 1st to 4th grades according to these codes are illustrated in Table 8.

**Table 8**

*Knowledge Levels of Pre-Service Teachers about the Relationship between Biodiversity and Climate*

| Knowledge level | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | |
| | f | % | f | % | f | % | f | % |
| Weak | 33 | 66.0 | 23 | 67.6 | 2 | 4.8 | 2 | 8.0 |
| Moderate | 16 | 32.0 | 10 | 29.4 | 10 | 23.8 | 2 | 8.0 |
| Good | 1 | 2.0 | 1 | 2.9 | 17 | 40.5 | 13 | 52.0 |
| Very good | 0 | 0 | 0 | 0 | 13 | 31.0 | 8 | 32.0 |
| Total | 50 | 100 | 34 | 100 | 42 | 100 | 25 | 100 |

When Table 8 is examined, it is seen that most of the 1st and 2nd year students were weak, while the 3rd and 4th years were at a good level. Similarly, while the 1st and 2nd year students could not give very good answers, a significant part of the 3rd and 4th years were able to respond at this level.

Examples of answers given by pre-service teachers according to these levels are given below.

*Very good: There is a great relationship between biodiversity and climate. Climate change affects the number of species, genetic diversity and ecological functions in a particular region. It is one of the most important factors affecting the distribution of biodiversity on earth. Climate change can damage biodiversity by disrupting the living relationships of a particular region. (4th Grade K21)*

(The relationship between biodiversity and climate change was coded as "very good" because it was explained by relating biodiversity to its species)

*Good: Climate change may lead to the inability of some living things to adapt to new climatic conditions and thus to a decrease in biodiversity. (4th Grade K5)*

(The relationship between biodiversity and climate change was coded as "good" because it was explained through the species diversity, one of the biodiversity types)

*Moderate: There is an inverse relationship between biodiversity and climate. The more the climate changes, the less biodiversity decreases. (2nd Class K11)*

(Coded as 'moderate' because the relationship between biodiversity and climate change was correctly explained without mentioning biodiversity types).

*Weak: Climate change is a natural process. There is a natural relationship between biodiversity and climate. (1st Class K6)*

(Coded as "weak" because the relationship between biodiversity and climate change was not explained)

The answers given by the pre-service teachers about the biodiversity in Turkey were evaluated with content analysis and their knowledge levels on this subject are shown in Table 9.

**Table 9**

*Knowledge Levels of Pre-Service Teachers about the Biodiversity in Turkey*

| Knowledge level | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | |
| | f | % | f | % | f | % | f | % |
| Weak | 32 | 64.0 | 26 | 76.5 | 1 | 2.4 | 1 | 4.0 |
| Moderate | 17 | 34.0 | 7 | 20.6 | 6 | 14.3 | 2 | 8.0 |
| Good | 1 | 2.0 | 1 | 2.9 | 19 | 45.2 | 10 | 40.0 |
| Very good | 0 | 0 | 0 | 0 | 16 | 38.1 | 12 | 48.0 |
| Total | 50 | 100 | 34 | 100 | 42 | 100 | 25 | 100 |

It is seen that most of the 1st and 2nd grades were weak, 3rd graders were good and 4th graders were very good. None of the students from the 1st and 2nd grades were able to give very good answers (See Table 9). Below are sample answers to these categories.

*Very good: Turkey is country rich in biodiversity. Having many transitional climates, being surrounded by seas on three sides, and the difference in elevation from west to east, support the survival of many species. Turkey has the diversity of ecosystems that enable living things to live. In addition, Turkey is a country where many endemic creatures live. (4th Grade K 19)*

(The biodiversity in Turkey was coded as "very good" because it was handled in terms of biodiversity types, climate and geographical features)

*Good: Turkey has many plant and animal species. There are many different ecosystems in our country. In this way, the number of living things is quite large. There are genetically rich species in our country, for example, there are only six fig species in Turkey. (3rd Class K23)*

(Turkey's biodiversity was coded as "good" since it was only considered in terms of biodiversity species)

*Moderate: Biodiversity in Turkey is quite high. Because we have very different climatic conditions and because of our geographical location, we can come across many living things. (2nd Class K32)*

(As biodiversity in Turkey was only considered in terms of climate and geographical features, it was coded at "moderate" level.)

*Weak: Turkey is not country rich in biodiversity. Many living things that used to exist no longer exist. (2nd Class K29)*

(Turkey's biodiversity was categorized as "weak" because it was not properly expressed.)

Results about experiences and perceived competencies of prospective science teachers in applying biodiversity teaching at school

The answers given by the pre-service teachers about the most important environmental problems and how to prevent them are shown in Table 10.

**Table 10**

*The Views of Pre-Service Teachers about General Environmental Problems.*

| Environmental problems | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | |
| | f | % | f | % | f | % | f | % |
| Water pollution | 11 | 15.1 | 9 | 18.8 | 15 | 21.1 | 6 | 15.4 |
| Air pollution | 10 | 13.7 | 14 | 29.2 | 15 | 21.1 | 12 | 30.8 |
| Soil pollution | 2 | 2.7 | 5 | 10.4 | 2 | 2.8 | 3 | 7.7 |
| Solid waste | 20 | 27.4 | 14 | 29.2 | 18 | 25.4 | 8 | 20.5 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Global warming | 5 | 6.8 | | | 2 | 2.8 | 1 | 2.6 |
| Natural disasters (i.e., Forest fires, erosion | 2 | 2.7 | 2 | 4.2 | | | 1 | 2.6 |
| Urban Sprawl | 2 | 2.7 | | | 1 | 1.4 | 3 | 7.7 |
| disappearance of green spaces | 3 | 4.1 | 4 | 4.2 | | | 1 | 2.6 |
| chemicals | 14 | 19.2 | | | 8 | 11.3 | | |
| Greenhouse effect | 1 | 1.4 | | | | | | |
| Climate change | 1 | 1.4 | | | 1 | 1.4 | 1 | 2.6 |
| Noise pollution | 2 | 2.7 | 2 | 4.2 | 3 | 4.2 | 1 | 2.6 |
| depletion of natural resources | | | | | 1 | 1.4 | | |
| Water shortage | | | | | 3 | 4.2 | | |
| desertification | | | | | 2 | 2.8 | | |
| Population growth | | | | | | | 1 | 2.6 |
| Light pollution | | | | | | | 1 | 2.6 |
| Total | 73 | 100 | 48 | 100 | 71 | 100 | 39 | 100 |

When Table 10 is examined, it is seen that the first-year teacher candidates focused on solid waste and water pollution, the second grade on air and soil pollution, the third grade on soil air and water pollution, and the fourth grade on air and soil pollution related to the most important environmental problems. In this question, it is possible to say that the answers about environmental problems were mostly given by the 3rd and 1st grade students, followed by the 2nd and 4th year students, respectively. In general, it is seen that pre-service teachers had an idea about important environmental problems, but they never mentioned the issue of biodiversity.

According to the data obtained from the students, it is seen in Table 11 in which courses they were taught on the subject of biodiversity.

**Table 11**

*Frequency and Percentages on the Courses in Which the Subject of Biodiversity Is Learned According to Year Levels*

| Grade | Courses | N | % |
|---|---|---|---|
| 1 | Biology | 14 | 28 |
| | Unlearned | 36 | 72 |
| 2 | Biology | 25 | 73.5 |
| | Renewable energy sources | 3 | 8.8 |
| | Learning and teaching approaches | 6 | 17.6 |
| 3 | Biology | 26 | 51 |
| | Turkey's biological richness | 14 | 27.5 |
| | Renewable energy sources | 2 | 3,9 |
| | Environmental education | 9 | 17.7 |
| 4 | Biology | 11 | 30 |
| | Turkey's biological richness | 10 | 27.8 |
| | Environmental education | 10 | 27.8 |
| | Renewable energy sources | 2 | 5.6 |
| | Earth science | 2 | 5.6 |
| | Science teaching | 1 | 2.8 |

*Note: Some students specified more than one course name.*

These results show us that as the year level increased, the number of courses related to biodiversity and pedagogy increased as well. As the number and variety of courses increased, the prior education experience of pre-service teachers on the subject increased as well (see Table 11).

When the experiences of the teacher candidates in environmental education are examined, it is seen that the majority of the 1st (76%) and 2nd (82.4) graders had no experience, and the majority of the 3rd (66.7) and 4th (60%) graders had an experience. (See Table 12).

**Table 12**

*Environmental Educational Experiences of Teacher Pre-Service Science Teachers*

| Status | Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | |
| | f | % | f | % | f | % | | |
| Yes | 12 | 24.0 | 6 | 17.6 | 28 | 66.7 | 15 | 60.0 |
| No | 38 | 76.0 | 28 | 82.4 | 14 | 33.3 | 10 | 40.0 |

It is clear that the pre-service teachers had limited experience with out-of-school formal and informal education on biodiversity. In this question, most of the 1st, 2nd and 4th grades stated that they had no experience, and most of the 3rd graders stated that they had informal education such as watching TV programmes on biodiversity (See Table 13).

**Table 13**

*Out-Of-School Environmental Experiences of Teacher Candidates on Biodiversity*

| Grade | Formal | | Informal | | No experience | |
|---|---|---|---|---|---|---|
| | f | % | f | % | f | % |
| 1 | 5 | 10 | 5 | 10 | 40 | 80 |
| 2 | 6 | 17.6 | 4 | 11.8 | 24 | 70.6 |
| 3 | 6 | 14.3 | 19 | 45.2 | 17 | 40.5 |
| 4 | 2 | 8.0 | 6 | 24.0 | 17 | 68.0 |

When Table 14 is examined regarding how competent teacher candidates felt in teaching the subject of Biodiversity, it is striking that most of the 1st (62%) 2nd (50%) and 3rd (45.2%) grades did not feel sufficient, whereas the 4th graders (40.0%) felt sufficient.

**Table 14**

*Perceived Competencies in Teaching Biodiversity*

| Grade | Knowledge level | N | % |
|---|---|---|---|
| 1 | Yes | 12 | 24 |
| | No | 31 | 62 |
| | Partially | 7 | 14 |
| 2 | Yes | 9 | 26.5 |
| | No | 17 | 50.0 |
| | Partially | 8 | 23.5 |
| 3 | Yes | 16 | 38.1 |
| | No | 19 | 45.2 |
| | Partially | 7 | 16.7 |
| 4 | Yes | 10 | 40.0 |
| | No | 9 | 36.0 |
| | Partially | 6 | 24.0 |

Regarding the question, "When you become a teacher, which teaching methods and techniques would you consider using in teaching the subject of Biodiversity?", the opinions of the pre-service teachers according to their grade levels can be seen in Table 15.

**Table 15**

*Opinions of Pre-Service Teachers about the Methods to Be Used in Teaching Biodiversity*

| Grade | Methods and Techniques | N | % |
|---|---|---|---|
| 1 | Presentation method | 16 | 32.0 |
| | Learning by doing techniques | 5 | 10.0 |
| | Case study method | 3 | 6.0 |
| | Computer based learning | 1 | 2.0 |
| | Trip-observation method | 1 | 2.0 |

| | | | |
|---|---|---|---|
| | Unspecified | 24 | 48 |
| 2 | Presentation method | 19 | 44.2 |
| | Trip-observation method | 11 | 25.6 |
| | Learning by doing techniques | 5 | 11.6 |
| | Constructivist approach | 2 | 4.7 |
| | Discussion method | 1 | 2.3 |
| | Unspecified | 5 | 11.6 |
| 3 | Trip-observation method | 16 | 27.6 |
| | Discussion method | 9 | 15.5 |
| | Presentation method | 8 | 13.8 |
| | Demonstration method | 7 | 12.1 |
| | Brainstorming | 5 | 8.6 |
| | Case study method | 5 | 8.6 |
| | Drama method | 4 | 6.9 |
| | Discovery learning based | 2 | 3.4 |
| | Experimental method | 2 | 3.4 |
| 4 | Trip-observation method | 9 | 22.5 |
| | Presentation method | 9 | 22.5 |
| | Project based learning | 6 | 15 |
| | Argumentation | 6 | 15 |
| | Learning by doing techniques | 5 | 12.5 |
| | Discussion method | 2 | 5 |
| | Discovery learning | 2 | 5 |
| | Drama method | 1 | 2.5 |

While most of the first graders could not express their opinions on this question, the teaching method that followed it was 'teaching by presentation'. 2nd graders stated the method of 'teaching through presentation' and 'trip-observation', respectively. 3rd graders reported 'trip observation', 'discussion and presentation methods', while 4th graders mentioned 'trip observation', 'presentation, project-based learning and argumentation' methods (See Table 15**).**

## Conclusions and Discussion

In this study, we implemented an investigation in attempt to identify the knowledge levels of pre-service science teachers about biodiversity and their prior education experiences and perceived competencies of them in applying biodiversity teaching at schools. In the present study, teacher candidates' general environmental problems, identification and protection of biodiversity, factors affecting biodiversity, the importance of protecting biodiversity, identification of number of living and species, the relationship between biodiversity and climate and biodiversity in Turkey, as well as their general knowledge levels about biodiversity and providing education on biodiversity and their general experiences of self-efficacy and pedagogical and content knowledge on biodiversity were all investigated.

When the knowledge levels of pre-service teachers about biodiversity are considered, positive and negative results stood out according to their year levels. To summarise the results according to class levels; 44% of first-year students either misidentified or failed to define biodiversity while another 44% defined biodiversity without mentioning its types. The results indicated that as the grade levels of pre-service science teachers increased, their level of knowledge on biodiversity increased as well. 48% of them either incorrectly stated the conservation of biodiversity and the factors it depended on or failed to answer. On the other hand, 46% could only explain the conservation of biodiversity or some of the factors it depended on. 50% of them could not explain the positive and negative factors affecting biodiversity or they explained it completely incorrectly. On the other hand, 46% were able to specify some of the positive or negative factors. Similarly, while 58% misexplained the importance of biodiversity conservation, 38% explained it only on its economic functions. 61.2% of them were able to explain only one of the numbers of living things or species. 66% of them about the relationship between

biodiversity and climate and 64% of them about biological richness in Turkey gave weak answers. Despite the fact that our country has a rich biological diversity, the answers given by the pre-service teachers about the biodiversity in Turkey indicated that there was not enough connection between knowledge and real life (Yüce and Önel, 2015).

Similar results were obtained in the knowledge levels of the second graders on biodiversity. 70.6% of the pre-service science teachers gave weak answers on the definition of biodiversity, 67.6% on the explanation of the relationship between biodiversity and climate, and 76.5% on the biological richness of Turkey. In the conservation of biodiversity, 52.9% were weak and 44.1% moderate, 55.9% weak and 38.2% moderate in the factors affecting biodiversity, 55.9% weak and 41.2% moderate in the importance of biodiversity conservation. On the other hand, 58.8% of them were able to define the number of living things and species at a moderate level.

When the first and second grades are evaluated together, it is possible to say that very low levels of good and very good answers were given in terms of their knowledge on biodiversity. As Tekin and Aslan (2022) stated in their study, the fact that the concept of biodiversity was an abstract and difficult concept to learn may have led to this situation. The results of similar studies conducted in different countries, in parallel with this study, show that the meaning and components of the concept of biodiversity are not understood (Dikmenli, 2010; Dresner, 2002; Gayford, 2000). Miani et al.(2016) stated that university students had limited views on the conservation of biodiversity, and the discussion of biological issues remained superficial and had difficulty in balancing the economic, social and environmental interests in order to identify the priority areas for conservation, and most of them were not aware of current concepts related to biodiversity conservation. However, when the literature is examined, it is seen that there are studies that contradict this situation (Jiwa & Esa, 2015; Palmberg et al., 2019; Wolff & Skarstein, 2020). Among these studies, the study conducted by Jiwa and Esa (2015) stated that although the knowledge levels of teacher candidates were sufficient, there were deficiencies in teaching methods. This indicates that having knowledge about the concept of biodiversity will not be sufficient for teacher candidates.

Considering the knowledge levels of 3rd and 4th grade teacher candidates on biodiversity, predominantly positive results were revealed. The results, in order of sub-headings, are as follows: a) Definition of biodiversity; 61.9% good and 16.7% very good (3rd grades) and 68% good and 12% very good (4th grades). Conservation of biodiversity; 69.5% good and 7.1% very good (3rd grades) and 60% good and 20% very good (4th grades). Factors affecting biodiversity; 59.5% good and 14.3% very good (3rd grades) and 64% good and 12% very good (4th grades). Importance of biodiversity conservation 54.8% good and 31% very good (grades 3) and 52% good and 36% very good (grades 4). Identifying the number of living and species; 42% good and 16.7% very good (3rd grades) and 48% good and 32% very good (4th grades). The relationship between biodiversity and climate; 40.5% good and 31.5% very good (3rd grades) and 52% good and 32% very good (4th grades). Biodiversity in Turkey; 45.2% good and 38.1% very good (3rd grades) and 40% good and 48% very good (4th grades). As is clearly seen, as the grade levels increased, the level of knowledge also increased. Naturally, these are expected results. Compulsory and elective courses taken by pre-service teachers on biodiversity increased according to their grade levels. Teacher candidates' knowledge levels regarding biodiversity may be affected by their previous training, personal experiences, interests, sociocultural life, and the richness of the materials in teaching environments (Jensen & Schnack, 2006). However, it is expected that individuals who choose to be a science teacher as a profession will be interested in nature, cycles in nature and biodiversity, and that knowledge in this field will develop over time (Yenice et al., 2022). The study results also parallel this situation. The results of the study done by Uzun et al. (2010) showed that pre-service teachers had limited pre-knowledge in the concepts of biodiversity, species diversity, ecosystem and ecology, whereas Yüce and Önel (2015)'s 4th grade science teacher candidates' had four elements of biodiversity. It is similar to the level of being able to relate species diversity, ecosystem diversity, genetic diversity and ecological events diversity. A similar situation was found by Venuste et al. (2017), Palmberg et al. (2019) and Wolff and Skarstein (2020). However, Bilir and Özbaş (2017) determined that the environmental beliefs of high school students differed according to their grade years, and that the

responsibilities and perceived abilities of 12th grade students were higher than those of 11th grade students. They also stated that, in a global context, 12th grade students' personal norms were higher than 10th and 11th grade students when compared in terms of academic year.

The second research question was to identify the experiences and perceived competencies of pre-service science teachers in applying biodiversity teaching at school. When the views of pre-service teachers on general environmental problems are examined, it is seen that there was an awareness at all grade levels, but none of the students had addressed a problem related to biodiversity. This is an interesting result when examining which courses the pre-service teachers learned about the subject of biodiversity; only 72% of the first graders stated that they did not learn it, while all of the 2nd, 3rd and 4th grades stated that they learned the subject in compulsory biology courses and various elective courses. However, most of the 1st and 2nd grades had no experience in environmental education, while the 3rd and 4th grades had environmental education experience. It was found that most of the 1st, 2nd and 4th grade teachers had no experience in out-of-school formal and non-formal education on biodiversity, and most of the 3rd graders had informal experiences. It is significant that most of the 1st, 2nd and 3rd grades of the pre-service teachers did not feel competent enough in teaching the subject of biodiversity, while the 4th graders felt competent. These results indicated the educational problems arising from the lack of clarity and understanding of the concept of biodiversity, as reported in the study of Yüce and Önel (2015).When the opinions of the pre-service teachers regarding the methods to be used in biodiversity teaching were examined, 1st and 2nd grades mentioned the traditional approaches such as the presentation method, while the 3rd and 4th grades stated that the student-centered methods such as travel-observation discussion, project-based learning and argumentation could be used. In order to teach biodiversity effectively, teachers needed to use more than one method and connect with students' lives and interests (Jiwa & Esa, 2015; Schaal et al., 2012). In this context, it is seen that the methods and method variety preferred by the 3rd and 4th grade teacher candidates in biodiversity teaching were more appropriate. Additionally, the results obtained are similar to Yli-Panula et al. (2018) is also parallel to the results of the study conducted. According to the data obtained from the analysis of 317 international articles examined within the scope of the study, the most preferred methods in biodiversity teaching were determined as applied teaching, experiential learning and teacher presentation.

When all these results are taken together, although the conceptual learning on biodiversity increased according to grade levels, only most of the 4th graders felt competent in teaching it. This result is believed to be due to the weaknesses of pre-service teachers in environmental education, their lack of out-of-school experience, and their inability to integrate theory and practice. On the basis of this situation, as stated in the study conducted by Lindemann-Matthies et al. (2011), only teacher education programs that aimed to fill the knowledge gaps related to biodiversity had a great impact. When other studies on pre-service teachers' views on biodiversity are examined, it is obvious that they had insufficient knowledge about biodiversity, their awareness of biodiversity was not at the desired level, and they had difficulty in associating the components that made up them (Palmberg et al., 2019; Venuste et al., 2017; Wolff & Skarstein, 2020). Abdullah et al. (2022) state that, in general, direct nature experiences have a positive effect on increasing biodiversity knowledge, and more specifically, increasing the frequency of visiting nature areas, contact with plants and contact with animals have an impact on biodiversity knowledge. For this reason, more emphasis should be given to out-of-school educational activities at all levels of education, from primary education to higher education. Erdoğan and Özsoy (2007) also emphasize that formal education from kindergarten to university can influence the development of environmental awareness by integrating relevant environmental issues into the curriculum. For this purpose, instead of emphasizing only theoretical knowledge about the environment, they recommend organizing practical activities such as field trips and nature trips in order to encourage the transfer of this theoretical knowledge into practice. They state that with this approach, children, young people, adults and the elderly can learn about environmental problems more easily and develop environmental awareness and action skills from a constructivist perspective.

The results of our study and the literature revealed that the lack of holistic environmental education and the incomplete/scientifically incorrect information of pre-service teachers might have an impact on their inadequacy in biodiversity. This issue should be taken into account in undergraduate teacher education, since instruction is one of the most important factors contributing to the conservation of biological diversity (Robles-Moral, et al 2022; Tekin and Aslan, 2022) and it is difficult to learn and teach because it is abstract due to insufficient examples (Palmberg et al., 2017). Because each teacher candidate, as a leading individual of the society, will educate many students and exchange ideas with his colleagues (Barker & Elliot, 2000). As a result, creating biodiversity awareness among the teacher candidates is important both in terms of increasing their awareness of various species in our country and transferring these species to future generations.

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## Appendix 1

| Question | LEVEL 1 (Weak) | 2 (Moderate) | 3 (Good) | 4 (Very Good) |
|---|---|---|---|---|
| What are the most important environmental problems in your opinion and how they can be prevented? | He/She did not touch on environmental problems, did not offer ideas for the prevention of environmental problems / presented wrong ideas. | He/She partly touched on environmental problems, did not offer ideas for the prevention of environmental problems / presented wrong ideas. | He/She touched on environmental problems scientifically and presented partially correct ideas for the prevention of environmental problems. | He/She touched on environmental problems scientifically and presented correct ideas for the prevention of environmental problems. |
| What is biodiversity? What does biodiversity mean to you? | Misidentified or not defined biodiversity at all. | He/she defined biodiversity without mentioning its species. | He/she defined biodiversity correctly by referring to its species partially. | He/she defined biodiversity with its species fully and accurately. |
| What does the protection of biodiversity mean and what factors does it depends on? | Incorrect or not specifying the definition of biodiversity conservation and the factors on which it depends. | It correctly stated only the conservation of biodiversity or only the factors on which it depends | He/She has partially corrected the definition of biodiversity conservation and the factors on which it depends. | It has fully and accurately stated the definition of biodiversity conservation and the factors on which it depends. |
| What are the positive and negative factors affecting biodiversity? | He did not address the positive and negative factors affecting biodiversity or gave wrong answers | He mentioned only positive or only negative factors affecting biodiversity. | He stated at most one of the positive and negative factors affecting biodiversity | He stated more than one positive and negative factors affecting biodiversity. |
| Why is it important that we protect biodiversity? | Misrepresented or misrepresented the importance of | He explained the importance of protecting biodiversity | He explained the importance of protecting biodiversity | He explained the importance of protecting biodiversity |

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|---|---|---|---|---|
| | biodiversity conservation. | only through economic functions. | only through ecological functions. | through ecological and economic functions. |
| What does the number of living things and the number of species mean to you? | He misunderstood or did not explain the concepts of the number of living things and the number of species. | He correctly explained only one of the concepts of the number of living things and the number of species. | He partially correctly expressed the concepts of the number of living things and the number of species. | He correctly expressed the concepts of the number of living things and the number of species. |
| What is the relationship between biodiversity and climate change? | He misrepresented or did not explain the relationship between biodiversity and climate change. | He explained the relationship between biodiversity and climate change without mentioning biodiversity types. | He explained the relationship between biodiversity and climate change by referring to some types of biodiversity | He explained the relationship between biodiversity and climate change by associating it with the types of biodiversity. |
| What do you think about biodiversity in Turkey? | He could not accurately describe the biodiversity in Turkey | He discussed the biodiversity in Turkey only in terms of the number of species. | He discussed the biodiversity in Turkey in terms of the number of species and habitat diversity. | He discussed biodiversity in Turkey in terms of number of species, habitat diversity, ecological function diversity and genetic diversity. |