REPORT ON BIOLOGY EDUCATION IN TÜRKİYE ISSUES, SOLUTIONS AND BEST PRACTICES

Series on Fundamental Sciences Education

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ECO
Educational Institute

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FOREWORD

The following report provides a summary of the outcomes from the two-day "Workshop on Challenges and Solutions in Biology Education at Secondary and Undergraduate Levels in Türkiye." The workshop was organized by the Economic Cooperation Organization Educational Institute (ECOEI) and took place on 23-24 February 2023 in Ankara. The reporting team responsible for documenting the workshop's insights and recommendations was led by Prof. Dr. Semra Mirici from Gazi University, Gazi Faculty of Education, who also pioneered the framework of the workshop and meticulously curated its sessions. The reporting team included Assoc. Prof. Dr. Duygu Sönmez from Hacettepe University, Assoc. Prof. Dr. Çiğdem Alev Özel and Assoc. Prof. Dr. Nurcan Uzel, both from Gazi University.

This was the third workshop of the Workshop Series on Fundamental Sciences Education which brings together researchers, educators, administrators, and students in different fields of fundamental sciences education. The objective of these workshops is to tackle the challenges, identify the strengths, and highlight the best practices in each respective field. These workshops aim to support the education of upcoming generations in fundamental sciences and help the advancement of education in applied fields such as engineering, economics, and medicine.

"Workshop on Challenges and Solutions in Biology Education at Secondary and Undergraduate Levels in Türkiye." explored innovative teaching methods that integrate multiple disciplines into biology education and provided a platform for educators, researchers, and professionals from various fields to come together and discuss the benefits and challenges of diverse approaches in biology education. In this workshop, ECO Educational Institute brought together several academicians from biology and biology education departments and teachers and administrators from high schools and middle schools, both public and private.

On the initial day of the workshop, participants engaged in a comprehensive exploration of the prevailing challenges within the discipline. Subsequently, on the second day, attendees shared their insights by presenting exemplary approaches and offering policy recommendations. Each session was followed by an interactive Q&A session, fostering further discussion, encouraging questions from fellow speakers, and facilitating valuable contributions.

I would like to extend my heartfelt gratitude to Prof. Dr. Semra Mirici for her contributions to both the organization of the workshop and reporting of its outcomes as well as the dedicated reporting team, Assoc. Prof. Dr. Duygu Sönmez, Assoc. Prof. Dr. Çiğdem Alev Özel and Assoc. Prof. Dr. Nurcan Uzel. Their invaluable efforts in documenting the insights and recommendations will have a valuable impact for enhancing biology education at various academic levels in Türkiye. I would also like to express my appreciation for graduate students Seher Akbay, Canan Bilgili, Ayşe Rümeysa Karacasoy, Özge Savran and Kader Nur Ocak for their enthusiasm and hard work, which brings hope and inspiration to our endeavors. Finally, I would like to thank all speakers, who graciously accepted our invitation and shared their valuable experience, research and insights.

ECOEI recognizes the significance of biology education as a cornerstone of fundamental sciences, fostering critical thinking, problem-solving, and scientific literacy. As we reflect on this workshop's achievements, we express our wishes for the promotion and advancement of fundamental sciences education throughout the ECO region and hope that this workshop serves as a catalyst for collaborative initiatives and inspire teachers who will raise the next generation of aspiring scientists and researchers and support them in their pursuit of knowledge and discovery.

Prof. Dr. M. Akif Kireçci
President
ECO Educational Institute

PREFACE

With the rapid advancement of science and technology, the field of biology offers more career opportunities than ever before. Biology and interdisciplinary biology are increasingly recognized as the professions of the future, with exponential growth. However, as we teach science to young people, it is crucial to provide learning environments that will enable them to make the right decisions through linking this knowledge with ethical and social values.

This workshop was organized with the participation of numerous academicians, undergraduate and graduate students, experts, and competent teachers, with the awareness and responsibility that scientific methods employed in educational settings can have significant impact on the whole lives of our country's children/youth while preparing them for the future.

The workshop has provided a platform for sharing experiences and information on various issues, including programs, textbooks, teacher competencies, student motivation and environmental factors in science education, sometimes by nature, in particular biology education at all levels of education from primary school to undergraduate level.

This report summarizes the presentations delivered at the workshop, the insights derived from these presentations and the findings from the focus group discussions. In the final section of the report, we discuss the main challenges in biology education and propose potential solutions within the framework of existing literature. The ultimate goal shared by all stakeholders participating in the workshop is for this report to contribute to the resolution of the challenges faced in biology education.

I would like to express my gratitude to Prof. Dr. M. Akif KİREÇCİ, President of the Economic Cooperation Organization Educational Institute, and his dedicated staff for their invaluable work. I also extend my thanks to all the participants, including academicians, teachers, and students, who contributed to

the workshop process. Special thanks go to Assoc. Prof. Dr. Duygu SÖNMEZ, Assoc. Prof. Dr. Çiğdem Alev ÖZEL and Assoc. Prof. Dr. Nurcan UZEL for their contributions to the preparation of the report.

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Workshop Series on Fundamental Sciences Education - 3

WORKSHOP ON CHALLENGES AND SOLUTIONS IN BIOLOGY EDUCATION AT SECONDARY, AND UNDERGRADUATE LEVELS

Ankara, 23-24 February 2023

Invited Speakers

Prof. Dr. Ali GÜL, Gazi University, Gazi Faculty of Education

Prof. Dr. Ertunç GÜNDÜZ, Hacettepe University, Faculty of Science

Prof. Dr. Mehmet YILMAZ, Gazi University, Gazi Faculty of Education

Prof. Dr. Hülya YILMAZ, Ege University, Faculty of Education

Prof. Dr. Feray KÖÇKAR, Balıkesir University, Faculty of Science

Prof. Dr. Füsun EYİDOĞAN, Başkent University, Faculty of Education

Prof. Dr. Tahir ATICI, Gazi University, Gazi Faculty of Education

Assoc. Prof. Dr. Duygu SÖNMEZ, Hacettepe University, Faculty of Education

Teacher Neslihan SOYSAL, Hacettepeliler Education Institution Anatolian High School

Teacher Yasemin HORASAN, İzmir Anatolian High School

Teacher Dr. Aynur Elif BULUT, Ankara Science High School

Teacher Kurtuluş ATLI, Nevşehir Şehit Furkan Demir Anatolian High School

Teacher Aylin Güner KAHRAMAN, Strategy Development Department R&D Unit, Ministry of National Education

Organized by

Economic Cooperation Organization Educational Institute

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Master's Student Kader Nur OCAK

INTRODUCTION

Biology is the science of human survival on earth. As the human population continues to grow, often disregarding the laws of biology and ecology, we try to live on a day-to-day basis by distancing ourselves from nature, forgetting that we are part of it. However, it is not possible for humanity to survive without knowing and being at peace with nature. Only by embracing ecological principles can the current generation secure a sustainable ecosystem for future generations.

Biology, often referred to as the life sciences, represents the fundamental scientific discipline of the 21st century that studies the structures of living organisms, the functioning of their organs and their interactions with both living and non-living elements in their environment. Biological diversity stands as an immense organic repository, in which the solutions to the challenges faced by living beings during millions of years of evolution are encoded in their genes. Therefore, the disappearance of any species signifies the disappearance of potential solutions to future challenges confronting humanity. All studies in the field of biology contribute to the preservation of natural balance and the continuation of life. In this regard, the significance of effective biology education is "vital" in the strictest sense of the word.

One of the misconceptions surrounding biology education is the belief that biology is a subject that requires rote memorization of numerous concepts and Latin names. However, effective biology education involves developing a conceptual understanding of fundamental biological ideas and processes. Another misconception is perceiving biology as solely relevant to those planning a career in science. In reality, biology education equips students with the knowledge necessary to make informed decisions about their futures. Learning biology imparts insights into the hows, whys and whens of life processes through discovery and experimentation. It cultivates an understanding of the dynamics of living organisms and how they interact with their environment. More importantly, studying biology nurtures students' critical thinking skills and problem-solving abilities. Moreover, through developing the ability to interpret data, evaluate situations realistically and construct logical arguments, students and individuals acquire critical thinking skills and problem-solving

abilities, which are among the most important proficiencies we aim to teach. These skills are vital to success accross diverse professions and careers in 21st century.

The field of biology presents more career opportunities than ever before, thanks to the advancements in the fields of science and technology. As one of the key professions of the future, the fields of biology and interdisciplinary biology (such as biotechnology and pharmaceuticals) occupy an increasing place with exponential growth. While intelligent robots may assume many of human tasks in the future, there are plans based on scenarios to integrate individuals with distinct human competencies (such as intuition, flexible thinking, holistic perspectives, decision-making abilities), that is, individuals with developed social and emotional skills, to work in collaboration with robots (Erkman et al., 2019). Therefore, as we teach science to our children, it is also crucial to establish learning environments that enable them to make well-informed decisions by associating this knowledge with ethical, social, political, and even economic values.

1.1. Objectives and Program Flow of the Workshop

Thise workshop aims to address the challenges, strengths, and best practices in the field of biology and biology education in order to facilitate the education of new generations, enabling them to make positive contributions to the development of the field of biology and biology education.

The "Workshop on Challenges and Solutions in Biology Education at Secondary and Undergraduate Levels in Türkiye" was held on 23-24 February 2023 with the support of the Economic Cooperation Organization Educational Institute (ECOEI), The workshop brought together academics, teachers, experts from the Ministry of National Education (MoNE), undergraduate and graduate students to discuss the current state of biology education at various levels and explore strategies to improve it (see Appendix 1-2).

The workshop started with opening speeches by Prof. Dr. M. Akif Kireçci, President of ECOEI and Prof. Dr. Mahmut Selvi, Dean of Gazi University, Gazi Faculty of Education. This was followed by a keynote presentation titled "Science Education in the 21st Century" by Prof. Dr. Semra Mirici, faculty member of Gazi Faculty of Education and Chair of the Workshop Organizing Committee.

The main objectives of the workshop are as follows:

- Identify the key challenges related to biology education curricula of at the secondary and undergraduate levels and to propose solutions.
- Identify the key challenges related to teacher and lecturer competencies in biology education at various levels and to propose solutions.
- Identify the key challenges related to student competencies in biology education at various levels and to propose solutions.
- Identify the key challenges related to the teaching environment and textbooks in biology education at various levels and to propose solutions.
- Identify the key challenges related to teaching methods and techniques in biology education at various levels and to propose solutions.
- Enhance the widespread impact of the workshop outcomes by collecting academic articles by academics and teachers on the subject and publish them in a book in Turkish and English languages.

This report provides a summary of the presentations made during the workshop, the shared perspectives reached at the end of the presentations and the findings from the focus groups. The report concludes by discussing the main challenges in biology education and presenting solutions supported by current literature. All stakeholders who participated in the workshop hope that this report will contribute to resolving these challenges.

1.2. Current State of Biology Education in Secondary Schools

This section provides an overview of the current state of biology education in secondary schools, focusing on the curriculum, courses, course materials and physical conditions.

1.2.1. Biology Curriculum in Secondary Schools

Secondary education institutions operate within the framework of the specific and general objectives of Turkish National Education, with the aim of promoting democracy, universal principles of law and human rights, student-centered and active learning environments.

The general objectives of secondary education institutions include the following:

- Developing students' physical, mental, moral, spiritual, social, and cultural qualities while instilling respect for democracy and human rights and preparing them for future by equipping them with knowledge and skills relevant to the contemporary age.
- Preparing students for higher education, professions, and various aspects of life and work by providing them with a solid general culture at the secondary education level.
- Creating healthy, balanced, and dynamic educational and professional relationships in accordance with the principles and policies of the MoNE.
- Provide students with skills including self-confidence, self-control, and responsibility.
- Cultivating a habit of working and engaging in situations of solidarity.
- Enabling students to learn a foreign language at a level that will allow them to keep up with the global developments.
- Encouraging students to produce information by developing projects using their knowledge and skills.
- Enhancing the quality of education through the effective improved use of technology.
- Promoting lifelong learning among individuals.
- Establishing education, production and services based on compliance with international standards and certification (MoNE, 2018).

Anatolian High Schools, Science High Schools and Social Sciences High Schools are secondary education institutions affiliated to the General Directorate of Secondary Education of the Ministry of National Education of the Republic of Türkiye Among secondary education institutions, Science High Schools aim to support students in the fields of science and mathematics, while Social Sciences High Schools focus on the fields of literature and social sciences in order to train students as future scientists.

In Türkiye, there are a total of 2.887 Anatolian High Schools, 345 Science High Schools and 93 Social Sciences High Schools. Among these, 454 admit students through central placement, while 2,433 admit students through local placement. In Science High Schools, Anatolian High Schools and Social

Sciences High Schools, biology is a compulsory course for 2 hours per week in the 9th and 10th grades. In the 11th and 12th grades, 4 hours of biology education is compulsory in Science High Schools and Anatolian High Schools offer 4 hours as an elective course, while Social Sciences High Schools do not include biology course in their curriculum for these grades (see Table 1.1).

Table 1.1. Biology Course Hours by High School Types for the 2022-2023 Academic Year

Types of High Schools	9th Grade Biology Course Hours	10th Grade Biology Course Hours	11th Grade Biology Course Hours	12th Grade Biology Course Hours
Anatolian High Schools	2	2	4 (Elective)	4 (Elective)
Science High Schools	2	2	4 (Compulsory)	4 (Compulsory)
Social Sciences High Schools	2	2	0	0

While designing the curricula, the concept of maximum flexibility and diversity in the assessment and evaluation process was embraced. Considering individual differences, it is unrealistic to expect curricula to cater to the needs of everyone. Various factors such as the individual himself/herself, educational level, course content, socio-cultural environment, and school competencies contribute to the diversity in education. Therefore, it is believed that the effectiveness of assessment and evaluation should stem not solely from the program but from the teacher's originality and creativity.

The Biology Course Curriculum aims to equip students with knowledge of fundamental concepts, principles, practices, theories, and laws of science in general and Biology in particular. It also aims to foster to an understanding of the nature of science and the ethical utilization of scientific knowledge. Moreover, the curriculum intends to familiarize students with renowned scientists and their contributions to science and to develop the students' ability to apply biology in daily life (MoNE, 2018). Accordingly, the 9th and 10th grades of the biology curriculum have 3 units each with a total of 72 hours of teaching. The 9th grade curriculum includes units titled "Life Science and Biology," "Cell" and "World of Living"; while the 10th grade curriculum covers units titled "Cell Divisions," "General Principles of Heredity" and "Ecosystem Ecology and Current Environmental Issues". In grades 11 and 12, the biology course hours are doubled to 144 hours. The 11th grade curriculum comprises 2 units titled "Human Physiology" and "Community and Population Ecology," while the 12th grade curriculum includes 4 units titled "From Gene to Protein," "Energy

Transformations in Living Things," "Plant Biology" and "Living Things and Environment" (see Table 1.2).

Table 1.2. Information on the 2022-2023 Upper Secondary School Biology Curriculum

9th grade biology curriculum				
Unit No.	**Unit Title**	**Number of Learning Outcomes**	**Recommended Duration (Course Hour)**	**Percentage**
1	Life Science and Biology	3	26	36,1
2	Cell	3	2	30,6
3	Living Things	3	24	33,3
Total		**11**	**72**	**100**
10th grade biology curriculum				
1	Cell Divisions	5	18	25
2	General Principles of Heredity	2	30	41,7
3	Ecosystem Ecology and Current Environmental Issues	10	24	33,3
Total		**17**	**72**	**100**
11th grade biology curriculum				
1	Human Physiology	29	116	80,6
2	Community and Population Ecology	5	28	19,4
Total		**34**	**144**	**100**
12th grade biology curriculum				
1	From Gene to Protein	8	56	38,9
2	Energy Transformations in Living Things	8	32	22,2
3	Plant Biology	11	44	30,6
4	Living Things and Environment	2	12	8,3
Total		**29**	**144**	**100**

Source: MoNE (2018) Biology Curriculum

In addition to the aforementioned types of high schools (Anatolian High Schools, Science High Schools, and Social Sciences High Schools), Vocational High Schools are affiliated to the General Directorate of Vocational and Technical Education, while Imam-Hatip High Schools (Science and Social Sciences) are affiliated to the General Directorate of Religious Education. The biology course hours per week are specified in the curricula of these high school types (see Table 1.3 and Table 1.4).

Table 1.3. Anatolian Imam-Hatip High School, Science and Social Sciences Program Weekly Schedule

Anatolian Imam-Hatip High School Science and Social Sciences Programs	**Weekly Schedule**				
Program Name	**Course Name**	**Course Hours**			
		9th Grade	**10th Grade**	**11th Grade**	**12th Grade**
Science	Biyoloji	2	2	3	4
Social Science	Biyoloji	2	2	-	-

Source: https://dogm.meb.gov.tr/meb_iys_dosyalar/2017_06/15113722_AIHL_Fen_Sosyal_Bilimler_ProgramY_Cizelgesi1.pdf

In Anatolian Imam-Hatip High Schools, the biology course is offered for 2 hours per week in 9th and 10th grades, 3 hours per week in 11th grade and 4 hours per week in 12th grade. The biology course in Social Sciences at Anatolian Imam-Hatip High School is 2 hours in 9th and 10th grades, with no biology course in 11th and 12th grades.

Table 1.4. Vocational and Technical Anatolian High Schools, Anatolian Vocational and Anatolian Technical Program Weekly Schedule (2022-2023 Academic Year)

Vocational and Technical Anatolian High Schools, Anatolian Vocational and Anatolian Technical Program	**Weekly Schedule**				
Field Name	**Course Name**	**Course Hours**			
		9th Grade	**10th Grade**	**11th Grade**	**12th Grade**
Justice	Biology	2	2	-	-
Family and Consumer Services	Biology	2	2	-	-
Footwear and Leathercraft Technology	Biology	2	2	-	-
Information Technology	Biyoloji	2	2	-	-
Biomedical Device Technologies	Biology	2	2	-	-
	Bio Measurement Workshop	9	-	-	-
	Biomedical Technical Drawing	-	2	-	-
	Bio Instrumentation Workshop	-	10	-	-
	Bio Signal Monitoring and Tracking Devices	-	-	12	-
Office Management and Executive Assistantship	Biology	2	2	-	-
Child Development and Education	Biology	2	2	-	-
Maritime	Biology	2	2	-	-
Handicraft Technology	Biology	2	2	-	-
Electrical-Electronics Technology	Biology	2	2	-	-
Industrial Automation Technologies	Biology	2	2	-	-
Journalism	Biology	2	2	-	-
Traditional Turkish Arts	Biology	2	2	-	-
Shipbuilding	Biology	2	2	-	-
Food Technology	Biology	2	2	-	-
Graphics and Photography	Biology	2	2	-	-
Beauty Services	Biology	2	2	-	-
Public Relations	Biology	2	2	-	-
Mapping, Land Registry, Cadastre	Biology	2	2	-	-

Patient and Elderly Services	Biology	2	2	-	-
	Anatomy and Physiology	4	-	-	-
	Prevention of Infectious Diseases	-	2	-	-
	Diseases and Drug Information	-	-	4	-
Animal Husbandry and Health	Biology	2	2	-	-
	Anatomy and Physiology Laboratory	6	-	-	-
	Introduction to Animal Husbandry	3	-	-	-
	Microbiology and Hygiene	-	2	-	-
	Zootechnics	-	4	-	-
	Disease Control	-	-	3	-
Construction Technology	Biology	2	2	-	-
Firefighting and Fire Safety	Biology	2	2	-	-
Chemical Technology	Biology	2	2	-	-
Accommodation and Travel Services	Biology	2	2	-	-
Jewelry Technology	Biology	2	2	-	-
Laboratory Services	Biology	2	2	-	-
	Laboratory Safety and Preparation for Analysis	4	-	-	-
	Laboratory Basic Operations	5	-	-	-
	Microbiological Analysis		7	-	-
	Animal Health Laboratory	-	-	6	-

Mining Technology	Biology	2	2	-	-
Machine and Design Technology	Biology	2	2	-	-
Printing Technology	Biology	2	2	-	-
Metal Technology	Biology	2	2	-	-
Metallurgical Technology	Biology	2	2	-	-
Micromechanics	Biology	2	2	-	-
Furniture and Interior Design	Biology	2	2	-	-
Fashion Design Technologies	Biology	2	2	-	-
Motor Vehicle Technology	Biology	2	2	-	-
Accounting and Finance	Biology	2	2	-	-
Marketing and Retail	Biology	2	2	-	-
Plastic Arts	Biology	2	2	-	-
Plastic Technology	Biology	2	2	-	-
Radio-Television	Biology	2	2	-	-
Rail Systems Technology	Biology	2	2	-	-
Health Services	Biology	2	2	-	-
	Anatomy and Physiology	4	-	-	-
	Infectious Diseases	-	2	-	-
	System Diseases	-	-	3	-
	Introduction to Basic Pharmacology	-	-	3	-
Ceramic and Glass Technology	Biology	2	2	-	-
Cyber Security	Biology	2	2	-	-
Agriculture	Biology	2	2	-	-
Textile Technology	Biology	2	2	-	-
Installation Technology and Air Conditioning	Biology	2	2	-	-
Aircraft Maintenance	Biology	2	2	-	-
Transportation Services	Biology	2	2	-	-
Renewable Energy Technologies	Biology	2	2	-	-
Food and Beverage Services	Biology	2	2	-	-

Source: http://85.111.5.189/?p=Ogretim-Programi&tur=mtal&sinif=9&alan=1

When weekly schedules of students enrolled in Vocational and Technical Anatolian High Schools, Anatolian Vocational and Anatolian Technical Programs were examined for the 2022-2023 academic year, it is evident that biology is taught for a duration of two hours in grades 9 and 10 across all fields. Additionally, in the specialized programs of Biomedical Device Technologies, Patient and Elderly Services, Animal Breeding and Health Laboratory Services, and Health Services, biology courses are also included in the curriculum for the 11th and 12th grades (see Table 1.4).

1.2.2. Course Materials in Biology Teaching and Physical Conditions in Secondary Schools

There are several studies that highlight the significance of optimal physical conditions in promoting effective biology teaching. Altunoğlu and Atav (2005) have identified that teachers have a common demand for improving the physical conditions of schools in terms of teaching aids.

Table 1.5. Some Information on the Physical Conditions of Secondary Education by High School Types (2023)

High School Types	**Number of Students and Physical Conditions**				
Anatolian High Schools	**School**	**Student**	**Gym**	**Library**	**Library**
	2.887	1.846.565	935	2.373	598
	Classroom	**Öğretmen**	**Laboratory**	**Z Library**	**Boarding House Capacity**
	61.387	120.797	3.542	333	101.691
Science High Schools	**School**	**Student**	**Gym**	**Library**	**Library**
	345	142.109	170	247	322
	Classroom	**Teacher**	**Laboratory**	**Z Library**	**Boarding House Capacity**
	6.137	9.951	847	93	67.771
Social Sciences High Schools	**School**	**Student**	**Gym**	**Library**	**Library**
	93	41.141	46	59	81
	Classroom	**Teacher**	**Laboratory**	**Z Library**	**Boarding House Capacity**
	1.836	3.080	128	48	16.316
Total	**School**	**Student**	**Gym**	**Library**	**Library**
	3.325	2.029.815	1.151	2.679	1.001
	Classroom	**Teacher**	**Laboratory**	**Z Library**	**Boarding House Capacity**
	69.360	133.828	4.517	474	185.758

When available information regarding the physical conditions of secondary education in different high school types were examined for the academic year 2022-2023, it is observed that the total number of classrooms at Anatolian High Schools, Science High Schools, and Social Sciences High Schools amount to 69.360, accommodating a total 2.029.815 students. Specifically, Anatolian High Schools have 61.378 classrooms with 1.846.565 students. Science high schools have 6.137 classrooms with 142.109 students, and Social Sciences High Schools have 1.836 classrooms with 41.141 students (see Table 1.5). It is evident that Anatolian High Schools possess the majority of physical facilities and students within secondary education, whereas Science High Schools exhibit a higher abundance of laboratories, Z libraries, and boarding house capacity compared to the number of students. However, it should be noted that not all Science High Schools are equipped with laboratories and libraries. Overall, the boarding capacity of these high schools appears to be sufficient (see Table 1. 5).

Table 1.6. The Number of Science, Anatolian, Vocational and Technical Anatolian, and Imam-Hatip Anatolian High Schools and Classrooms in Türkiye and the Demographic Distribution of Teachers and Students in These Schools

School Types	Number of Schools	Number of Students			Number of Teachers			Classroom
		Total	Male	Female	Total	Male	Female	
Science High School	316	121.024	56.641	64.383	8.712	5.706	3.006	5.665
Anatolian High School	2846	1.576.390	709.325	867.065	104.713	51.672	53.041	56.761
Vocational and Technical Anatolian High School	2486	1.125.448	669.394	456.054	105.518	54.104	51.414	49.515
İmam-Hatip Anatolian High School	1635	494.174	219.331	274.843	49.098	24.142	24.956	35.471

When the number of schools in Türkiye categorized as Science, Anatolian, Vocational and Technical Anatolian, and Imam-Hatip Anatolian High Schools were examined it becomes evident that Science High Schools have the lowest number with 316 schools. Vocational and Technical Anatolian High Schools hold the highest number with 2.486 schools, followed by Imam-Hatip Anatolian High Schools with 1.635 schools. In terms of classrooms, Science High Schools have the lowest number with 5.665, while Vocational and Technical Anatolian High Schools have the highest number with 54.104 classrooms.

When examining the teachers and students in these schools demographically, Science High Schools have a higher number of male teachers compared to female teachers, while the distribution of male and female teachers in other school types is approximately equal. The gender distribution of students accross school types is notable as well, with female students preferring Science, Anatolian, and Imam-Hatip Anatolian High Schools, whereas male students prefer Vocational and Technical Anatolian High Schools (see Table 1.6).

1.3. Biology Education Undergraduate Programs

This section provides general information about the characteristics of the students enrolled in Undergraduate Biology Education Programs, as wells as an overview of the current situation regarding Undergraduate Biology Education Program competencies and courses.

1.3.1. Some Information on Student Profiles in Undergraduate Biology Education Programs

In Türkiye, there are nine Biology Teaching Programs offered in nine Faculty of Education departments at public universities. The Council of Higher Education (CoHE) assigns a quota of 21 students to each program. In 2022, Van Yüzüncü Yıl University admitted four students, and Dokuz Eylül University's Turkish Republic of Northern Cyprus (TRNC) campus admitted 1 student. Atatürk University Faculty of Education had no student enrollment that year. However, Biology Teacher Education Programs of other universities successfully filled their quota of 21 students.

Table 1.7. 2022 YKS Base Scores and Number of Students Placed in Biology Teacher Education Programs in Faculties of Education

University	Year	Type	Coefficient	Score	Placed
Hacettepe University	2022	Public	0.12	**341.26958**	21
Marmara University	2022	Public	0.12	326.06291	21
Gazi University	2022	Public	0.12	326.50923	21
Dokuz Eylül University	2022	Public	0.12	312.65903	21
Ondokuz Mayıs University	2022	Public	0.12	299.71536	21
Necmettin Erbakan University	2022	Public	0.12	298.06117	19
Balıkesir University	2022	Public	0.12	298.48214	20
Dokuz Eylül University* (TRNC)	2022	Foundation	0.12	349.85941	1

Van Yüzüncü Yıl University	2022	Public	0.12	300.31967	4
Atatürk University	2022	Public	0.12	-	-

* Due to having only one student record, it was not included in the comparisons.

There are significant differences between the base scores of the Faculty of Education Biology Teaching Department across different universities (see Table 1.7). Necmettin Erbakan University (298.06117), Balıkesir University (298.48214) and Ondokuz Mayıs University (299.71536) have the the lowest scores in the Higher Education Institutions Examination (YKS), while Hacettepe University (341.26958), Gazi University (326.50923) and Marmara University (326.06291) have the highest YKS base scores (see Table 1.7).

Regarding the high school types from which the students admitted to the Biology Teaching Programs in the Faculty of Education graduated in 2022, Balıkesir and Van Yüzüncü Yıl University received students exclusively from general high schools. Necmettin Erbakan University (21.1%) and Ondokuz Mayıs University (19%) have the highest percentage of vocational high school graduates among the universities (see Table 1.8).

Table 1.8. Percentage Values of Students Enrolled in the Biology Teacher Education Program in Faculties of Education in 2022 according to the Type of High School They Graduated From

University	**Vocational High School Graduate***	**General High School Graduate****
Balıkesir University (4 Years)	0	**100**
Dokuz Eylül University (4 Years)	9.5	90.5
Dokuz Eylül University (TRNC national) (4 Years)*	0	100
Gazi University (4 Years)	4.8	95.2
Hacettepe University (4 Years)	9.5	90.5
Marmara University (4 Years)	9.5	90.5
Marmara University (TRNC national) (4 Years)*	0	100
Necmettin Erbakan University (4 Years)	21.1	**78.9**
Ondokuz Mayıs University (4 Years)	19	81
Van Yüzüncü Yıl University (4 Years)	0	100

* **Vocational High School group** includes Trade Vocational High Schools, Technical High Schools, Industrial Vocational High Schools, Girls Vocational High Schools, Health Vocational High Schools, Hotel Management and Tourism Vocational High Schools, Secretarial Vocational High Schools, Imam-Hatip High Schools, Open Education High Schools (Vocational High School programs), Vocational High Schools for the Hearing Impaired, Multi-Program High

Schools (Vocational High School programs), Vocational and Technical Education Centers (METEM) and other vocational high schools and Non-Commissioned Officer Preparation Schools (YÖK Atlas, 2022) (CoHE Atlas, 2022).

****General High School group** includes High School, Foreign Language Intensive High School, Private High School, Anatolian High School, Private Foreign Language Intensive High School, Science High School, Private Science High School, Social Sciences High School, Sports High School, Military High School, Police College, Evening High School, Private Evening High School, Open Education High School (high school program), Multi-Program High School (high school program, foreign language intensive high school program), Anatolian Fine Arts High School, Fine Arts High School, Fine Arts and Sports High School, Private Fine Arts and Sports High School, Anatolian Teachers High School, Private Anatolian Teachers High School, Teachers High School, Teachers School and Village Institute (CoHE Atlas, 2022).

Table 1.9. 2022 YKS-OBP Average Base Scores and AYT Exam Biology Average Net Scores of Students Enrolled in Biology Teacher Education Program in Faculties of Education

University	Average YKS-Secondary Education Achievement Scores of the Placed Students	AYT Exam Biology Average Scores (13 Questions)
Balıkesir University	414.963	**6.0**
Dokuz Eylül University	413.592	5.4
Gazi University	426.912	5.4
Hacettepe University	437.176	5.4
Marmara University	428,337	4.4
Dokuz Eylül University (KKTC national)	471.111	10.5*
Necmettin Erbakan University	425.841	**3.7**
Ondokuz Mayıs University	431.247	4.3
Van Yüzüncü Yıl University	408.722	4.5

* Due to having only one student record, it was not included in the comparisons.

In the 2022-2023 academic year, the average base scores of the students admitted to the Biology Teaching program at 8 Faculties of Education ranged from 408.722-437.176. The students with the lowest average were admitted to Van Yüzüncü Yıl University, while the students with the highest average were admitted to Hacettepe University.

In the 2022 AYT exam, there were 13 biology questions. The average biology scores of students admitted to the Biology Teaching program ranged from 3.7 (Necmettin Erbakan University) to 6 (Balıkesir University) (see Table 1.9). It is evident that candidates enrolled in these programs answered less than half

of the biology questions on average. Since there is no specific threshold for the number of correct answers in biology to become a biology teacher, candidates can enroll in these programs by achieving a certain score with questions from other fields. This clearly highlights the significance of strong field courses in biology education programs.

The courses in the 2022-2023 Undergraduate Biology Teaching Program consist of Pedagogical Knowledge, General Culture and Pedagogical Content courses. When examining the courses and teaching hours of Professional Knowledge, it can be observed that students complete 28 hours of theoretical courses and 12 hours of practical courses to graduate (see Table 1.10).

1.3.2. Undergraduate Biology Education Programs Curriculum

Between 2014 and 2018, within the teacher training programs implemented in the Faculties of Education, Undergraduate Biology Education Program consisted of a total of 101 courses, including 62 compulsory and 39 elective courses. Among these courses, 55 were related to field education, 25 focused on teaching professional knowledge, and 22 were general culture courses. According to the decision made by the General Assembly of CoHE on February 28, 2017, the distribution of courses in Biology Education Undergraduate Programs was defined as follows: Field Education (FE) courses accounted for 48%, Professional Knowledge (PK) courses accounted for 34%, and General Culture (GC) courses accounted for 18% (CoHE, 2018). With this regulation, the undergraduate program of Biology Education included 16 compulsory and 22 elective courses in Professional Knowledge, 8 compulsory and 18 elective courses in General Culture, and 30 compulsory and 13 elective courses in Content Education (Gül, 2023).

One of the most criticized aspects of the 2018 program was the reduction of field and laboratory courses (see Table 1.10). For instance, in the 2014 program, separate courses for invertebrate and vertebrate animals were taught for 8 hours of theoretical and 4 hours of laboratory sessions per week. However, in the 2018 program, these two courses were combined, and only 2 hours of theoretical classes were provided (see Table 1.10). Similar situations were observed in other field courses.

The 2018 program was made non-compulsory after two years, as stated in the decision dated August 18, 2020. In the 2018 program, it was decided that "the relevant boards of higher education institutions would be authorized to determine the courses, curricula, and credits of the courses in teaching programs,

considering the grouping and order of 'number of courses, number of course hours/credits and intensity' (field knowledge 50%, professional knowledge 35%, general culture 15%)" (CoHE, 2020). Following this decision, Faculties of Education at universities started developing their own programs. The first program in this regard was developed by Gazi University Gazi Faculty of Education Division of Biology Education and was implemented in the 2021-2022 academic year after the necessary approvals from the relevant boards. The competencies of the program, updated by the relevant boards, are provided in Table 1.11. The complete Biology Education Undergraduate Program can be accessed on the website of Gazi University, Gazi Faculty of Education, Department of Mathematics and Science Education, Division of Biology Education.

Table 1.10. Comparison of 2014 and 2018 Undergraduate Biology Education Programs in Terms of Some Field Courses

2014 Undergraduate Program		**2018 Undergraduate Program**	
Course Title	**Hours**	**Course Title**	**Hours**
General Zoology	4	General Biology 1	3
General Zoology Lab.	2	General Biology Lab. 1	2
General Botany	4	General Biology 2	3
General Botany Lab.	2	General Biology Lab. 2	2
Animal Physiology	3	Zoology 1	2
Invertebrate Animals	4	Zoology 2	2
Vertebrate Animals	4		
Invertebrate Animals Lab.	2	Zoology 2 Lab.	2
Vertebrate Animals Lab.	2		
Microbiology	4	Microbiology	2
Special Teaching Methods-I	4	Biology Teaching 1	3
Special Teaching Methods-II	4	Biology Teaching 2	3
Plant Morphology and Anatomy	3	Botany 1	2
Plant Physiology	3		
Plant Morphology and Anatomy Lab.	2	Botany 1 Lab.	2
Plant Physiology Lab.	2		
Cytology	4	Cytology	2
Biochemistry	4	Biochemistry	2
Genetics	4	Genetics	2

Table 1.11. Undergraduate Biology Education Department Program Competencies (2021)

No	Undergraduate Program Competencies
1	Explains the concepts, symbols, formulas, theories, models, principles, and generalizations in biology, analyzes biological events and mechanisms in the light of generalizations, establishes relationships between concepts.
2	Has knowledge about the history of science and the nature of science.
3	Makes and applies a teaching plan in accordance with the standards of the biology curriculum and the gains related to the subject.
4	Knows and applies the most appropriate teaching strategies, methods, and techniques by taking into account the students' readiness levels, characteristics of the subject area and achievements in the education and training process.
5	Provides appropriate learning and teaching environments by considering individual differences, development, and learning characteristics.
6	Conducts research to access information about biology and biology education, uses national and international resources, pays attention to scientific and ethical values.
7	Has the knowledge and skills of the field and teaching profession in order to successfully carry out the lessons related to the field.
8	Recognizes and uses biology laboratory techniques, tools and equipment, applies biology laboratory methods and techniques such as biological dye, preparation of solution-preparate, anatomical-morphological examination, and tissue culture.
9	Takes into account the multifaceted nature of learning, evaluates the process as well as the product, uses traditional and alternative assessment and evaluation techniques effectively.
10	Designs a material related to the field and uses this material in relevant learning and teaching situations.
11	Designs a project related to the field, makes critical evaluations in the case of challenges encountered in practice.
12	Adopts lifelong learning, applies learning and teaching approaches open to innovations and changes, knows his/her strengths and weaknesses, uses his/her strengths, and improves his/her weaknesses.
13	Uses different ways in the face of problems encountered in the teaching process, follows a critical, inquiry-based approach in the evaluation of the knowledge he/she has.
14	Establishes the relationship between biology and other disciplines such as medicine, pharmacy, physics, chemistry, agriculture, and biotechnology.
15	Take parts in social projects related to the field, collaborates with relevant institutions, expresses his/her thoughts orally and in writing.
16	Uses a foreign language in daily life and professional development.
17	Uses information and communication technologies effectively in learning and teaching environments.
18	Identifies learning needs for professional development and directs his/her learning.
19	Has environmental awareness and prepares environments for students to develop this awareness.
20	As a biology literate individual, knows the ways of accessing information and uses them effectively.

In the Biology Education Undergraduate Program, the pedagogy sciences courses consist of 28 hours of theoretical instruction and 12 hours of practical training in schools affiliated to the Ministry of National Education (Teaching Practice) for two semesters, resulting in a total of 40 hours.

Table 1.12. 2022-2023 Undergraduate Biology Education Program Pedagogy Sciences Courses and Course Hours

Undergraduate Educational Sciences Courses	**Theorethical**	**Practical**	**Total**
Introduction to Education	2	0	2
Educational Psychology	2	0	2
Instructional Technologies	2	0	2
Teaching Principles and Methods	2	0	2
Classroom Management	2	0	2
Assessment and Evaluation in Education	2	0	2
Teaching Practice I	2	6	8
Teaching Practice II	2	6	8
Counseling at Schools	2	0	2
Turkish Education System and School Management	2	0	2
Research Methods in Education	2	0	2
Program Development in Education	2	0	2
Special Education and Inclusion	2	0	2
Information Technologies	2	0	2
Total	**28**	**12**	**40**

Source: http://sgb.meb.gov.tr/www/icerik_goruntule.php?KNO=396

METHODOLGY

The workshop format was composed of in two phases. The first stage was shaped by the presentations of the lecturers who are experts in their fields and the field teachers who are actively working in private and public institutions on the problems and solution suggestions in biology education and the contributions of the participants to the subject as question and answer. The presentations made at this stage were structured based on the current problems experienced in biology education, the causes of these problems and solution suggestions, research results and professional experiences of the participants. The first phase was carried out with a total of 63 participants; 8 academicians and 5 teachers made presentations, while 50 participants consisting of academicians, teachers, experts, master's, and doctoral students contributed to the process in the question-answer phase with their opinions. Information about the participant profile is given in Table 2.1.

Table 2.1. Information on the Participant Profiles

Participants	Academician			Teacher		Master's Student	MoNE	Total
	Biology Education	Biology Department	Science Education	Biology Education	Science Education	Biology Education	Expert	
Presenter	4	1	3	4	1			13
Focus Group 1			4		7[b,c]	1		12
Focus Group 2	3			9[a]		2		14
Focus Group 3	5			3		2		10
Focus Group 4		6				2		8
MoNE Observer				2	1		3	6
Total	12	7	7	18	9	7	3	63

[a] 1 teacher titled Assoc. Prof. Dr.

[b] 1 teacher titled Dr. and [c] 1 administrator teacher

Nineteen faculty members employed at different universities participated in the workshop (Table 2.2). Six of these participants hold positions at public universities (Gazi University, Hacettepe University, Balıkesir University, Kırıkkale University, Ege University and Yozgat Bozok University), while one is employed at Başkent University, a foundation university.

Table 2.2. Afilliations of Faculty Members who Participated at the Workshop

State University						Foundation University	Total
Gazi University	Hacettepe University	Balıkesir University	Kırıkkale University	Ege University	Yozgat Bozok University	Başkent University	7
6	5	3	2	1	1	1	19

The workshop was attended by seventeen teachers who graduated from various universities, completing their education in the fields of Science Education, Biology Education and Biology. These teachers hold positions in different public and private institutions, including primary schools as classroom teachers, secondary schools as science teachers, high schools as biology teachers, as well as Science and Art Centers and R&D units under the MoNE. Ten of the participant teachers hold a doctoral degree. The institutions where these workshop participants are currently employed are listed in Table 2.3.

Table 2.3. Afilliations of Teachers who Participated at the Workshop

Primary School	Secondary School				High School						MoNE Expert and Teacher Observer
MoNE	MoNE			Private	MoNE				Private		
Grade	Science	R&D	Science and Art Center	Secondary/ High School	Anatolian High School	Vocational and Technical Anatolian High School	Science High School	Science and Art Center	Anatolian High School	Foundation	Ministry
1	1	2	1	1*	2	2	4	1	1	1	6

* Administrator

A total of seven graduate students participated in the workshop. 6 of these students are currently pursuing their master's degree in Biology Education at the Institute of Educational Sciences, while 1 student is studying in the field of Bioengineering at the Institute of Natural and Applied Sciences.

On the first day of the workshop, a series of 10 presentations were delivered. These presentations were categorized into main themes such as how science education should be, challenges in undergraduate programs, issues in middle and high school programs, deficiencies in course materials used in middle

and high schools (including scientific errors in textbooks and infrastructure limitations), lack of laboratory applications, and pedagogical formation. The topic titles of the presentations presented during the first phase are listed in Table 2.4. Following each presentation, a discussion session was held, allowing all participants to express their opinions on the subject matter.

Table 2.4. Topic Titles of Presentations at the First Phase of the Workshop

Topic Titles of Presentations	Presenter	Afilliation
Science Education in the 21st Century	Prof. Dr. Semra Mirici	Gazi University/ Gazi Faculty of Education
Challenges and Solutions in Undergraduate Biology Education Programs	Prof. Dr. Ali Gül	Gazi University/ Gazi Faculty of Education
My First Year in the Profession	Teacher Neslihan Soysal	Private Hacettepeliler Educational Institution Anatolian High School
Teachers' Opinions on High School Biology Curriculum	Teacher Yasemin Horasan Teacher Aynur Elif Bulut Teacher Kurtuluş Atlı	İzmir Anatolian High School Ankara Science High School Nevşehir Şehit Furkan Demir Anatolian High School
Analysis of High School and Secondary School Biology Teaching Materials	Prof. Dr. Ertunç Gündüz Prof. Dr. Mehmet Yılmaz	Hacettepe University / Faculty of Science Gazi University / Gazi Faculty of Education
Challenges and Solutions in Undergraduate Biology Programs	Prof. Dr. Feray Köçkar	Balıkesir University / Faculty of Science
Science Education in Basic Education	Prof. Dr. Füsun Eyidoğan	Başkent University / Faculty of Education
Challenges and Solutions in Undergraduate Science Education Programs	Doç. Dr. Duygu Sönmez Prof. Dr. Hülya Yılmaz	Hacettepe University / Faculty of Education Ege University / Faculty of Education
Challenges Related to Pedagogical Formation Education	Prof. Dr. Tahir Atıcı	Gazi University / Gazi Faculty of Education
Teachers' Opinions on Secondary School Science (Biology) Curriculum	Teacher Aylin Güner Kahraman	Ankara Provincial Directorate of National Education Strategy Development Department R&D Unit

The second phase of the workshop involved conducting focus group discussions. Participants were divided into study groups based on their respective fields and voluntary interest in contributing to specific topics. The sub-topics identified based on the literature to describe the current state of biology education were discussed through debates in small focus groups for a duration of 3 hours (Balbağ et al., 2016) (see Table 2.5). The findings and proposed solutions that emerged from the interviews conducted under four main themes were documented and shared with all participants. During the question-answer phase, participant opinions were actively incorporated into the process.

Table 2.5. Focus Group Topics and Sub-Topics

Groups	Discussion Topics	Sub-Topics
Group I	Challenges and Solutions in Secondary School Science (Biology) Teaching	✓ Curriculum Competencies ✓ Faculty Member Competencies ✓ Student Motivation ✓ Environmental Factors
Group II	Challenges and Solutions in High School Biology Teaching	
Group III	Challenges and Solutions in Biology Education (Teacher Education) at Undergraduate Level	
Group IV	Challenges and Solutioıns at Biology Undergraduate Level	

Following the focus group discussions, the reports highlighting the identified challenges and solution suggestions for each sub-topic in biology teaching were presented to all participants. Group spokespersons delievered concise presentations summarizing the reports within a forty-five-minute timeframe. At the conclusion of each presentation, a question-and-answer session was held to gather the opinions of other participants.

FINDINGS OBTAINED FROM THE PRESENTATIONS AND DISCUSSIONS

This section provides an overview of the presentations and discussions held during the workshop, along with the main themes and findings derived from the focus group discussions.

3.1. Twenty-first Century Skills and Future Occupations

The presentation by Prof. Dr. Semra Mirici encompassed sub-topics of "21st Century Skills and Future Professions," "The Importance of Social and Emotional Learning Skills" and "Teachers' Renewal Skills." The presentation emphasized the significance of equipping students with 21st century skills through science education and how these skills contribute to preparing young individuals for future professions. Analytical thinking and innovation were highlighted as the foremost skills, while other emerging skills included active learning and learning strategies, creativity, originality, initiative, technology design and programming, leadership, and social impact (see Table 3.1).

Table 3.1. Skills that Stand Out in the Future Professions

2018	Trend 2022	Less Important Skills
Analytical thinking and innovation	Analytical thinking and innovation	Manual dexterity, endurance and precision
Complex Problem solving	Active learning and learning strategies	Memory, verbal, visual and spatial abilities
Critical thinking and analysis	Innovation, originality and initiative	Resource management and operations
Active learning and learning strategies	Technological literacy and programming	Technology setup and maintenance
Innovation, originality and initiative	Critical thinking and analysis	Reading, writing and mathematics and listening
Dependability and attention to detail	Complex Problem solving	Staff management
Emotional intelligence	Leadership and social influence	Quality control and security

Reasoning , problem solving and creative thinking	Emotional intelligence	Coordination and time management
Leadership and social influence	Reasoning , problem solving and creative thinking	Visual, audatory and speaking skills
Coordination and time management	Systems thinking and analysis	Use of technology and management

2018	**Trend 2022**	**Less Important Skills**
Analytical thinking and innovation	Analytical thinking and innovation	Manual dexterity, endurance and precision
Complex Problem solving	Active learning and learning strategies	Memory, verbal, visual and spatial abilities
Critical thinking and analysis	Innovation, originality and initiative	Resource management and operations
Active learning and learning strategies	Technological literacy and programming	Technology setup and maintenance
Innovation, originality and initiative	Critical thinking and analysis	Reading, writing and mathematics and listening
Dependability and attention to detail	Complex Problem solving	Staff management
Emotional intelligence	Leadership and social influence	Quality control and security
Reasoning , problem solving and creative thinking	Emotional intelligence	Coordination and time management
Leadership and social influence	Reasoning , problem solving and creative thinking	Visual, audatory and speaking skills
Coordination and time management	Systems thinking and analysis	Use of technology and management

Source: The Future of Jobs Report 2018, World Economic Forum

The speech highlighted the rapid increase in new inventions in today's world, leading to rapidly evolving work environments. Consequently, skills such as adaptability and cooperation have gained significant importance. The World Economic Forum's Future of Jobs Report estimates that 65% of children starting primary school today will work in professions that do not even exist today (WEF, 2018). Examining the growth potential of future professions, the speaker pointed out that while the growth potential for currently known professions is 14%, STEM (Science, Technology, Engineering, Maths) professions are projected to grow between 16% and 62%. This reiterates once again the importance of effective science education. It was also highlighted

that studies indicate a declining trend in the number of young people who choose science as a career both in our country and worldwide (Braund & Reiss, 2006). Prof. Dr. Semra Mirici emphasized that especially as students progress to higher grade levels, their interest in science decreases, which potentially leads to a future employment gap in related professions.

The speaker empehsized the research showing that children's creativity wanes as they progress through grade levels, highlighting the need to revise learning environments and programs accordingly. Additionally, the speaker drew attention to the fact that while robots equipped with artificial intelligence will perform various tasks in the future, human competencies (such as intuition, flexible thinking, holistic understanding, and effective decision-making) will become paramount. Therefore, the development of students' social and emotional learning skills by teachers was emphasized to support the holistic child philosophy. The speaker also noted that studies reveal a negative trend in the social tendencies of students (see Table 3.2).

Table 3.2. Social Tendencies of Students According to Teachers

Increasing values	Decreasing values
Materialism and the instinct of possession	Empathy
Focus on school success	Understanding of support and cooperation
The objectification of love	Tolerance
Depersonalization	Authenticity
Negative instructions instead of affirmation	Curiosity for learning
De-identification and masking	Inquiry and cognitive flexibility
Failure to see the whole	Taking responsibility
Priority of self	Love for nature and living things
Legitimization of violence and bullying	Respect and love for the teaching profession

Source: Social and Emotional Learning Skills (TÜSİAD, 2019)

It was explained that future schools will have classrooms with multiple teachers and either one student or a community of students. Students will engage in temporary task forces, project groups, constantly changing groups, and occasionally work independently. The purpose behind these arrangements is to prepare students for the dynamic organizational structure of the future. Prof. Dr. Semra Mirici continued her presentation by sharing sample scenarios of future learning environments and professions and concluded her speech by discussing the importance of teacher competencies as reflected in the literature.

3.2. Challenges and Solutions in Biology Education Undergraduate Programs

The second presentation of the workshop was delievered by Prof. Dr. Ali Gül, titled "Challenges and Solutions in Biology Education Undergraduate Programs". The presentation began with a discussion of the historical development of Biology Education Undergraduate Programs. Emphasis was placed on the problems in teacher education following the introduction of programs prepared by the CoHE and sent to the Faculties of Education in 2018. In response to these challenges, Gazi Faculty of Education Biology Education Department program was introduced in 2021, developed according to the CoHE's decision to establish undergraduate programs for the Faculties of Education at specified rates.

At the end of the presentation, a question was asked: "Do teachers receive literature review training in the new program?". Prof. Dr. Ali Gül addressed this query by highlighting the library orientation trainings provided to undergraduate and graduate students in biology education.

Another question posed to Prof. Dr. A. Gül concerned the inclusion of project writing courses in biology education within the new undergraduate program, as teachers face difficulties in providing project guidence to their students. Prof. Dr. Gül shared that the the undergraduate program includes an elective course on Project Preparation in Biology at the 1st year. Additionally, Prof. Dr. Mahmut Selvi, Dean of Gazi Faculty of Education, mentioned, "We organize free project writing trainings for the students of our faculty. In 2022, our faculty had the highest participation in the Scientific and Technological Research Council of Türkiye (TUBITAK) undergraduate students' project competition."

One participant asked, "What was the reason behind the program change in 2018?" Prof. Dr. Gül explained, "The CoHE declared that it was necessary to update the undergraduate programs of the Faculties of Education/Educational Sciences in line with the needs and demands of society. However, numerous objections and dissatisfactions were expressed soon after the programs were sent to the faculties."

One of the most striking questions raised during the workshop was, "What is the difference between the undergraduate programs/education offered by Faculties of Education and Faculties of Science?". Prof. Dr. A. Gül responded, "In Faculties of Education, students receive content education and pedagogical knowledge courses, both theoretically and practically, for four years. The most

significant difference lies in the fact that students who enroll in the Faculty of Education are given the opportunity to evaluate and internalize every knowledge and skill they acquire in all learning environments from day one until graduation from a teaching perspective, envisioning their future roles as teachers. In addition, in the 2018 program, the hours and content of field knowledge and laboratory practices in teacher training were reduced. A teacher with insufficient field knowledge will be unable to effectively teach biology to students." Prof. Mirici also stressed the importance of content knowledge, stating that "... teachers are also expected to prepare students for competitions such as project consultancy and Olympiads, as well as equip them with 21st-century skills." Prof. Mirici also highlighted another difference between the teaching of content knowledge in Faculties of Science and Faculties of Education, stating, "While faculties of education provide content knowledge, they also offer training on the materials to be used by prospective teachers for teaching the acquired knowledge and rectifying potential student misconceptions." Furthermore, Prof. Mirici emphasized that teaching is a profession that requires idealism, similar to being a doctor or a soldier, and that the spirit of teaching should be instilled from the beginning of teacher education. Taking the floor, Prof. Selvi shared that 22 programs were renewed in 2021, and approximately 60 Faculties of Education requested Gazi Faculty of Education to share with them their new undergraduate programs. He also mentioned that there are over 1 million teachers working in MoNE, 27% of whom are the graduates of Gazi Faculty of Education.

The final question of the presentation was, "To what extent do departments at Science Faculties collaborate with the departments at Faculties of Education to enhance biology undergraduate programs in Faculties of Education? How much do we come together and share our problems like we do here? I believe we are lacking in this regard." Mr. Gül acknowledged the importance of cooperation and concurred, stating, "You are absolutely right about this, we need more collaboration in this area."

3.3. My First Year in the Profession

The workshop proceeded with a presentation titled "My First Year in the Profession," where a recently graduated teacher shared her experiences regarding the contributions and areas of improvement in her undergraduate program. Neslihan Soysal, the presenting teacher, mentioned that she had chosen teaching as her top preference in the university exam and secured

enrolling in her first choice. She highlighted the significant impact of the presence of 17 faculty members with expertise in the field content knowledge education in the department she studied in. The availability of these faculty members greatly contributed to her development in terms of professional knowledge, field education as well as professional skills. Additionally, she considered it advantageous to receive practice courses which granted access to five different well-equipped laboratory facilities. Soysal emphasized that her active participation in various departmental activities (alumni workshops, sapling planting activities, TUBITAK undergraduate students' competitions, community service practices, career planning, biointeraction student seminars, national and international conferences, etc.) provided her with valuable skills in communication, cooperation, project preparation, and presentation. However, she noted some deficiencies, including limited time and space for teaching practice, which resulted in a lack of practical experience. She also mentioned the absence of foreign language education as a disadvantageous aspect.

During the pandemic, Soysal observed that the efficiency and accessibility of distance education courses were low. She realized the inadequacy of educational technologies during this period and acknowledged that her communication and socialization skills were negatively affected. Additionally, Soysal mentioned that the job application process presented challenges due to the lack of work experience and the high number of applicants for available positions. On the positive side, she highlighted that the certificates she obtained during her undergraduate education, her participation in the TUBITAK project competitions, as well as the papers she presented at conferences were significant factors that attracted the attention of employers and gave her an advantage.

3.4. Teachers' Opinions on High School Biology Curriculum

3.4.1. Teacher Opinion I (Yasemin Horasan)

During the workshop session on "Teachers' Opinions on High School Biology Curriculum" Yasemin Horasan, an experienced teacher with twenty-seven years of teaching experience delivered the fourth presentation. Yasemin Horasan stated that she began her teaching career in a small school with just one classroom and has since worked in various types of schools, including Multi-Program High School, Anatolian High School, and Science High School. She highlighted her achievements, such as being the second runner-up in Türkiye in TUBITAK's high school project competitions and earning top rankings in multiple international competitions with two world championships, two world second rankings and one world third ranking.

In her presentation, Horasan first provided concrete examples to illustrate the issues within the biology teaching, focusing on various grade levels and subject matters. She discussed these challenges under four main themes: Biology Curriculum, Teacher Competence, Student Motivation and Environmental Factors (see Table 3.3). Horasan based her findings on her personal experiences as well as the feedback she gathered from her colleagues.

Table 3.3. Teachers' Opinions on Challenges in Biology Education-I

Themes	Issues	Solutions
Biology Curriculum	Due to being divided into different years due to the spirality and being usually included at the end of the year, edology topics are not covered and learned sufficiently and at the desired level. In addition, since these topics are spread over different years due to the spirality, they are included in the 11th and 12th grade curriculum.	• Collection of ecology subjects at only one grade level • Not leaving to the end of the year • Teaching them at the earlier grades levels (9th and 10th grade) since everyone should know these subjects.
	The difficulty of covering 9th grade level subjects in 2 class hours per week, Only theoretical teaching of the course due to the effort to finish the subjects, Due to the theorethical and intensive teaching of the subject matter in the course, frustration in some students who distance themselves from biology in their first year of high school.	At the 9th grade level, weekly class hours should be increased to 3 or 4 hours or subjects should be reduced.
	Teaching the subject of reproductive system in the 11th grade, resulting in teaching only a limited number of students who chose science-field. Since the issues related to the reproductive system are not discussed within the family, students trying to learn the relevant information in nonreliable ways,	This subject should be taught at the 9th and 10th grades to ensure that all students learn the correct information.

	Lack of activities that can be done with limited opportunities in the textbooks prepared according to the biology curriculum.	• Activities that can be done with easily available materials should be added to the biology curriculum as in the 2008 curriculum, • The biology course should be transformed from a theoretical course format to a practical course format, • In order for the course to be taught practically, there should be a "Biology Practice" course in addition to the existing biology course; tests should not be solved in this course; in order to ensure this, the Biology Practice course should be conducted by a different teacher than the course teacher.
	In the 9th grade, the subject of classification of living things, which is left to the end of the year, is not at a level to attract the interest of the students (it is tried to be memorised and forgotten) and it cannot be processed sufficiently because it is left to the end of the year.	Classification of living things is important for students to recognise biological diversity and to love and respect it through visuals and trips to places such as natural life parks.
	The values in the curriculum (the "root values" in the curriculum are: justice, friendship, honesty, self-control, patience, respect, love, responsibility, patriotism, benevolence) are not sufficiently included in the lesson.	• Values, which are important for all human beings, should be addressed and emphasised separately for each lesson, • Performance assignments should be associated with values, • In the biology clubs established in schools, the subject of values should be handled in relation to the subjects, • The contents related to the values in the biology curriculum should be exemplified in the teacher's manuals (for example, an activity related to empathising with and respecting the visually impaired while teaching eye defects).

	The fact that there are two different curricula for high schools and science high schools may cause problems in practice. For example, some schools have both science high school and regular high school programs. The same teacher has to teach in types of schools and perform different applications (experiments, written exams, etc.) in the same school. This situation creates an extra workload for teachers. In addition, while the science high school curriculum is applied in science high schools, the TYT-AYT exam is held according to the high school curriculum, not the science high school curriculum. This situation causes anxiety in both teachers and students and forces them to take into account both curricula.	A single curriculum should be implemented in all schools or Common textbooks should be prepared for different curricula and the common subjects for both science high schools and other high schools should be shown in different colours and the subjects for science high schools should be shown in different colours. Therefore, Anatolian high school or vocational high school students who are interested in biology should be able to learn extra information.
Teacher Competencies	Teachers not having sufficient laboratory knowledge,	Teachers should be taken to applied in-service training in the universities of the province they are affiliated to during the seminar periods at the beginning and end of the year and should be developed especially in experiments that can be done with few materials.
	Since biology is a rapidly developing science, many teachers do not have sufficient knowledge about updated information (especially molecular biology, biotechnology, and microbiology).	Teachers should be provided with up-to-date information through in-service training, In schools such as science high schools, some subjects should be taught face-to-face by academics who are experts in the field.
	Lack of a separate laboratory course in biology, especially for science high schools.	In science high schools, the applications of biology courses should be a separate course which sould be taught by a different teacher, Öğretmenlere labaratuvar uygulama becerileri konusunda yoğun ve tam öğrenmenin kazandırıldığı hizmet içi eğitimler düzenlenmeli, In-service trainings should be organised for teachers to gain intensive and complete learning about laboratory application skills, Experiment contents should be prepared for teachers.

	In qualified schools such as Science High Schools, assigning teachers 24-30 hours of lectures per week, project consultancy, preparing students for the Olympiad, DYK courses, boarding in dormitories, TUBITAK projects (4004, 4005, 4006, etc.), reduce teacher productivity,	The number of teachers in these schools should be increased and there should be a division of labour among teachers in terms of the tasks available.
	Teachers' insufficient knowledge of technological tools	Effective in-service trainings on technological tools and new teaching programmes should be conducted face-to-face.
	Some teachers, due to TYT-AYT anxiety, instead of having practice (experiment, excursion-observation, etc.), teach only exam-oriented theoretical subjects and make the students only practice solving test questions.	Periodically, teachers and students should be asked by the administration for the implementation reports of the basic activities carried out.
	Teachers' lack of competence in literature review and the ability to conduct a scientific study.	Teachers should be provided with practical training on literature review and project management, "On my own behalf, the project counselling training I received from TUBITAK and MoNE enabled me to prepare national and international projects with my students and made great contributions to my students becoming science literate. This situation has aroused interest and curiosity not only in the students for whom I prepared projects but also in other students and teachers. These studies increase the interest in our course."
Student Motivation	Classical "teacher-centred (question and answer, etc.)" education is no longer sufficient for students and does not attract their interest.	By establishing contact with universities, students should be made to make applications on topics such as problem identification, literature review, hypothesis formulation, experiment planning and execution, and reporting.
	After the distance education period, students' technology addiction increased, they still cannot adapt to the transition to face-to-face education, they are very prone to absenteeism, and they tend to sleep and eat during the lesson.	Students should be taken out of the classrooms, directed to practice, taken out to nature, made to do excursions, observations, interactive applications related to the lessons and students' interest should be attracted.
	In project schools such as Science High Schools, students demand for the teaching of courses with a multidisciplinary approach, Decrease in student motivation when the teacher lectures for a single subject.	Teachers in project schools should receive face-to-face in-service training on multidisciplinary teaching, Especially in science high schools, students should be given project-based education, and be made to do homework and studies in the form of a graduation thesis. Creating environments where students' opinions about the new ideas, study topics, and area of research can be taken.

	Planning of biology curriculum according to spirality; which is not suitable for subjects such as molecular biology, microbiology (teaching a part of the subject at each grade level causes confusion in students)	Some subjects should be clearly divided into molecular biology, microbiology, etc. to enable students to explore their interests, especially in biology.
	The fact that the low number of biology questions in TYT and AYT decreases students' motivation towards the course, (The fact that only 6 questions are asked in TYT and only 13 questions are asked in AYT in addition to 4 years of biology teaching and education from a course that is a life science reduces the interest in the course.).	Increasing the number of biology questions in TYT and AYT (Depending on the department (biology, medicine, pharmacy, molecular biology, and genetics, etc.) that the student will choose at the university, the number of questions from the courses related to that department should affect the exam score. In previous years, there were 30 biology, 30 chemistry and 30 physics questions in the university placement exam, and for example, the number of questions from biology and chemistry for students who would prefer medicine, and the number of questions from mathematics and physics for students who would prefer engineering would bring them more points. It is known that students were more interested in the lessons under the se conditions.
Environmental Factors	Some subjects of the biology course should be taught in nature. Some administrators do not want the trips to be made due to reasons such as transport costs, necessary permissions, paperwork burden, etc.; therefore, the lessons are always held in the classrooms.	School administrators should be informed that some subjects should be taught in nature and trips should be facilitated.
	In many schools, laboratories have been turned into classrooms because of the high number of students in the classrooms. Boredom of students due to theoretical education without laboratory.	Different solutions other than laboratories should be found for classrooms.
	Although there are laboratories in some schools, there are not enough materials.	At the end of the year, deficiencies in the school's laboratory materials (microscope, ready-made preparations, etc.) should be determined and reported and provided in time for the next academic year.
	Schools need budget for activities such as project studies, symposiums and congresses, the lack of which reduces the motivation of both students and teachers.	Especially project schools should be allocated a budget for these activities and local administrations and NGOs should be involved in budget creation.

3.4.2. Teacher Opinion II (Dr. Aynur Elif Bulut)

In the workshop session titled "Teachers' Opinions on High School Biology Curriculum," the fifth presentation was delivered by teacher Dr. Aynur Elif Bulut, at teacher with fourteen years of experience in the profession. Throughout her career, she has worked as a teacher and administrator in various types of schools, including multi-program high schools, Anatolian high schools, and science high schools. Dr. Bulut also reported that she possessed specialized certifications such as Amgen Teach, Scientix, Fellowship, and Amgen Master Teacher. She has received regional awards and achieved first and second place in national and international project competitions. In addition, Dr. Aynur Elif Bulut stated that she is actively engaged in academic research, contributing to national and international publications, papers, book chapters, notices, and projects. She also continues to participate in in-service training programs to enhance her personal and professional development.

During her presentation, Dr. Aynur Elif Bulut organized her speech under three main themes: international teacher and student standards, identified deficiencies in biology education according to the literature, and suggestions for teachers to address these issues (see Table 3.4). She explained the teacher and student standards set for biology education within the framework of UNESCO Sustainable Development Goals, International Society for Technology in Education (ISTE) student standards, and ISTE teacher standards.

Table 3.4. Teachers' Opinions on Challenges in Biyology Education-II

Themes	Standart	Examples
1. International teacher and student standards	Unesco Sustainable Development Goals	**SDG 4. 1. Universal primary and secondary education** By 2030, all girls and boys completing free, equitable and quality primary and secondary education, leading to relevant and effective learning outcomes. **SDG 4. 2. Early childhood development** By 2030, all girls and boys having access to quality early childhood development, care and pre-primary education and being ready for primary education.
	ISTE (International Society for Technology in Education) Student Standards	**Singapore High School Biology Education Key Objectives** 1. To provide students with an experience that deepens their knowledge and skills and develops the attitudes necessary for further studies in related fields, 2. To develop in students an appreciation of the application, value, and importance of biology as a discipline, 3. To develop in-depth, lateral, and critical thinking skills about biological topics so that students can critically analyse what they read and respond by writing well-structured arguments that integrate knowledge and skills from different areas of biology, 4. To develop in students the skills necessary for effective communication with diverse audiences through a variety of styles, modes, and media. **Australian Science Curriculum** Skills expected from students are: 1. Investigate body systems and ecosystems as examples of interconnected, interacting systems, 2. Investigating changes in our genes, 3. To deepen their understanding of the changes in systems that can be caused by changes at the atomic level, 4. Critically analyse and evaluate arguments and approaches used to solve problems, taking into account relevant ethical issues and how people's lives may be affected, 5. Critically reflect on the importance of science-based careers. **Next Generation Science Skill Standards** 1. Asking questions and identifying problems 2. Developing and using models 3. Research enquiry-based planning and execution 4. Data analysis and interpretation 5. Using maths and computational thinking 6. Constructive explanation and solution design 7. Relevance to the argument consisting of evidence and arguments 8. Obtaining, evaluating, and communicating information

	ISTE Teacher Standards 1. Analyst teacher 2. Learning Teacher 3. Designer Teacher 4. Cooperative Teacher 5. Leader Teacher 6. Facilitating Teacher 7. Digital Citizen Teacher	**Analist Teacher** 1. To be able to use assessment data for students to develop self-control, 2. Using technology for process evaluation, 3. Finding alternative ways. **Learning Teacher** 1. To follow current research results, 2. Discovering and applying technological innovations, 3. Participation in local and global networks. **Designer Teacher** 1. Explore and apply instructional design and principles, 2. Independent learning and differences, 3. Use of digital tools. **Cooperative Teacher** 1. Using collaborative tools for the experience, 2. Co-operation with colleagues, 3. Co-operation with students, 4. Communicating with parents. **Leader Teacher** 1. Being a role model for colleagues, 2. Having a vision, 3. To be able to conduct research studies. **Facilitating Teacher** 1. Creating learning opportunities, 2. To ensure that the student takes responsibility for learning, 3. Use of technology, 4. Role modelling in creativity. **Digital Citizen Teacher** 1. To be able to model and encourage the student, 2. To be able to provide digital guidance, 3. To be able to gain experience in digital environment, 4. To be able to create a digital learning culture.

At the conclusion of the presentation, when asked about the extent to which skills are incorporated into the high school biology program, Dr. Aynur Elif Bulut highlighted the importance of students acquiring skill standards. The speaker also emphasized the need for students to gain STEM competencies through programs like TUBITAK 2237-A Scientific Education Activities Support Program and TUBA trainings. Drawing from her own experience, Dr. Bulut shared that she assigned students to create diagnostic keys for skills training and enhanced their STEM achievements by engaging them in a "robotic irrigation" STEM activity.

3.4.3. Teacher Opinion III (Dr. Kurtuluş Atlı)

In the session of the workshop focused on "Teachers' Opinions on High School Biology Curriculum," the sixth presentation was delievered by Teacher Dr. Kurtuluş Atlı. With twenty years of experience in the field, Dr. Atlı has worked as a teacher in various types of schools, including secondary schools, vocational and technical Anatolian high schools, imam-hatip high school, and Anatolian high schools. He also served as an executive, trainer, and guide in TUBITAK project competitions. Notably, Dr. Atlı won the first place in the Biology Branch at the MoNE, EBA 3rd Science Experiments Video Contest in 2017 and was recognized as the Teacher of the Year in Nevşehir Province in 2018. In addition to his practical work, Dr. Atlı continues to engage in academic research, authoring national and international articles, papers, book chapters, communiqués and projects.

During his presentation titled "Challenges and Solutions in Biology Education", Dr. Kurtuluş Atlı discussed environmental factors and teacher competencies (see Table 3.5). He emphasized the crucial role of laboratory studies in biology education, mentioning that he has enriched his laboratory by collecting biological materials and that classrooms can be transformed into makeshift laboratories when dedicated lab spaces are not available. He also highlighted his YouTube channel, where he shares science experiments with relevant stakeholders (teachers and students), offering those who lack the opportunity to conduct experiments a chance to understand and follow the experimental processes. Emphasizing the importance of out-of-school learning environments in science education, he discussed the benefits of using school gardens, parks and natural areas in biology teaching. Dr. Atlı further noted that the absence of outdoor environments in biology education can lead to increased videophilia, obesity, autism, eye disorders, attention deficit hyperactivity disorder, stress, and depression. He suggested planning biology-related activities with students

outside of class and gave an example of a project involving growing plants from ancestral seeds in the school garden.

Table 3.5. Teachers' Opinions on Challenges in Biyology Education-III

Themes	Challenges	Proposed Solutions
Environmental Factors	Inadequacy of biology laboratory facilities	Classrooms can be converted into laboratories, Can enrich the laboratory by collecting biological materials from nature, Digital, printed, or three-dimensional materials can be developed, Science libraries can be set up in classrooms, Field studies can be carried out, -School gardens, parks and natural areas can be used, Biology clubs can be established, Remote (instagram, youtube, etc.) sharing media can be used with students, Extracurricular work (research project competitions, social responsibility projects, etc.) can be done with relevant students.
	Distance Education (videophilia) during the pandemic process	Out-of-school learning environments can be used more.
	Administrator communication	Administrators can be included in the studies.
Teacher Competencies	Students' level of readiness	Lesson appropriate to the students' levels can be taught.
	Independent teaching of biology course from other disciplines	Teacher competence in interdisciplinary teaching can be increased through in-service trainings.
	Student motivation	The teacher's ability to be decisive and use different strategies can be improved.
	Selectivity in student recruitment to education faculties	Strategies can be developed to attract higher percentile students to the Faculties of Education.
	Insufficient number of staff in teacher appointments	Sufficient vacancies can be advertised to cover the shortage of teachers.

3.5. Analysis of Middle and High School Biology Education Textbooks

The following session of the workshop features the presentation "Analysis of Middle and High School Biology Education Materials" by Prof. Dr. Ertunç Gündüz and Prof. Dr. Mehmet Yılmaz. Prof. Dr. Mehmet Yılmaz, the presenter, explained that textbooks serve as instructional materials used to systematically convey the subjects outlined in the curriculum and teach concepts to students. Prof. Yılmaz emphasized the importance of textbooks being free from inaccuracies and highlighted the presence of scientific errors in the middle school science textbooks and high school biology textbooks published by the MoNE. These errors have the potential to create misconceptions among students. During the presentation, Prof. Yılmaz shared some of the scientific errors identified in biology units of science textbooks (see Table 3.6) and biology textbooks (see Table 3.7). Additionally, he provided correct scientific explanations for these erroneous statements (Appendix 3 and Appendix 4).

Table 3.6. Scientific Analysis of Biology Units in Science Textbooks

Erroneous or Controversial Statements	Correct Explanation
"The joints of the vertebrae and the joints between the ribs and the sternum are examples of semi-flexible joints." "The joints between the vertebrae are examples of semi-flexible joints."	The human spine has 33 vertebrae. There are no semi-flexible joints between all of them. The vertebrae in the rump and tail are fully fused and do not move. The joints where the ribs connect to the sternum can flex but do not move. Similarly, between the first two cervical vertebrae (atlas and axis) there is a movable joint that allows the neck to rotate (Marieb et al., 2017: p.253; Gosling et al., 2008: p.397-401) As can be seen, the vertebrae in different parts of the spine have different characteristics. For this reason, it would be more appropriate to give the joints between the dorsal vertebrae and lumbar vertebrae as an example of semi-flexible joints.
Smooth Muscles (White Muscles)	It is scientifically incorrect to refer to smooth muscles as white muscles. White muscles are not smooth muscles but a type of skeletal muscles. Skeletal muscles of this type are called *white muscles* because of containing much less myoglobin than red muscles (Hole, 1993: p.281; Van De Graaff and Fox, 1992: p.270; Seeley et al., 1992: p.292).

"The upper part of the skull of newborn babies consists of a soft cartilaginous tissue."	This statement is scientifically incorrect. It may cause mislearning in students. The soft fontanelle at the top of babies' heads is the area formed by connective tissue where the skull bones have not yet joined with each other (Sadava et al., 2014: p.1020; Hickman et al., 2016: p.636). It would be appropriate to correct the statement in the book in accordance with the explanation.
"Absorption of water, minerals and vitamins takes place in the large intestine."	Nutrients are absorbed in the small intestine. All nutrient molecules from food are absorbed by the villi in the small intestine. The small intestine accounts for about 90 per cent of the absorption of nutrients. Some medicines are absorbed from the stomach. The breakdown products of carbohydrate, protein, fat and nucleic acid digestion, as well as vitamins, electrolytes and water are absorbed in the small intestine by various mechanisms. Most of the remaining water, minerals and vitamins produced by bacteria are absorbed from the large intestine. In this way, the large intestine forms semi-solid faeces (Sadava et al., 2014: p.1081; Hickman, 2016: p.704; Simon et al., 2017: p.483; Hall, 2021: p.828; Marieb, 2017: p.840). In textbooks, a perception has been created that the absorption of minerals and vitamins is only in the large intestine. However, the absorption of vitamins taken with food is carried out in the small intestine. Vitamins absorbed from the large intestine are vitamins produced by the bacteria living there.
"In the chemical digestion of food, enzymes act to initiate and accelerate the chemical reaction."	**An enzyme** is a macromolecule that acts as a catalyst, a chemical agent that accelerates a reaction without being consumed by the reaction. Enzymes do not initiate, but they accelerate reactions (Reece et al, 2013: pp.1048-1049; Nelson and Cox, 2005: p.247).
*	*

* The rest of the table is given in Appendix 3.

Table 3.7. Scientific Analysis of Units in Biology Textbooks

Erroneous or Controversial Statements	Correct Explanation
"Lipids have a polymer structure."	Lipid's are not polymers.A triglyceride is consist of a glycerol and three molecules of fatty acid. These structures are not monomer. (Urry vd., 2022).
"The most distinctive feature of vertebrates is that they have a spine made of vertebrae that follow each other on the back of their bodies. Because of this structure, organisms in this group are called **vertebrates (chordata).**"	Vertebrate animal and chordata are not the same concepts. Animals belonging to the sub-branches of the chordates (Chordata), tail chordates (Urochordata) and head chordates (Cephalochordata) do not have a backbone (Hickman, et al., 2016: p.498-501).
"Plants produce all the vitamins they need."	Vitamins are essential substances and are not produced by the organism itself (Reece et al., 2013: p.876).
"Vitamin D is also a hormone-acting substance."	This information is completely wrong. The substance that is said to have a hormone effect is not Vitamin D but another substance that is its analogue (Vieth, 2004).
"All vertebrates reproduce through amphigenesis."	This statement is scientifically incorrect. Some lizards, some fish and amphibians can also reproduce by parthenogenesis, a form of monogenetic reproduction (Hickman, et al., 2016: p.496).
"Oxytocin is a hormone secreted only by females".	This statement is scientifically incorrect. In humans, this hormone is secreted in both sexes. The hormones testosterone, prolactin, and oxytocin each appear to influence sexual activity in both males and females (Urry et al, 2022: p.1014).
"Any foreign substance that enters the body is called an antigen".	Substances that cause body cells to produce antibodies are called antigens. For example, there are hundreds of types of drugs used by humans that enter the body, which are foreign to the body, and these are not antigens (Reece et al., 2013: p.935).
*	*

* The rest of the table is given in Appendix 4.

Prof. Yılmaz addressed the presence of scientific errors and conceptual confusions in the examined textbooks, which may lead to misconceptions among students. He also highlighted scientific errors in the unit evaluation questions and in assessment and evaluation aspects. The speaker expressed his concern about the impact of these inaccuracies and errors, as they can result in mislearning and misconceptions among students. Particularly in the context of national exams, students may face difficulties and answer the questions incorrectly due to these issues. Prof. Dr. Yılmaz emphasized the importance of textbooks being free from scientific errors and compatible with the learning outcomes in the curriculum to ensure holistic and effective teaching nationwide. Citing previous studies on the issue (Karakaya, Yılmaz, Çimen, and Adıgüzel, 2020; Yeşilyurt and Gül, 2012), he emphasized that textbooks with flawed content can lead to misconceptions not only among students but also among teachers.

In response to the question "Why is the order of the subjects at classroom level not appropriate?", Prof. Dr. Ertunç Gündüz provided an explanation stating, "... the order of the subjects is arranged in accordance with the achievements outlined by the MoNE; however, the distribution of the subjects may differ from current scientific sources. Therefore, it is important to consider current scientific sources when determining subject distributions and sequencing." In addition, he emphasized the significance of teachers staying updated with current information in biology, suggesting that the MoNE biology curriculum and learning outcomes should be periodically reviewed and renewed. He added that students exhibit less interest in subjects that are not included in the exam system, indicating the need for a more holistic approach in the exam system or subject distribution. Assoc. Prof. Dr. Miraç Yılmaz also contributed to the discussion, noting, "… having students from different school types take the same Higher Education Institutions Exams (Basic Proficiency Test – TYT and Field Proficiency Tests - AYT) can result in inequality among students."

In response to the question "Did the reduction of biology course hours decrease the interest in biology?", Prof. Dr. Tahir Atıcı clarified the issue by sharing his observation that teachers themselves expressed the desire for a reduction in course hours and content during a meeting he attended. Prof. Dr. Tahir Atıcı explained that when updating curricula and determining the course hours, the MoNE takes into account the demands of the teachers invited to the meetings. However, he acknowledged that these demands may not always reflect the overall situation. For instance, he pointed out that teachers from different types of schools may have different needs and opinions concerning the same biology program. Consequently, reaching a consensus on a single biology program

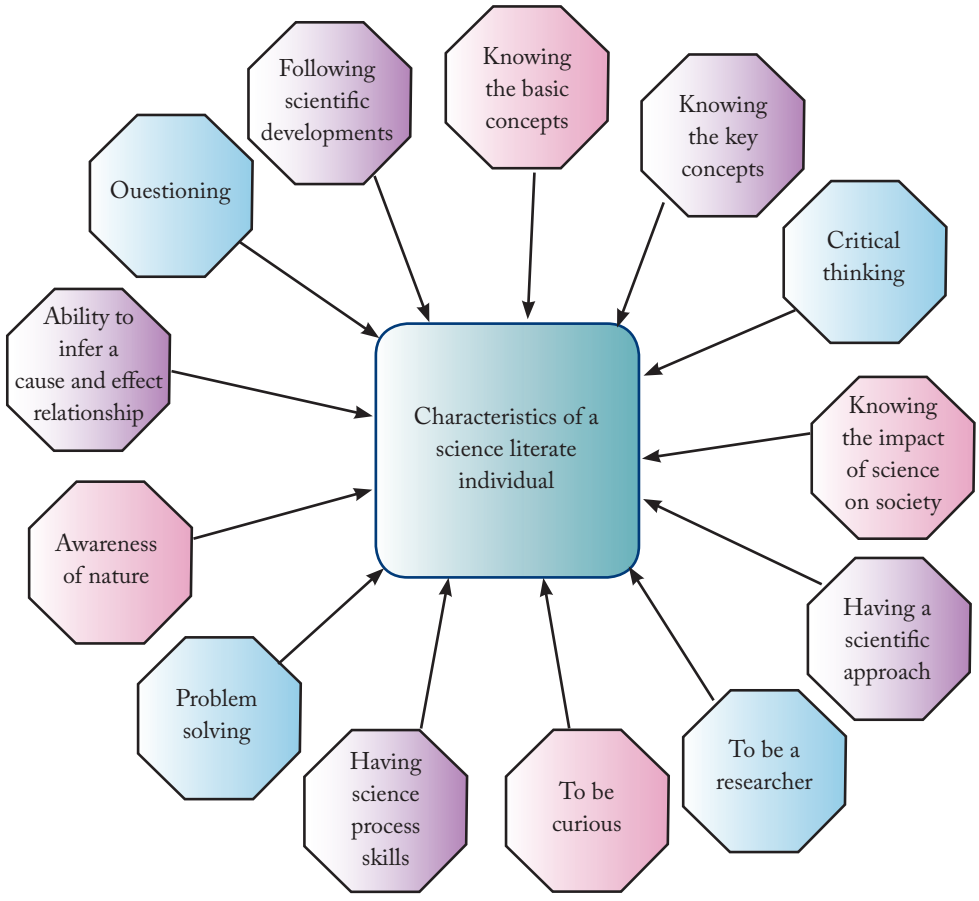
becomes challenging, resulting in new problems such as demands for decreasing or increasing biology course hours.

3.6. Science Education in Elementary School

The workshop continued with a presentation on "Science Education in Elementary School" delivered by Prof. Dr. Füsun Eyidoğan from Başkent University. The speaker emphasized the importance of providing students with high-level skills, such as scientific thinking, questioning, and problem-solving skills, from an early age in order to achieve an effective science education. Prof. Dr. Eyidoğan stated that only in this way can science literate individuals be raised (see Figure 1). She highlighted the aim, both globally and in recent years in Turkiye, to nurture generations equipped with 21st-century skills, including complex problem-solving, critical thinking, creative thinking, innovative production, effective communication, respect for cultural differences, high level of cooperation, international competitiveness, and entrepreneurship. The speaker emphasized that these aims necessitate a redefinition of curricula and the desired characteristics of teachers. From this point of view, the speaker shared insights on the importance of elementary education and classroom teaching, noting that the Department of Classroom Teaching is available in a total of 82 universities, including 72 state universities, 5 foundation universities, and 5 foreign universities, with a YKS quota of 4,236 students admitted through Equal Weight (EA) score type. Prof. Dr. Eyidoğan emphasized the inclusion of field-specific skills in the curriculum, such as scientific process skills, life skills (analytical thinking, decision-making, creative thinking, entrepreneurship, communication, teamwork), and engineering and design skills (innovative thinking). To provide these skills to prospective teachers, theoretical and applied science courses are necessary. A comparison was made between the 2013 program, implemented until the 2018-2019 academic year, and the revised Classroom Teaching undergraduate program in 2018 in terms of compulsory courses and science course semester. Prof. Dr. Eyidoğan stated that with the revision made in 2018, science theoretical and practical (laboratory and science teaching) courses decreased in terms of content, number, and hours. The speaker emphasized the importance of supporting the development of field knowledge among classroom teachers and pre-service teachers to address the lack of field knowledge in science subjects. Rather than decreasing field courses, there is a need to increase their presence in primary teaching programs at the university level. In addition, the speaker shared findings from studies conducted on the perception of special field competence among prospective primary school

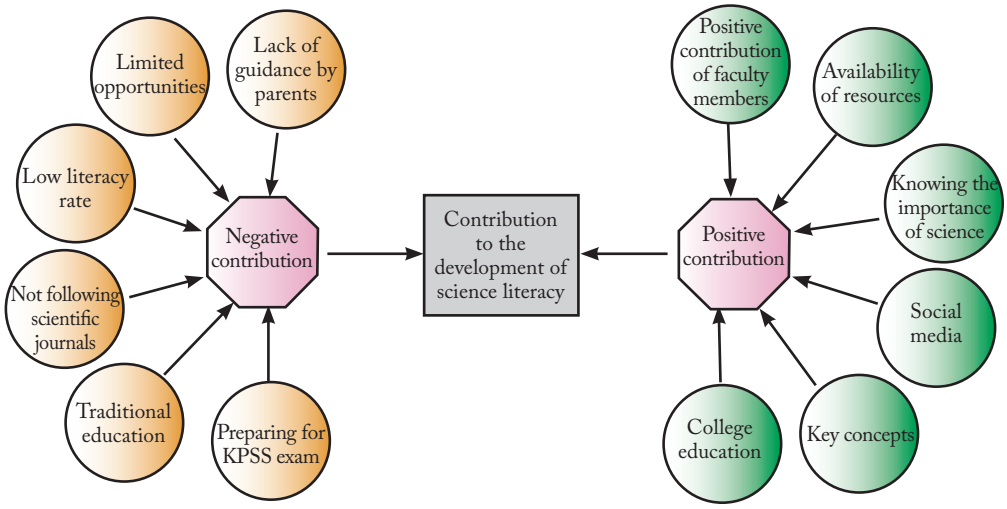
teachers, revealing that the lowest perception of competence was observed in the field of "scientific and technological development."

Prof. Dr. Eyidoğan referred to Kaya and Bacanak's (2013) study when discussing the positive and negative factors affecting the science literacy of classroom teachers (see Figure 2), highlighting factors such as traditional teaching methods during pre-service teacher education limited or no guidance from parents, limited opportunities, preparing for the KPSS exam, and insufficient engagement with scientific journals.



Source: Kaya ve Bacanak, 2013.

Figure 1: Preservice teachers views on the factors that impacts science literacy levels



Source: Kaya ve Bacanak, 2013.

Figure 2: Prospective Teachers' Opinions on the Reasons Affecting Their Science Literacy

Levels

Classroom teachers play a crucial role in fostering science literacy among primary school students. The speaker stated that although individuals begin receiving science education at the preschool level, they officially encounter the science course at the primary school level. However, due to the fact that the Department of Classroom Teaching admits students with an "equal weight (EA)" score type, teacher candidates may not reach the desired level in science courses. The speaker also noted that this situation aligns with research findings indicating that classroom teachers lack knowledge about the concepts in the MoNE curriculum (Özkara and Güven 2018; Koştur, 2019). Consequently, when assigned to the profession, they may struggle to explain scientific phenomena accurately to their students, leading to misinformation and misconceptions in students. In addition, the speaker concluded by emphasizing that classroom teachers predominantly utilize lecture, question-answer, field trip, observation, case study, and brainstorming methods in science lessons (Koştur, 2019), highlighting the need for incorporating new teaching approaches and techniques.

Placement of Candidates in Classroom Teaching Programs

Preschool and primary school teachers plays a fundamental role in students' education, including subjects such as Turkish and mathematics, and science (biology). Therefore, the science background of preschool and primary school teachers, particularly in the areas of physics, chemistry, and biology, is of utmost importance.

Table 3.8. Basic Proficiency Test

Considering the Score Type for the Target Program	Tests			
	Turkish Language and Literature Social Sciences-1	Social Sciences-2	Mathematics	Science
For Verbal Score	X	X		
For Numerical Score			X	X
For Equal Weight Score	X		X	
For Verbal+Equal Weight Score	X	X	X	
For Numerical+Equal Weight Score	X		X	X
For Verbal+Numerical+Equal Weight Score	X	X	X	X

Table 3.9. Distribution of Questions in Basic Proficiency Test (TYT)

Fields	Number of Questions
Turkish Test	40
Social Sciences Test	History 5 Geography 5 Philosophy 5 Religious Culture and Ethics5 (additional Philosophy questions) 5
Basic Mathematics Test	40
Science Test	Physics 7 Chemistry 7 Biology 6
Total	120

The YKS exam consists of three sessions: Basic Proficiency Test (TYT), Field Proficiency Test (AYT), and Language Proficiency Test (YDT). There are 4 score types in the exam: Numerical, Verbal, Equal Weight, and Language. The fact that the candidates selected for the Department of Classroom Teaching predominantly come from the equal weight field affects their level of readiness in science courses during their undergraduate education. While the numerical score type is obtained by solving science and mathematics questions, the equal weight score type is achieved by answering questions from mathematics, social sciences, and Turkish Language and Literature courses (see Table 3.8). Therefore, primary school teaching students admitted with the EW score type may have limited exposure to solving science questions. Their science background mainly stems from their high school education, where science courses (physics,

chemistry, biology) are elective for students in the Turkish-Mathematics field in the 11th grade. However, teachers report that almost none of these students choose to take science courses.

Including students in the Department of Classroom Teaching with the Numerical Score type (MF) in the TYT exam would equalize the readiness of students in terms of science content knowledge. This approach would ensure that they possess sufficient competence not only in biology but also in chemistry and physics for classroom teaching. A similar discussion can be raised for Preschool Teaching, which primarily admits students with the Verbal Score type, considering the same reasons.

3.7. Challenges and Solutions in Science Education Undergraduate Programs

The session on "Challenges and Solutions in Science Education Undergraduate Programs" was presented by Assoc. Prof. Dr. Duygu Sönmez. The speaker stressed that the Science Teaching Program, a 4-year undergraduate program in Türkiye, is offerred at 69 universities, with two different curricula being implemented. The 2018 Science Teaching Program, prepared by CoHE, underwent revisions in 2020 when the authority for program development was delegated to universities through a Higher Education decision dated August 10, 2020. Assoc. Prof. Dr. Sönmez explained that the 2018 curriculum consisted of three categories, including 1) Field Education Courses, 2) Pedagogical Knowledge Courses, and 3) General Culture Courses. New curriculum included increased number of elective courses. However, the most criticized aspect of the 2018 program was the combination of Field Education courses, which were taught as separate laboratory courses in the 2006 Science Teaching Undergraduate Program, with the theoretical courses, resulting in a reduction in the total hours compared to the 2006 program. Considering the importance of laboratory courses, this change posed a problem in terms of the knowledge and skill development for prospective teachers. The speaker informed that, fortunately, some universities have reincluded laboratory courses for field courses in their programs after 2020, which is considered a positive approach. Moreover, in the 2006 Science Teaching Undergraduate Program, the Instructional Technologies and Material Design course consisted of 4 hours, with 2 hours dedicated to theory and 2 hours to practice. However, in the 2018 program, this cource was integrated into the edagogical Knowledge course and reduced to only 2 hours. The Pedagogical Knowledge courses are open to all Facult of Education students, similar to general culture courses. As a result, teacher candidates from different

teaching programs can take the same course. This mixed student profile poses the risk of having too general or superficial content for courses, which require specialized knowledge, like instructional technology and material design. Considering the differences in the instructional technologies and materials that preschool teachers and science teachers will use in the classroom, it is clear that the course content of pre-service teachers studying in these teaching programs should be different. In addition, the removal of the practice hours in the 2018 program's Instructional Technologies course deprived pre-service teachers of practical experience in this context. Another challenge encountered in courses that are open to all faculty students is that the course instructor is likely to have a problem of expertise when it comes to the content of the course and the teaching branch.

Within the scope of the 2018 program, the inclusion of new courses, such as microteaching, museum education and out-of-school learning in science teaching, is considered positive as such courses address the changing requirements of the age.

On a positive note, the revised curricula implemented after 2020 by some universities have seen an increase in teaching practice hours starting from the 2nd grade. These programs also include courses that address changing requirements of the time such as informal learning environments and STEM. The credit structure varied in the programs changed after 2020. For example, the hour structures applied for the Biology I course are as follows:

I. 2 theoretical + 2 practical = 4 hours (no separate laboratory course)

II. 3 theoretical + 2 laboratory

III. 4 theoretical + 2 laboratory

Discrepancies in the number and hours of courses in compulsory education courses, as exemplified above, pose equivalence problems for student exchanges between programs and risks in terms of teacher competencies. Therefore, it is important to consider a common structure, including courses and course hours, for compulsory courses in teacher education undergraduate programs.

Furthermore, foreign language (English) education in science teacher training programs needs improvement. Given the intensity of the program, providing English preparation in the first year would greatly benefit teachers. It would equip them with important skills for pursuing master's degrees, doctorates,

e-twinning projects, literature reviews, accessing international resources in the field, and communicating with foreign colleagues.

3.8. Teachers' Opinions on Middle School Science (Biology) Curriculum

Teacher Aylin Güner Kahraman delievered the final presentation in the session on "Teachers' Opinions on the Middle School Science (Biology) Curriculum." At the beginning of her speech, Aylin Güner Kahraman mentioned her thirteen years of experience as a teacher in different middle schools and her role as a Project Specialist in the National Projects Team at the Ankara Provincial Directorate of National Education R&D Unit since 2019, as well as national and international projects and organizations she carried out or contributed to. The speaker stated that she continues her academic studies including national and international articles, papers and projects. Teacher Aylin Güner Kahraman mentioned the importance of environmental factors and teacher competencies in her speech on "General Problems and Solutions in Middle School Science (Biology) Education" (see Table 3.10). She emphasized that teachers who lack content knowledge and field pedagogical content knowledge cannot provide effective learning experiences for students, which negatively affects the students' knowledge, behavior, and attitudes towards the course. Aylin Güner Kahraman explained various projects conducted by the National Projects Unit of the R&D Unit, where she is currently working, to address this issue in teacher trainings. These projects include the "Başkent Teacher Workshops," "Mentor Academicians" and "Develop-Apply-Share" teacher training programs, where collaboration with faculty members in the relevant field is emphasized. She reported that such applied trainings are highly appreciated by teachers, resulting in high levels of participation. As an example, she mentioned the "Daphnia STEM Workshop" activity conducted by Prof. Dr. Semra Mirici at the Feza Gürsey Science Center with the theme of "Effective Use of Science Centers as Out-of-School Learning Environments in Biology Education," which was planned for biology and science teachers within the scope of the Başkent Teacher Workshops.

Table 3.10. Challenges and Solutions in Secondary School Science (Biology) Education

Themes	Challenges	Solutions
Environmental Factors	Failure to carry out laboratory studies due to physical inadequacies	The number of science laboratories in schools should be increased and the teachers who will use these laboratories should be trained in such a way that they can make applications in almost every subject, and these competences should be improved through in-service training activities.
	Misconceptions and visuals in textbooks	Taking into account the academic studies on the scientific errors identified in biology and science textbooks, the textbooks should be examined by commissions to be formed from academics and field experts, and the necessary corrections should be made and enriched. The visuals used in existing textbooks should be enriched with visuals from internationally recognised scientific sources. Textbooks should be transformed into interactive tools that facilitate the learning of information rather than just being a tool where information is brought together. Textbooks should be examined by commissions to be formed from academicians and field experts, and necessary corrections should be made and enriched.
	Course material deficiencies	Materials prepared by supporting with visual, auditory and technology will be effective in eliminating students' knowledge deficiencies in biology, developing positive attitudes towards the course and increasing their desire to learn.
	Ineffective use of out-of-school learning environments	The realisation of the activities carried out in science centres in line with the targeted gains will enable thecurricula to progress the scientific attitudes of the students in the desired direction. In this regard, teachers' needs should be taken into consideration and support should be given through professional development trainings.
Teacher Competencies	Deficiencies in field and field education knowledge	Practical in-service training courses can be organised by academicians and field experts in cooperation with the MoNE and universities.

3.9. Challenges Related to Pedagogical Formation Trainings

3.9.1. Historical Background of Pedagogical Formation Trainings

The next session of the workshop titled "Challenges Related to Pedagogical Formation Trainings" was presented by Prof. Dr. Tahir Atıcı. The speaker began his speech by explaining that pedagogical formation is a training program required for individuals who have not graduated from the Faculty of Education but want to teach in educational institutions related to their fields. He said that, in Türkiye, pedagogical formation trainings are provided by universities in 94 branches based on teacher qualifications and course registrations specified by the MoNE. Prof. Dr. Atıcı discussed the historical background of pedagogical formation, which involved various attempts after the establishment of the Republic to address the need for teachers in primary and secondary education institutions. These attempts included reserve officer teachers, substitute teachers, teacher training courses, training teachers by letter, teacher training with accelerated programs, and appointment of teachers from graduates of faculties other than the Faculty of Education (Tuncel, Z. A. 2016).

The historical milestones of pedagogical formation are as follows:

- In 1973, the National Education Basic Law No. 1739 allowed higher education graduates to become teachers by completing a teaching formation program (Bilir, 2011: 237).
- In 1974, 46,000 people participated in and were appointed as teachers through the Teacher Training by Letter program (Bilir, 2011).
- In 1980, the Ministry of National Education launched the 21-credit Teaching Formation Program.
- In the 1990s, this program was replaced by the 33-credit Primary Classroom Teaching Certificate Program (Bilir, 2011).
- In 1995-1996, graduates from any undergraduate program were appointed as classroom teachers without requiring teaching formation (Bilir, 2011).
- In 1997, the CoHE, with its decisions dated 04.11.1997 and numbered 97, 39, 2761 on teaching certificate programs, restructured teacher training, introducing non-thesis master's degree programs with the claim that teaching certificate programs for secondary education teaching were too distant from practice and inadequate in terms of content and duration.

- These programs were carried out in two ways, a total of 5 years, including 3.5+1.5 years, for students of the Faculty of Education, and a total of 5.5 years, including 4+1.5 years, for students of the Faculty of Science and Technology. Following this decision, all teaching certificates programs were closed (CoHE, 1998).
- In 2007, pedagogical formation authorization was granted by the CoHE to the Faculties of Science and Literature, and the decision of the General Assembly of the CoHE allowed students to receive 21 credits of pedagogical formation during their undergraduate education (Bilir, 2011).
- In 2010, the non-thesis master's degree program for secondary education in the Faculty of Education was transformed back into a pedagogical formation certificate program (Ayvaz Tuncel, 2016).
- In addition, senior students of the Faculty of Science and Literature and students in their fifth semester became eligible to receive pedagogical formation certificate training.
- In 2011, with the decision of the CoHE, pedagogical formation certificate training has been open to students or graduates of all departments in all faculties, including graduates of science and literature faculties.
- Every year, the CoHE announces universities authorized to offer the pedagogical formation certificate program.

The number of universities authorized by the CoHE since 2011 to offer pedagogical formation certificate programs are as follows:

- 53 universities in the 2011-2012 academic year,
- 64 universities in the 2012-2013 academic year,
- 110 universities in the 2014-2015 academic year,
- 108 universities in the 2015-2016 academic year (CoHE, 2017).

The quotas of the pedagogical formation certificate program by years are as follows:

- Approximately 114,525 people in the 2014-2015 academic year,
- Approximately 33,050 people in the 2015-2016 academic year,
- Approximately 84,370 people in the 2016-2017 academic year,

- Approximately 38,990 people in the 2017-2018 academic year,
- Approximately 35,540 people in the 2018-2019 academic year
- The number of people benefiting from the program in the 2021-2022 academic year is parallel to the numbers in previous years.

3.9.2. Comparison of Pedagogical Formation Training Certificate Program and Biology Education Curricula

The speaker Prof. Dr. Tahir Atıcı stated that no linear relationship could be established when the number of students enrolled in the pedagogical formation certificate program was compared to the number of faculty members in Biology Education Departments of the Faculties of Education (see Table 3.11).

Table 3.11. Number of Faculty Members at Biology Education Departments and Number of Students Enrolled in Pedagogical Education Certificate Programs

University	Number of Faculty Members	Number of Students Registered at the Programs	Faculty Member per Student
Gazi University	17	102	0.166
Hacettepe University	11	100	0.100
Marmara University	4	105	0.038
Atatürk University	5	6	0.833
Dokuz Eylül University	3	97	0.020
Necmettin Erbakan University	8	88	0.090
Van Yüzüncü Yıl University	6	11	0.545

The base scores and number of students placed in the Biology Teacher Education Program in public universities were analyzed over the past three years (see Table 3.12). The findings showed an increase in student base scores. For example, in the 2020-2021 academic year, 122 students in the range of 343.950-444.250 points were placed in seven universities, whereas 123 students in the range of 384.831-471.122 points were placed in seven universities in the 2021-2022 academic year. In the 2022-2023 academic year, 123 students in the range of 374.211-471.111 points were placed in nine universities.

In contrast, when looking at the base scores and number of students enrolled in Biology programs in state universities, a decrease in the number of departments, student base points, and quotas was observed (see Table 3.12). For instance, in the 2020-2021 academic year, 1988 students between 310.700- 476.193

points were placed in 60 universities, whereas 1532 students between 294.690-480.583 points were placed in 55 universities in the 2021-2022 academic year. In addition, 1726 students between 314.667-485.207 points were admitted to 50 universities in the 2022-2023 academic year.

Based on these statistical data, Prof. Dr. Atıcı highlighted the significant difference in student quotas between Biology Teaching and Biology Programs in state universities in the 2022-2023 academic year, with approximately a three-fold advantage for the biology program (509/1726). On the other hand, he also noted that students enrolled in the Biology Program were placed with relatively low base scores (374.211-314.667) compared to Biology Teaching (see Table 3.12).

Table 3.12. Base Scores of Biology Teaching and Biology Programs in State Universities

Years	Biology Teaching			Biology		
	Number of Universities	Base Score Range	Number of Students	Number of Universities	Base Score Range	Number of Students
2020	7	444.250 – 343.950	122	60	476.193 – 310.700	1988
2021	7	471.122 – 384.831	123	55	480.553 – 294.690	1532
2022	9	471.111 – 374.211	509	50	485.207 – 314.667	1726

In terms of course requirements, students in the Faculty of Education Biology Education Program must complete 50 credits of courses, including elective courses such as education and formation courses in order to prepare for teaching, while candidates graduating from the biology departments in Science Faculties who receive the Pedagogical Formation Education Certificate are required to take only 10 courses totalling 24 credits (see Table 3.13). Prof. Dr. Atıcı emphasized that courses that are prerequisites for each other take place in the same semester and concluded his presentation providing an example to this situation. He informed that students take the Teaching Practice in the second semester simultaneously with the Instructional Technologies and Material Development and Special Teaching Methods courses, which are prerequisites for this course.

Table 3.13. Courses at the 2021-2022 Pedagogic Formation Education Certificate Program

Course Title	**T**	**U**	**K**	**EKTS**
Introduction to Education	3	0	3	6
Teaching Principles and Methods	3	0	3	6
Classroom Management	2	0	2	4
Special Teaching Methods	3	0	3	6
Teaching Practice I	1	6	4	8
II. Semester				
Assessment and Evaluation in Education	3	0	3	6
Educational Psychology	3	0	3	6
Counseling and Special Education	3	0	3	6
Instructional Technologies	2	0	2	4
Teaching Practice II	1	6	4	8
Grand Total	24	12	30	60

During the discussion session, the question "Are the courses given in the Pedagogical Formation Certificate Program equivalent to the curriculum in the Biology Education Undergraduate Program?" In response to this question, Prof. Dr. Tahir Atıcı expressed that there are education courses in the Biology Education undergraduate program that are not given in the formation program.

Another question was whether it is possible to complete pedagogical formation education in one or two semesters during undergraduate education. Prof. Dr. Atıcı responded that it is not a scientific approach to switch to education without having a good command of the field.

Regarding the question of why individuals who do not prefer undergraduate teaching programs later choose to become teachers through pedagogical formation, two perspectives were presented. One perspective highlighted economic reasons, such as difficulties in finding employment as a biologist, while the other perspective highlighted the higher entrance requirements for Faculties of Education, which led individuals to choose the formation route. It was also noted that some undergraduate students initially chose the Faculty of Education as their first choice because they were aspired by teaching as a profession from the very beginning. The issue of pedagogical formation was one of the most debated and discussed topics of the workshop.

FINDINGS OF FOCUS GROUP DISCUSSIONS

4.1. Findings of the Work Group on Challenges and Solutions in Middle School Science (Biology) Education

During the focus group interview addressing current issues in science teaching at the 5-8 grades level, the identified issues were categorized into four main themes: curriculum competencies, teacher competencies, environmental factors, and student motivation.

4.1.1. Curriculum Competencies

The workshop addressed several issues related to the curriculum competencies that could impact effective science teaching. The following areas were highlighted for improvement:

1. Textbook Content: Upon examination, it was observed that certain subjects covered in the science curriculum were not fully aligned with the content of the textbooks. To address this, it was suggested to associate the contents and activities of the textbooks with the desired learning outcomes. This alignment would enhance the effectiveness of science education.

2. Active Student Participation: Active participation of students in science lessons and activities is important for effective learning process. Upon reviewing the curriculum, it was noticed that the time allocated for achieving learning outcomes varied across different units. As a result of this, some units allowed sufficient time for conducting activities and experiments, while others did not. For instance, upon analyzing the 5th-grade science curriculum, it was found that teachers had ample time to conduct activities and experiments aligned with the objectives. It is recommended to strive for a similar balance in other secondary school classes. To achieve this, it is essential to consider the relationship between the learning outcomes and the time allocated, enabling effective planning that encourages students' active participation.

3. Coordinated Curriculum: Currently, curricula are designed and implemented independently, resulting in challenges for students to perceive the connections between different disciplines (biology, chemistry, physics, and mathematics). As a solution, it is proposed to develop a coordinated curriculum that aligns with other discipline starting from preschool education. The program contents should be evaluated for quality and organized in planned sequence with other fields, ensuring a cohesive educational experience.

4.1.2. Environmental Factors

During the workshop, several environmental factors were emphasized as significant considerations for effective science teaching. The following issues were emphasized:

1. Misconceptions in Textbooks: Misconceptions have been one of the most emphasized issues in terms of textbooks in science teaching. It was highlighted that misconceptions identified in science textbooks have persisted over the years, and it is essential to address them promptly. Since the MoNE textbooks serve as a guide for teachers, schools, and science education, it is crucial to resolve the existing misconceptions quickly. One suggestion to update their content and rectify existing misconceptions is to transfer the textbooks to a platform accessible to all teachers and academics. This would enable the academics and teachers, who are experts in the field, to evaluate and provide feedback on the content of the textbook, which would allow facilitating more effective updates based on the feedback received.

2. Connecting Biology with Nature: Biology, being closely intertwined with nature, needs better integration in textbooks to establish strpng associations with real-life contexts.

3. Shortage of Materials: Teachers emphasized the lack of materials as a significant deficiency. Production and dissemination of course materials that attract students' attention and transform abstract information into tangible concepts can greatly enhance biology, which will make biology teaching both easier and more engaging.

4. Practical Learning: Emphasizing practical experiences for students, the inclusion of agricultural areas in schools was suggested as an example. Establishing "Ecological Schools" that will allow students to step outside the boundaries of the classroom, engage with ecology and agriculture first-hand, and learn biology concepts more efficiently was proposed.

5. Laboratory Infrastructure: Laboratory applications are vital for effective science teaching and learning. Schools lacking or deficient in microscope and other laboratory infrastructures should address these shortcomings and provide consumable materials to support hands-on learning.
6. Integration of Technology: Incorporating current technologies into teaching processes is crucial. It is important to utilize technology-supported teaching materials to capture students' attention and motivation, as well as creating modular classroom environments that facilitate interactive learning experiences.
7. Enrichment of Teacher's Guidebooks: In previous periods, teacher's guidebooks were considered more supportive in terms of guiding and assisting teachers. It is recommended to enrich the content of the guidebooks, which serve as invaluable resources and guides for teachers.
8. Enriching Activities: The activities provided in textbooks often rely on traditional paper-and-pencil tasks, which may limit student motivation. To foster skill development and critical thinking, these activities should be structured accordingly. In addition, alternative activities catering to different student levels should be developed, allowing teachers to choose the most suitable ones for the level of their classes.
9. Interdisciplinary Approach: Evaluating biology activities reveals a gradual decrease in the integration of mathematics. For example, activities related to topics like Mendelian Crossover, lacking a mathematical dimension, fail to support students' multidimensional and interdisciplinary thinking skills. Integrating interdisciplinary education into lessons is crucial.
10. Enrichment of Educational Portals: The EBA Education Portal, a reliable portal frequently used by teachers, should be enriched with content provided by experts. Increasing the availability of such platforms where teachers can communicate and share resources with one another is recommended.
11. Collaborative Strategy: Organizing meetings between pre-service teachers and experienced educators in the field to share good examples and new information in science and science education will foster valuable exchanges for both groups.

4.1.3. Teacher Competencies

The workshop focused on various issues related to teacher competencies that can significantly impact science teaching. The following issues were emphasized:

1. Curriculum Implementation: The curriculum is designed to enable students to conduct research-oriented and skills-based teaching. However, many teachers expressed a lack of confidence in their qualifications in this area. In addition, they highlighted the need for support in adapting to curriculum changes. To address these concerns, regular in-service training sessions should be organized, levering technology and expertise from the field.

2. Direct Student Research: Feedback obtained from teachers revealed that they struggle with guiding students in conducting research. According to recent studies, teachers should possess interdisciplinary thinking skills and encourage students to think critically and make connections between subjects. In-service training programs should be enriched to enhance competencies such as literature review, analytical thinking, problem identification, and problem solving.

3. Mentorship and Learning Communities: As part of professional development, teachers can benefit from being observed and sharing experiences with expert mentors who are experienced in their field. Approaches such as mentorship and learning communities are considered effective practices for enhancing professional development of teachers.

4. Practice-based Workshops: Universities should widely offer practice-based workshops based on needs analysis conducted with teachers to support their professional development. These workshops should focus on open-ended inquiry, develop imagination, and follow interdisciplinary approaches.

5. Pedagogical Formation Programs: Instead of requiring a pedagogical formation certificate for those graduating from departments and programs other than the Faculties of Education in order to pursue teaching careers, it may be more effective to incorporate this education through minor or double major programs. This structure would allow candidates to interact with Faculty of Education students. In addition, admission to pedagogical formation programs sould require meeting minimum success ranking requirements set by the CoHE for teaching programs in Faculties of Education.

6. Field-Based Pedagogical Formation Groups: Pedagogical formation groups in faculties currently consists of students from various disciplines without any field-specific distinctions. This creates challenges for course instructors who must teach students with different areas of specialization. To address this issue and improve the quality of education, pedagogical

formation groups should be organized on a field-specific basis. For example, universities without a biology undergraduate program should not offer pedagogical formation quotas for biology teacher candidates. This approach would eliminate the incompatibility between course instructor and student groups.

7. Collaboration and Support Networks: Establishing social networks can help address issues such as professional burnout, communication breakdown between teachers, and administrative staff, and foster dialogues among educators. It is important for academics cooperate with teachers in the field. Faculties of Education should foster a culture of personal criticism and development. These social networks can serve as platforms for educators to support and critique each other, facilitate subject-specific dialogues, and encourage teacher-academic collaboration.

8. Recognition and Rewards: Implementing a standardized system for rewarding teachers' professional achievements and successes (e.g., master's degree, and project successes) through certificates of achievement, financial support, etc., can greatly increase teacher motivation.

4.1.4. Student Motivation

The workshop also highlighted key factors related to student motivation that can be effective in science teaching. These key factors are as follows:

1. Creating a Comfortable Environment: To enable students to express themselves correctly and encourage them to practice actively, teachers should provide a safe and supportive environment where students do not feel afraid or ashamed of making mistakes.
2. Efficient Learning Environments: Planningahead for alternative methods such as distance education and creating efficient learning environments are essential for motivating students during the educational process.
3. Innovative and Collaborative Practices: Implementing innovative, technology-supported, and collaborative teaching practices that develop 21st-century skills can significantly increase student motivation.

4.2. Focus Group Findings on Challenges and Solutions in High School Biology Teaching

The focus group discussion addressed current problems in Biology teaching at the high school 9-12th grade level, categorizing them under four main

themes: curriculum, teacher competencies, environmental factors, and student motivation.

4.2.1. Curriculum Competencies

During the workshop, the following issues were pointed out about the curriculum competencies that can have ab impact on high school biology teaching:

1. Concept Placement: Placing texts on the concept of biomimicry in appropriate sections of the chapters can make it easier for students to associate biology with daily life.

2. Scope of 9th Grade Curriculum: The scope of the 1st unit of the 9th grade was considered too broad, as it introduces chemical concepts that that students have not yet learned in the chemistry courses. Simplifying this unit would alleviate students' learning difficulties.

3. Streamlining Topics: The chemistry of living organisms should be shortened by specifying only the names of organic and inorganic compounds, as well as the structural units of carbohydrates, lipids, proteins, and nucleic acids. The basic (essential) nutrients for humans should be specified, and common characteristics of living things should be simplified to general characteristics only.

4. Class Hour Allocation: Due to the difficulty of completing three units within two class hours in the 9th grade, it is recommened to either increase class hours or rearrange the sequencing, placing the 3rd unit, "The World of Living Things," before the "Ecosystem Ecology" unit in the 10th grade.

5. Unit Sequencing: It is considered appropriate to teach the 3rd unit in the 10th grade, "Ecosystem Ecology" as the 3rd unit in the 9th grade.

6. Integration of Endosymbiotic Theory: Adding an explaination of the endosymbiotic theory to the 9th grade achievement descriptions was proposed.

7. Environmental Course: Considering the significant impact of environmental problems caused by human-induced and natural factors (extinction of living things, fragmentation of habitats, spread of invasive species, global climate changes, affecting communities with abiotic factors such as drought, fire, flood, erosion), causing devastating effects from the smallest habitats to the biosphere, even the name of the Ministry of Environment and Urbanization

was changed to the Ministry of Environment, Urbanization and Climate Change. Considering these situations, it was suggested to introduce a compulsory course on the environment in the high school curriculum. An example course title could be "Environmental Changes and Human."

8. Reinstatement of Biology Applications Course: There was a common opinion among participants that the Biology Applications course should be reintroduced into the curriculum.

4.2.2. Teacher Competencies

The teaching profession requires high competencies to bear the responsibility of shaping human lives. To achieve the desired outcomes in the field of education, it is crucial that teachers can effectively utilize in learning environments the innovations introduced in the field of education (MoNE, 2017). High teacher qualifications play a vital role in realizing knowledge-based economic development. In this context, general competencies for the teaching profession consist of three competency areas: professional knowledge, professional skills, and attitudes and values.

During the workshop, the following issues were emphasized regarding teacher competencies that can be effective in high school biology teaching:

1. Keeping Pace with New Knowledge: New knowledge in biology is increasing at a dizzying pace. For the teachers to catch up with these rapid developments in biology, collaboration between the MoNE and universities was identified as crucial. In addition, teachers should be encouraged to pursue postgraduate education by removing any barriers that can absent them from these goals.

2. School-Based Professional Development Model (SBPD): Teachers who have completed postgraduate education could be given the opportunity, based on official assignments, to provide informative trainings to other teachers in their areas of expertise within their provinces, following the SBPD model.

3. Teacher-Led Trainings: Teachers who have received project cycle training and carried out successful projects could be given the opportunity, based on official assignments, to provide information trainings to other teachers.

4. Collaborative Work and Role Modeling: It is important for teachers to develop qualities that promote collaborative work, interdisciplinary studies, and serve as role models for creativity.

5. FAuthentic Assessment Strategies: Instead of relying solely on written exams on specific dates during the semester, formative and process-based assessment such as portfolios, pop-up quizes, self-assessment forms, peer assessment forms, and rubrics, should be prioritized. Therefore, in-service trainings should be organized to familiarize teachers to use more authentic assessment and evaluation strategies.

6. Standardized Exam Questions: It is suggested to develop appropriate common exam questions aligned with the assessment and evaluation criteria mentioned in the curriculum, ensuring content validity of the achievements. These questions can be implemented nationwide once academic regulations are in place.

7. Motivation and Professional Development: Improving teacher salaries would motivate teachers to seek professional development opportunities such as trainings, conferences, and workshops, that enhance their skills.

8. Alignment of Starting Grades: Adjustments should be made to ensure that graduates from Faculty of Education start their professional careers by teaching the 9th grades, while graduates from Faculty of Science who received pedagogical formation education start teaching the 8th grades.

9. Specialized Training for Science and Art Centers: Biology teachers are employed as teachers in either high schools or science and art centers after graduation. Biology teachers assigned to science and art centers should receive training in project design, instrumental devices, and other relevant skills. To achieve this, it is recommended to collaborate with universities in terms of training and project design.

10. Project Design and Technology Use: In-service trainings should focus on project design and effective use of technology.

11. Social and Emotional Learning Skills: Teachers should enhance their knowledge, skills, and attitudes to develop students' social and emotional learning skills.

4.2.3. Student Motivation

The workshop drew attention to the following issues regarding student motivation that can be effective in high school biology teaching:

1. Addressing Student Engagement: The pandemic has negatively affected

reduced students' connection with the school, resulting in their absence without valid reasons for 1-2 days per week. Efforts should be made to improve student motivation and encourage regular attendance.

2. Readiness Assessment: It is considered necessary to assess students' readiness levels at the beginning of each new academic year. In order to assess this level, it is recommended to develop appropriate assessment tools aligned with the learning outcomes and academic regulations.

3. Increasing Exam Questions: To enhance students' motivation towards biology throughout high school education, it is recommended to increase the number of biology questions in the YKS (TYT and AYT) as was the case in previous years.

4. Active Participation: Approaches and methods such as projects, debates, and competitions should be employed to ensure students' active participation in learning processes as much as possible.

5. Out-of-School Learning: Increasing the number of activities in out-of-school learning environments, where students can actively engage and collaborate, is essential for enhancing motivation.

4.2.4. Environmental Factors

During the workshop, the following issues were emphasized regarding the environmental factors that can be effective in high school biology teaching:

1. Support for Out-of-School Environments: Facilitating official procedures and providing financial support for out-of-school learning environments would be beneficial.

2. Teacher Participation in Scientific Trainings: Facilitating official procedures and encouraging teachers to participate in scientific trainings such as seminars, congresses, and workshops is considered important.

3. Dedicated Use of Biology Laboratories: Existing biology laboratories at schools should be exclusively allocated for laboratory purposes and not be used for other purposes such as classrooms.

4. Training on Lavoratory and Experimental Techniques: Teacher competencies in laboratory and experimental techniques should be improved through collaboration between the MoNE and universities.

5. Availability of Materials and Equipment: It should be ensured that the necessary materials and equipment required for conducting experiments mentioned in the MoNE high school biology textbooks are purchased at the beginning of each year.

6. Supplementary Resources: Some academic studies have shown that there are significant errors in textbooks and that using them as teaching materials can lead to incorrect learning. Teachers who depend on textbooks as the only source will not be able to convey to their students' information free from scientific errors. For this reason, teachers should be ensured to follow current academic books widely used worldwide, in addition to textbooks and supplementary materials, to ensure accurate information transmission.

7. Accuracy of Visual Elements: In addition to scientific content, scientific errors in visual elements are also a source of misconceptions in MoNE textbooks. Therefore, it should be ensured that visual elements used in textbooks do not contain erroneous information that could lead to misconceptions.

8. Informing about Misconceptions: While preparing the MoNE extbooks, the authors should be provided with necessary information about misconceptions by the relevant general directorate.

9. Expert Review of Textbooks: Books prepared by MoNE, which have been approved by commissions, should be reviewed by field experts to identify errors, and provide necessary feedback.

10. Communication of Identified Errors: All stakeholders should be informed by the relevant units about the errors identified by field experts in the current MoNE textbooks.

4.3. Focus Group Findings on Challenges and Solutions in Undergraduate Biology Education Programs

During the workshop, the following issues were highlighted regarding the curriculum competencies that can be effective in undergraduate biology education (biology teacher education):

4.3.1. Curriculum Competencies

1. Challenges in Program Codes: Biology curriculum has been revised several times. These frequent revisions have resulted in students being registered under different codes and programs within the same department. This

situation causes various difficulties in student transactions and the overall functioning of education. An example to this situation is Balıkesir University, where some students were registered under 5 different codes in the same department.

2. Criticism of Program Changes: Especially the 2018 program change received significant and frequent criticism from all stakeholders, including teaching staff and prospective teachers. The reduction of field knowledge courses and the removal of laboratories were particularly criticized. To compensate for this deficiency, lecturers were reported to have conducted extracurricular laboratory practices.

3. Need for Stable Program Changes: Upon criticism, the CoHE left the programs of the Faculties of Education to the faculties in 2021, and this time, only 1 of the 8 Biology Education Departments revised its program and the others have not yet completed this process. In short, frequent, and radical changes in teacher education programs have not rewarded the time and effort spent to deal with the emerging problems. While it is necessary to incorporate developing educational innovations in education programs, changes should be made while preserving the beneficial aspects of the program.

4. Addressing Erasmus+ Program Constraints: It has been reported that students face challenges participating in the Erasmus+ program due to the risk of losing a semester. Creating opportunities such as additional credits can prevent this loss.

5. Enhancing English Education: Foreign language (English) education in biology teacher education programs is inadequate. Considering the intensity of the program, introducing English preparation courses in the first year of the undergraduate program would provide significant gains, such as pursuing a master's and doctoral degree, engaging in e-twining projects, conducting literature reviews, accessing global resources in the field, and communicating with international colleagues.

6. Diversifying Teaching Practice: Instead of the same school in both semesters, it is recommended to hold the Teaching Practice Course in different schools, including vocational high school, science high school, and Anatolian high schools, to expose teacher candidates to students at all levels.

7. Application-Based Curriculum: The biology curriculum should include applied courses that accurately incorporate project-based learning and STEM approaches.

8. Alumni Follow-Up and In-Service Trainings: Establishing a graduate follow-up system for biology education graduates and allowing them to attend courses at universities to address their perceived deficiencies would be beneficial. Additionally, opening applied in-service training programs for graduates would be valuable.

9. Collaboration Among Faculties of Education: Faculties of Education should be aware of each other's challenges and hold experience-sharing meetings to discuss problems and potential solutions in biology education programs within the scope of common ideas.

4.3.2. Faculty Member Teacher Competencies

During the workshop, the following issues were emphasized regarding the competencies of instructors that can be effective in undergraduate biology education (biology teacher education):

1. Specialized Field Education: Some field education courses in the Biology Education Program should be taught by faculty members specialized in the subject area.

2. Managing Workload: Due to the low number of assistants in the Departments of Biology Education, lecturers face increased workload especially during the exam periods. For instance, one participant shared that he had to invigilate in 42 exams in a week. Allocating part-time scholarships to graduate students at master's level by the universities' Administrative Departments of Health, Culture and Sports could help meet the need for invigilation of exams.

3. Expertise in Biology and Educational Sciences: Since both biology and educational sciences courses are given in the Departments of Biology Education, Faculty of Education graduates trained in the field of biology should be appointed to Faculties of Education in addition to field educator positions. In fact, encouraging some students or assistants in the Faculty of Education to pursue a doctorate in biology would contribute to raising faculty members who are experienced in both teaching and biology.

4. Increasing the Number of Faculty Members: The number of faculty members in faculties of education should be increased to allow time for research, applied studies, and projects.

5. Supporting Field Education: Field and field education academic studies in Biology Education Programs are considered very necessary for the curriculum competencies to reach their goals. Therefore, initiatives should be taken to facilitate field education studies during master's and doctoral programs in order to enhance the curriculum competemcies.

6. Collaboration Between Field Educators: Field educators and field education specialists should work in cooperation within Biology Education Programs.

7. Interdisciplinary Doctoral Programs: A double doctorate in both field and field education is recommended for training faculty members for the Faculties of Education. On the other hand, doctoral programs in both field and field education were recommended to be offered, ideally interdisciplinary and hybrid formats within Educational Sciences Institutes, eliminating the need for double doctorate. Another suggestion was that faculty members trained in the field of biology education should at least do a post-doctorate and be trained in both field and field education.

8. Enhancing Faculty Competencies: In-service trainings covering necessary subjects, such as information technologies, assessment and evaluation and especially communication skills, should focus on increasing the competencies of faculty members in the Departments of Biology Education.

9. Monitoring the Schools: Faculty members in the Departments of Biology Education should engage in necessary examination, research and application activities related to the schools where teacher candidates practice.

10. Field Courses in Graduate Programs: Graduate students in biology education should be required to take compulsory field courses in addition education courses.

4.3.3. Student Motivation

During the workshop, the following issues were emphasized regarding student motivation that can be effective in Undergraduate Biology Education (Biology Teacher Education) Programs:

1. Enhancing the Prestige of the Teaching Profession: Increasing the prestige of the teaching profession is crucial. Equalizing teachers' personal rights, addressing salary differences in private schools, and increasing economic income can contribute to motivating aspiring teachers.

2. Engagement through Activities: Field studies, congresses, and social responsibility projects can increase student motivation.
3. Establishing a Sense of Belonging: Creating a sense of belonging from the moment students enter university, emphasizing their future role as teachers, can positively impact motivation.
4. Interaction with Peers: Organizing activities that bring students from different universities together can increase student motivation.
5. Strengthening Field Proficiency: Offering various certificate programs that allow students to develop expertise in their field before entering the profession can enhance their professional self-efficacy.
6. Nature-Based Learning Environments: Increasing activities that expose pre-service teachers to nature and out-of-school learning environments can enhance motivation.
7. Improving Language Proficiency: Language proficiency of the students enrolling in the Faculties of Education is quite low. Emphasizing foreign language education in teacher education programs can increase student motivation.
8. Encouraging Exchange Programs: Encouraging and informing students about domestic and foreign exchange programs from the first year can boost student motivation.
9. Providing Career Planning: Offering career planning from the first year and providing counseling to support students' personal and professional development is important for their motivation.
10. Embracing Technology: Providing equipment that allows the implementation of approaches such as the use of online learning environments, the development of virtual/augmented reality materials, and the use of movies in teaching, which are among the new learning-teaching approaches, can increase student motivation.
11. Issues Concerning Pedagogical Formation: Allowing the right to become teachers with pedagogical formation certificates decreases the motivation of students studying in education faculties.
12. Fostering Self-Efficacy: Implementing self-efficiacy practices that support motivated learning, collaboration, and academic self-efficacy can positively contribute to students' development and reduce professional burnout.

4.3.4. Environmental Factors

During the workshop, the following issues were emphasized regarding environmental factors that can be effective in Undergraduate Biology Education (biology teacher education) Programs:

1. Preparing for Unexpected Situations: Planning and developing in advance the pre-crisis scenarios related to decisions to be taken in unexpected situations in the education process, such as distance education can ensure effective decision-making in the education process. For example, implementing Emergency Action Plans can help manage unexpected situations.

2. Flexible Learning Environments: Adopting the physical structure of the classrooms in biology education programs to different teaching methods, such as group work, and ensuring that laboratory equipment and infrastructure align with 21st-century skills are important considerations.

3. Collaboration with the MoNE: Faculty members and researchers at the Faculties of Education conduct research with their own initiatives and within their own means. The MoNE should enhance cooperation with universities by announcing research/project opportunities in priority areas.

4. Financial Support for Out-of-School Learning: Allocating financial resources to facilitate the use of out-of-school learning environments in Faculties of Education is recommended.

5. Sustainable Laboratory Maintenance: Sufficient budget allocation for the maintenance of consumables and equipment is essential to ensure the sustainability of laboratories in the Departments of Biology Education.

4.4. Focus Group Findings on Challenges and Solutions in Undergraduate Biology Programs

The focus group interview on the current problems in the Biology Departments of the Faculties of Science and Arts and Sciences identified four main themes: curriculum competencies, faculty member competencies, student motivation, and environmental factors.

4.4.1. Curriculum Competencies

During the workshop, the following issues were highlighted regarding curriculum competencies that can be effective in undergraduate biology education:

1. Insufficient Laboratory and Field Studies: Participants reported that there were too few hours dedicated to laboratory and practice courses. It was suggested that field studies should be increased, and compulsory internships should be included in the programs.

2. Standardizing Curriculum: The courses offered in Biology Departments vary based on the faculty members' areas of expertise. To create consistency, it was recommended to equalize the theoretical and practical components of compulsory courses within the department. Accreditation of the departments would help standardize the curricula.

3. Optimizing Undergraduate Programs: There are essential courses that all Biology program students must take as a requirement. In certain universities offering Biology programs, specialized module courses are introduced after the initial two years. These specialized programs solely focus on courses specific to the chosen area of specialization. Consequently, some compulsory courses are not taken by students, resulting in them receiving a "Biology" diploma. Those aspiring to specialize in sub-disciplines of biology such as microbiology, biotechnology, or hydrobiology can pursue these subjects at the graduate level. It is important to optimize undergraduate education in all Biology programs to ensure a comprehensive Biology diploma. One suggestion proposes the implementation of flexible core program arrangements.

4. Including Entrepreneurship Courses: To foster innovative ideas and value creation, it was recommended to include compulsory entrepreneurship courses in the program.

5. Curriculum Audit: Participants emphasized the importance of conducting internal or external audits to evaluate whether the declared curriculum competencies in biology departments are being realized.

6. Continuous Program Updates: It was suggested to update the programs by monitoring the needs of graduates.

7. Enhancing Skills Training: Participants emphasized the need to prioritize skills training in the program, update infrastructure of application laboratories, and ensure the availability of consumables for sustainability.

4.4.2. Faculty Member Competencies

During the workshop, the following issues were emphasized regarding faculty member competencies that can be effective in undergraduate biology education:

1. Innovative Assessment Methods: Faculty members in the Faculty of Science lacked training in innovative measurement and evaluation methods, relying mainly on classical methods. In-service trainings were recommended to address this gap.
2. Research Assistant Capacity: The insufficient number of research assistants in Biology programs was highlighted. Increasing their numbers would enhance faculty members' research capacity and student motivation.
3. Pedagogical Field Knowledge: Faculty members were encouraged to teach in both classrooms and laboratories, and their pedagogical field knowledge in these areas should be improved through in-service trainings.

4.4.3. Student Motivation

During the workshop, the following issues were emphasized regarding student motivation in undergraduate biology education:

1. Developing Research Skills: It was emphasized that students' research and project writing skills should be developed. Faculty members were encouraged to support and encourage students to participate in activities such as TUBITAK projects and student congresses.
2. Engaging Student Interest: Organizing activities related to students' interests in biology student societies was seen as an effective way to increase their interest in academic studies.
3. Readiness Levels: Participants noted that the readiness levels of students entering biology departments, as indicated by their YKS scores, were not at the desired level. However, the aim of these departments is to increase the number of individuals conducting research and development in basic sciences, contributing to the country's scientific development. It was suggested to increase the employment of biologists in the public and private sectors.
4. Innovative Teaching Methods: Adopting new teaching methods to increase student motivation in courses was recommended.
5. Career Planning: Creating career planning opportunities based on students' interests from their first years of study was suggested to foster a high level of professional belonging.
6. Facilitating TUS Exams: Participants highlighted the need to remove obstacles preventing graduates from taking the TUS basic sciences exam.

7. Language Proficiency: Emphasizing the importance of creating environments that improve students' language proficiency for research purposes.

4.4.4. Environmental Factors

The workshop drew attention to the following issues regarding environmental factors that can influence undergraduate biology education:

1. Employment Opportunities: Biology graduates face challenges in finding employment, and it was recommended that government policies be established to increase employment opportunities.

2. Rationalizing Biology Departments: It was emphasized that a large number of biology departments were opened due to the obligation to open Faculties of Science and Letters in every university opened until 2008. Thisresulted in some departments closing due to the lack of teaching staff, leading to wasted economic resources.

3. Admissions and Quotas: Participants emphasized that students should not be admitted to programs solely to fill quotas.

4. Faculty Member Qualifications: Concerns were raised about the involvement of faculty members in Biology programs who did not graduate from the Biology program itself, highlighting the importance of having sufficient numbers and qualified faculty members.

5. Upgrading Infrastructure: Participants stressed the need to update the infrastructure of biology laboratories and ensure the availability of consumables for sustainability.

6. Comprehensive Assessment: The current ÖSYM field proficiency exam includes only 13 biology questions, which is considered insufficient for comprehensive assessment. Participants suggested evaluating students who choose this field with 30 biology questions using the MF-3 score system. Adjustments should be made to address this issue, emphasizing the importance of admitting students to programs based on qualifications rather than quotas.

CONCLUSIONS

This section discusses the results of the workshop presentations, question and answer sessions, and focus group interviews under three main headings. These headings are:

I. Challenges and Solutions in Secondary School (K-12) Science and Biology Teaching

II. Challenges and Solutions in Undergraduate Biology and Science Teaching Programs

III. Challenges and Solutions in Undergraduate Biology Programs

Each heading is further evaluated under four subheadings: Curriculum Competencies, Teacher/Faculty Member Competencies, Student Motivation, and Environmental Factors. Environmental factors are included as a subheading because they influence students' learning processes. In the literature, environmental factors may include different definitions (Balog 2018). In this study, environmental factors refer to physical aspects such as classroom environments, textbooks, and laboratory infrastructure.

5.1. Challenges and Solutions in Secondary School (K-12) Science and Biology Teaching

Curriculum Competencies

Research has revealed that the curriculum and textbook content do not completely align (Adıgüzel and Yılmaz, 2020; Karakaya et al., 2020; Yılmaz et al., 2018). Furthermore, an examination of the curriculum reveals a discrepancy between the allocated time for achievements and the corresponding units. Consequently, some units have sufficient time for activity implementation, while others do not. To address this issue, it is recommended to plan the relationship between achievement and duration based on unit-specific activities and active student participation. The current curriculum structure exhibits interdisciplinary disconnections, hindering students' ability to perceive the interconnectedness of different disciplines. Therefore, a coordinated curriculum encompassing biology, chemistry, physics, and mathematics should be developed. Furthermore, the

order of concepts and related texts/units in textbooks impacts how students relate subjects to their daily lives, thus necessitating the consideration of teacher and expert opinions in this matter.

During the curriculum updating process, the MoNE gathers input from stakeholders, including teachers and academics, through meetings. Although teachers across different school types employ the same biology curriculum, they hold varying views on biology course hours and curriculum content due to their students' diverse levels and needs. Attempting to create a universal strategy for a singular biology curriculum introduces new challenges, such as requests to reduce or increase biology class hours.

Today, issues like climate change, natural disasters, and sustainable living are crucial knowledge that every individual should possess, warranting a separate course in secondary education. This approach would facilitate the mitigation of human-induced environmental problems and the establishment of sustainable ecosystems, fostering positive attitudes and behaviors through knowledge development.

Teacher Competencies

As advancements and new information emerge rapidly in the field of science, it is crucial for teachers to keep pace with these developments, enhance their knowledge and skills, and incorporate them into their classroom teaching. In-service trainings play a significant role in the professional growth of teachers. Hence, collaboration between the MoNE and universities is highly regarded in this context. Furthermore, teachers should be encouraged to participate in professional development activities such as pursuing master's degrees, attending conferences, and engaging in relevant trainings. Financial support should be provided to facilitate their involvement, and efforts should be made to improve the current challenging conditions.

Regarding the topics for in-service trainings, workshop participants expressed the need for training specifically in laboratory skills, molecular biology, biotechnology, microbiology, STEM education, assessment and evaluation, out-of-school learning environments, interdisciplinary approaches, project consultancy, instructional technologies, alternative teaching methods, and distance education.

The Pedagogical Formation Certificate program, which is required for Faculty of Science graduates to become teachers, consists of 8 courses and a teaching

internship. Workshop participants agreed that it would be more effective to integrate this education through minor or double major programs instead of making it mandatory for individuals graduating from departments and programs other than the Faculty of Education. This approach would enable candidates to interact with students from the Faculty of Education, supporting their development. If pedagogical formation programs continue, it should be a requirement for candidates to meet the minimum success ranking determined by the CoHE for teaching programs in faculties of education. Additionally, when determining the quotas for Pedagogical Formation Certificate Programs, attention should be given to the relevant department of the Faculty of Education. For instance, a faculty without a Biology Education Department should not allocate quota positions to students from the field of Biology in the Pedagogical Formation Certificate Programs.

Upon reviewing the undergraduate programs of Primary Teacher Education, it was noted that the content, number, and hours of theoretical and practical courses (including laboratory and science teaching) in science were reduced in the 2018 curriculum. This reduction hinders prospective primary school teachers from acquiring sufficient knowledge and skills in science subjects. A possible solution to this problem would be to increase the number, hours, and content of science courses. Classroom teachers who teach science to primary school students are expected to identify and correct misconceptions while teaching accurate scientific facts and concepts. However, the fact that pre-service primary school teachers are admitted to programs based on an equal weighted score (EW) type in YKS exams negatively impacts their readiness in science courses. The EA score type focuses on mathematics, social sciences, and Turkish Language Literature courses, while the numerical score (MF) type assesses science and mathematics. A student who selects the TM field in the 11th grade of high school can receive an EA score without choosing any elective science courses (physics, chemistry, biology) or answering science questions in the YKS exams. Consequently, students with EA scores face challenges in becoming scientifically literate classroom teachers. To address this issue, admitting students to the Department of Classroom Teaching with a numerical score type (MF) would create a suitable foundation for equipping classroom teachers with the necessary knowledge in biology, physics, and chemistry (science). The same concern applies to the Preschool Teaching Department, which admits students based on a verbal score type.

Student Motivation

During the workshop, teachers highlighted that students' connection with the school has weakened amidst the pandemic. They observed that students were frequently absent without valid reasons and expressed the need for motivation to encourage school attendance. To address this concern, it was suggested to enhance the number of activities in out-of-school learning environments where students can actively engage in fun and cooperative experiences.

Workshop participants also expressed that students exhibit limited interest in subjects included in the science high school program but not assessed in the Higher Education Institutions Examination (Basic Proficiency Test (TYT) and Field Proficiency Tests (AYT)). They noted that students tend to disregard these subjects, assuming they will not appear in the exam. To mitigate this issue and improve student motivation, it is recommended to increase the number of exam questions that cover the content of all programs in the Higher Education Institutions Exams.

The inadequate representation of science-related questions (Biology, Physics, Chemistry) in the Basic Proficiency Test (TYT) and Field Proficiency Tests (AYT) poses challenges in conducting effective measurement and evaluation processes.

To enhance students' motivation towards the biology course, it was proposed to restore the previous practice of increasing the number of questions related to biology in the YKS exams (TYT and AYT), as it had been done in previous years.

Environmental Factors

The utilization of out-of-school learning environments within the classroom setting often involves complex authorization procedures and limited funding, which may not always be readily available. Simplifying official procedures and allocating adequate financial resources would be advantageous.

Research indicates that textbooks contain significant inaccuracies in both information and visuals, potentially leading to misconceptions among students. Relying solely on textbooks as a source of information restricts teachers from imparting knowledge that is free from scientific errors. Therefore, it is essential to ensure that teachers have access to current academic books widely used worldwide, in addition to textbooks and supplementary materials.

Participating teachers noted that schools face challenges related to large class sizes and overcrowded classrooms, leading to the conversion of laboratories into regular classrooms. Consequently, students are deprived of valuable laboratory experiences, which are integral to biology and other science courses.

5.2. Challenges and Solutions in Undergraduate Biology Education and Science Education Programs

Curriculum Competencies

The objective of undergraduate teacher education programs is to prepare teachers capable of meeting the demands of the current era. Consequently, it is natural for these programs to undergo revisions and modifications as needed. In Türkiye, the undergraduate education programs of the Faculty of Education have been subject to changes or revisions in 1992, 1998, 2006, 2011/2013 (as part of the Bologna Process), 2018, and 2020-2023 (following the transfer of authority to the CoHE). An essential step in these processes is conducting an analysis of the current program outcomes and future requirements. This analysis helps identify the strengths of the program and areas that require improvement. It is vital to share the analysis results with stakeholders such as academics, teachers, the MoNE, administrators, and civil society organizations, and incorporate their feedback when designing future programs.

Examining the implementation timelines of the programs introduced and implemented in education faculties, it becomes evident that particularly the teaching programs introduced in the 2018 curriculum and those implemented from 2020 onwards underwent rapid changes. Rapid program changes have their drawbacks: 1. Since there were no graduates from the altered program, it was impossible to analyze the program outcomes, and 2. Resources invested in the curriculum development process (human resources, time, finances) were wasted due to the swift changes. In light of this, questions may arise as to why the 2018 curriculum was modified within such a short period. The 2018 curriculum faced considerable criticism from all stakeholders, including faculty members and teacher candidates. The most significant point of contention was the significant reduction in content courses and the elimination of laboratory sessions. Faculty members voiced their objections to these changes, emphasizing that biology, physics, and chemistry (science) education cannot be effectively conducted without laboratory components. Consequently, with the transfer of authority to universities by the CoHE in 2020, departments and programs began developing their own curricula.

When examining the programs altered by universities after 2020, discrepancies are noticeable in their structures and credit distributions. Such differences can create problems in terms of equivalency and hinder student mobility. Therefore, it would be beneficial for the relevant departments and sub-disciplines to collaborate in the program development process, at least on minimum criteria such as elective course credits and separate theoretical and laboratory courses.

In-service teachers require foreign language skills for their professional development activities, including postgraduate education (master's and doctoral programs), project consultancy, e-twinning projects, literature reviews, accessing international resources, and communication with international colleagues. Considering the demanding nature of teacher education curricula, incorporating English preparatory classes in the first year of the undergraduate program would offer significant advantages to teachers.

To meet the demands of the current age, science teacher education programs should include project-based learning, out-of-school learning environments, contemporary instructional technologies, and content areas such as STEM. Given that the primary objective of science education is to teach the nature of science, courses like the nature of science and philosophy of science should be compulsory in biology education and science education programs.

When it comes to the advantages and disadvantages experienced by newly graduated teachers in the field, three main factors play a role: the education received during the undergraduate program, personal professional development efforts, and the institutions where they potentially work. Within the scope of undergraduate education, the number and quality of teaching staff, infrastructure facilities (including adequate and up-to-date equipment in educational environments like laboratories), and activities promoting personal and professional skill development (career planning, alumni workshops, TUBITAK competitions, community service practices, conferences, etc.) are of utmost importance for the growth of prospective teachers. It has been noted that distance education practices, necessitated during the pandemic and after earthquakes, have negatively affected the development of pre-service teachers, particularly in terms of communication, socialization skills, and laboratory application skills. It is recommended to effectively utilize alumni tracking systems to identify the in-service training needs of graduates and meet their requirements. Collaborating with the MoNE in in-service trainings will increase their impact.

Faculty Members Competencies

The process of training academic staff is a comprehensive journey that typically spans at least 10 years. The assistantship period holds significant importance as it allows individuals to continue their education under the guidance of experienced scholars in their respective fields. Considering the extensive workload of academic staff, which includes undergraduate and graduate education, research, social responsibility projects, and administrative duties, the equitable distribution of these responsibilities greatly influences the productivity of faculty members. Thus, it is crucial to plan academic and research assistant positions in departments while taking into account the workload considerations. When examining the distribution of faculty members across the Departments of Biology Education (as shown in Table 3.11), it becomes apparent that one department has three faculty members, while another has seventeen. However, the student quota (20+1) determined by the CoHE remains the same for all departments. Planning based on workload considerations will also allow faculty members to effectively manage their time for professional development, including areas such as information technologies, assessment and evaluation, and particularly communication skills.

Given that the Departments of Biology Education offer both field-specific (biology) and pedagogy courses, it is argued that lecturers should possess expertise in both domains. Therefore, it is recommended that programs aiming to train instructors in mathematics and science education departments establish a structure where individuals can specialize in both science and pedagogy.

Student Motivation

There was an emphasis on the need to enhance the prestige of the teaching profession, given the evolving perception of the field within society. To achieve this, it was suggested that teachers' personal rights should be equalized, including addressing salary differences between private and public schools, and implementing measures such as paid teaching opportunities. Additionally, increasing the economic income of teachers was highlighted as a crucial step.

The use of teaching approaches that foster a sense of belonging was emphasized for prospective teachers to develop positive attitudes towards the profession during their undergraduate education. It was proposed to enhance pre-service teachers' professional self-efficacy by offering opportunities for participation in activities such as certificate programs, field studies, congresses, and social responsibility projects. Moreover, supporting pre-service teachers in career

planning from their first year and facilitating communication with instructors in social settings would enhance their professional, emotional, and social learning skills. Encouraging domestic and international exchange programs and promoting student participation in these initiatives would allow students to explore different cultures and engage with peer groups from diverse universities.

Environmental Factors

The Covid-19 pandemic in 2020 highlighted the necessity of considering the potential for extraordinary situations when planning education. In such cases, adapting educational environments and implementing alternative teaching formats (such as distance education) may be required. These changes not only directly impact teachers as practitioners but also necessitate different infrastructure requirements. Therefore, it is crucial to proactively structure Emergency Action Plans to address the possibilities of unforeseen circumstances.

Research conducted by academics in education faculties plays a vital role in bridging the gap between theory and practice. Such research is essential for developing solutions to existing problems. Collaboration between the MoNE and universities holds significant potential for identifying field-related challenges and incorporating them into the research dimension. To foster this cooperation, the MoNE should enhance its collaboration with universities by issuing research/project announcements in priority areas where assistance is needed.

5.3. Challenges and Solutions in Undergraduate Biology Programs

Following the evaluation and discussions among participants regarding the programs implemented in the Faculty of Science Biology Department, problems and proposed solutions were identified under four main categories.

Curriculum Competencies

When developing biology programs, the Turkish Qualifications Framework serves as a foundation, but the specific courses are determined based on individual universities and the scientific fields of faculty members. Consequently, there is variation among Biology Department programs. To ensure that biology graduates possess common foundational knowledge and skills as biologists, it is crucial to at least equalize the theoretical and practical aspects of compulsory courses. Some universities employ a module structure in their biology programs, allowing students to specialize in sub-disciplines (e.g., microbiology, biotechnology, hydrobiology) after the second year. However, this specialization

results in students graduating without completing certain compulsory courses. It is recommended that students interested in sub-branches of biology have the option to specialize through elective courses during their undergraduate education or at the graduate level.

Concerns were raised regarding the limited hours dedicated to internships, laboratory work, fieldwork, and application courses in the undergraduate biology programs. Given the applied nature of biology, individuals graduating with a biology degree should possess not only theoretical knowledge but also practical skills. Therefore, it is suggested to increase the number of practical hours to ensure students gain sufficient experience in laboratory work, field research, and project development. In addition, for basic science departments (biology, physics, chemistry, etc.) that aim to train scientists, it is important to include compulsory courses such as the nature of science and philosophy of science.

One of the missions of the Faculty of Science is to train innovative and entrepreneurial individuals who contribute to the advancement of science and technology. In this context, it is emphasized that biology graduates should gain exposure to both the fundamental scientific fields and their practical applications in various sectors. To support the creation of added value, it is suggested to include compulsory internship and entrepreneurship courses in the program. Conducting graduate monitoring studies will help identify the specific needs of biology graduates working in different sectors, enabling program adjustments to address these requirements. Establishing a communication network between undergraduate students and alumni can also facilitate the students' development.

Faculty Members Competencies

In addition to conducting research and projects, one of the responsibilities of faculty members in the Faculty of Science is to teach at the undergraduate and graduate levels. It has been observed that faculty members, who possess expertise in their respective subject areas (e.g., hydrobiology, etc.), often rely on traditional teaching methods. To foster effective teaching in learning environments, there is a need for in-service trainings focusing on current teaching approaches (such as project-based learning), assessment and evaluation techniques, instructional methodologies, and teaching psychology. Participants suggested providing in-service trainings on these and similar topics.

Given the structure of the Faculties of Science, activity-rich environments like laboratories, projects, and research and development (R&D) centers

(technopolis) exist. In these environments, research assistants play a crucial role in maintaining these activities. However, participants emphasized the insufficient number of research assistants in the departments and highlighted the importance of capacity building. Strengthening the research assistantship program was deemed necessary, as it would not only contribute to sustaining the activities but also enhance student motivation.

Student Motivation

It was emphasized that the students entering biology departments do not achieve the desired YKS scores, resulting in a low readiness level among incoming students. The goal of Biology and other Faculty of Science departments is to train individuals who contribute to research and development, fostering the country's progress through scientific knowledge. However, the limited scores of incoming students hinder the achievement of this objective. To enhance student motivation and attract more prepared individuals to biology programs, increasing the employment opportunities for biologists in both public and private sectors has been suggested. Furthermore, removing the barriers that prevent graduates from taking the TUS basic sciences exam, as it was done in the past, is also recommended.

To boost student motivation within undergraduate biology programs, it was proposed that faculty members employ innovative teaching methods in their courses and encourage student participation in activities such as TUBITAK projects and student congresses. Additionally, structuring programs to develop the necessary language skills for biology graduates, enabling them to access information and employment opportunities both nationally and globally, was highlighted. Emphasizing the importance of high levels of professional belonging among students, it was recommended to initiate career planning based on their interests from their first year of study.

Environmental Factors

The participants acknowledged the positive development of abolishing the obligation to establish a Faculty of Arts and Sciences for university openings since 2008. However, when analyzing the employment rates of biology graduates, it was noted that the employment rate is low, and the job search period is lengthy. One of the factors contributing to this problem is the excessive quotas in existing biology departments. It was suggested that government policies should be implemented to increase employment opportunities.

Regarding the ÖSYM field proficiency exam, which determines admission to Biology Departments, it was stated that the inclusion of only 13 biology questions is insufficient to assess biology knowledge. The previous system, in which ÖSYM evaluated students who selected this field with 30 biology questions using the MF-3 scoring system, was considered more appropriate. In addition to the number of questions used for evaluation, another issue raised was the low base scores of students admitted to biology programs. Over the years, there has been a decline in the percentiles and base scores of students entering biology departments. For example, the lowest ranking for students entering Gazi University Biology Department decreased from 202,000 in 2012 to 295,566 in 2021. Similarly, the lowest ranking for students entering Şelçuk University Biology Department dropped from 218,000 in 2012 to 391,000 in 2021. Considering the expectations for graduates to engage in research and development activities as biologists, entrance scores should not be lowered merely to fill quotas.

Research and project studies, integral activities of biology departments, require the establishment of infrastructure facilities and regular provision of consumables. It is crucial to allocate the necessary financial resources (such as project budgets) to meet these needs.

DISCUSSION AND SUGGESTIONS

As stakeholders of this workshop, it is our greatest hope that the outcomes of the workshop will advance biology education in the near future, even though we acknowledge that it is not possible to solve all the problems related to biology teaching. An inquiry-based biology curriculum is crucial for nurturing inquiring individuals. Moreover, it is essential for science teachers (biology, physics, chemistry, science) as well as kindergarten and classroom teachers, to possess sufficient conceptual knowledge, creativity, and intellectual capacity. In today's world, where science applications direct our lives, it is of great importance for science teachers to have the ability to establish the relationship between biology and other disciplines (physics, chemistry, environmental sciences, mathematics, etc.), since no branch of science can exist independently. Integrating the nature of science and the nature of research into their teaching is also critical for science teachers.

Biology Curricula (primary, secondary, undergraduate)

Science curricula are generally programs that develop metacognitive skills, promote meaningful learning, and foster interdisciplinary integration. Curriculum evaluations are conducted to ensure the successful attainment of curriculum objectives (acquiring 21st-century skills, etc.), at all levels of education, including primary, secondary and university levels. However, the workshop findings indicate a significant mismatch between the outcomes of primary and secondary education programs and the content of textbooks. This incompatibility is related to the relationship between achievement and duration, resulting in teachers not being able to allocate enough time to engage in activities for certain achievements. Furthermore, the absence of interdisciplinary connections within the structure of the curriculum poses challenges for students in recognizing the connection between different disciplines.

Secondary School Curricula

Despite the changes, an analysis of the literature from 2013 to 2021 reveals an emphasis that content and target achievements of the high school biology curricula is not sufficiently appropriate for student levels. These findings, coinciding with the conclusions of the workshop, indicate that the problem

continues (Ayvacı and Devecioğlu, 2013; Seçken and Kunduz, 2013; Öztürk Akar, 2014; Büyükbayraktar Karamustafaoğlu and Özdoğan, 2018; and İpek et al. 2021). The application of a curriculum that is unsuitable for students' level leads to low academic achievement and decreases motivation for class participation (Çevik and Atıcı, 2015; Özenoğlu Kiremit, 2013). To address these issues, it is recommended to reorganize school types based on students' readiness levels and scientific criteria, while also restructuring the university entrance exam system accordingly. Since curricula serve as essentials important guides for teachers indicating what, when and how much to teach, it is crucial to develop comprehensive curriculum guidebooks for teachers.

Biology Education Undergraduate Programs

All the studies available in the literatüre consistently highlight the persistent issues despite continuous updating of the 2007, 2013 and 2018 Undergraduate Biology and Science Teaching Programs. The reason for this is the implementation of changes in a short period of time, the lack of inclusive discussion platforms, and the failure to share the results of teacher and student feedback and the adjustments made accordingly at the end of the pilot implementation of the programs (Öztürk Akar, 2014; İpek, 2021). In addition, the frequent changes in the curricula negatively affect the motivation of teachers. The 2011/2013 curriculum underwent a radical change in 2018 without preserving its positive aspects (such as laboratory courses and field course hours), and the 2018 program was quickly handed over to universities for further changes due to objections from stakeholders. While updating the programs according to the requirements of the time is certainly necessary, the focus should be on preserving the successful and strong aspects of the program and updating the weaknesses to prevent the recurrence of the same problems after the program changes. Assessing the strengths and weaknesses of the programs can be achieved at the earliest by following and monitoring the graduates of the program in their professional lives. The advantages and disadvantages experienced by graduates in their professional lives will shed light on the programs to be developed, and this requires a period of at least 7-8 years.

2018 Biology Teaching and Science Teaching Programs are criticized for integrating laboratory courses into the theoretical courses. Laboratory courses hold significant importance in science education due to their positive effects on student performance and learning processes (Basey et al., 2008; Hofstein and Lunetta, 2004). Academics emphasize the necessity for separate courses dedicated to laboratory hours in science disciplines (biology, physics, chemistry).

Studies indicate that teachers do not gain sufficient professional experience during their university education, thus lack the necessary field knowledge (Akıncı et al. 2015). The teaching profession requires high competencies to ensure the effective and adequate education of future generations, and meeting these competencies even with the most ideal program is challenging. Therefore, it is crucial for students enrolling in faculties of education to a have high levels of readiness. In other words, higher criteria could be set for the selection of students to be admitted to faculties of education.

Evaluation of Faculty of Science Biology Undergraduate Programs reveals that there are variations in specialization among universities, with students specializing in sub-disciplines of biology (microbiology, biotechnology, hydrobiology, etc.) after the 2nd year. As a consequence of this type of specialization of programs, students graduate without taking some compulsory courses while taking only courses specific to their chosen field of specialization. A potential solution to this issue could be offering elective courses for specialization within undergraduate programs or providing specialization opportunities at the graduate level after completing the core biology courses of the biology discipline.

Competencies of Teachers/Faculty Members

The professional development of teachers and lecturers at primary, secondary and university levels is of great importance for ensuring the quality of education. Especially in the field of biology, it is possible for teachers to keep up with rapidly changing information and developments through in-service trainings. In-service training programs are the most common approach for teachers' professional development. The Ministry of National Education (MoNE) offers in-service training programs in two: face-to-face and online. However, the rates of face-to-face and online training programs have changed in favor of online training over the years, especially during and after the pandemic. In 2014, the rate of online education was 2%, but this rate reached 85% during the pandemic in 2018 (MoNE, 2019). Online education has become a preferred method due to its advantages in terms of cost and the ability to reach a larger number of teachers (MoNE, 2005). However, skills training in-service programs should necessarily be conducted face-to-face.

Teachers who participated in the workshop and presented good examples demonstrated Life and Career Skills, one of the 21st-century skills, in their personal development. These teachers have continuously pursued professional development uninterruptedly through activities such as in-service trainings, courses, project competitions, and graduate education since the beginning of

their professional careers. Therefore, the importance of effective pre-service and in-service training is recognized, and all teachers should be encouraged to participate in these trainings. The R&D units of the Provincial Directorates of National Education have recently been actively working on planning and implementing effective in-service training in collaboration with universities, science centers and other relevant stakeholders, which indicates the need for these efforts to be more widespread.

During the workshop, participants made some suggestions for more effective professional development of teachers. These suggestions include providing opportunities for teachers with postgraduate degrees or those who have carried out successful projects to share their experiences by assigning them to their areas of expertise, planning training programs based on teachers' needs (e.g., assessment and evaluation, project design, etc.), and increasing motivation through adopting a professional satisfaction and reward approach.

Although distance education, as a form of in-service training, is preferred for its economic benefits and reaching more people, it is not the first choice for some teachers. When the opinions of teachers about distance in-service training are examined, both positive aspects (time and space independence, supporting individual learning) and negative aspects (communication limitations and passive receiver role) are identified (Tekin, 2020). It is also observed that the trainers in in-service training activities lack sufficient specialization/qualification in their fields, their contribution to teachers' professional development is limited, they do not take the training seriously enough, and the training sessions are often conducted as formalities. In terms of the quality of in-service training, teachers who participated in in-service training activities conducted by academicians who are experts/qualified in their fields with high quality of education reported significant gains in their professional development and increased level of motivation (İpek et al. 2021).

Regarding the competencies of the academic staff in the Faculty of Education, the importance of academicians' expertise in field and field education is emphasized. It is suggested that academicians should engage in academic studies (such as minor or double major model) in the field and field education subjects during their graduate education. In addition, increasing the duration of postgraduate education and the number of courses taken in this context is presented as another suggestion. Another aspect highlighted in relation to the assistantship period, which is part of the training process for academicians, is

the lack of assistant positions in departments and the high workload carried by academic staff.

For academicians working in Faculty of Science Biology Undergraduate programs, it is concluded that they receive in-service training on pedagogical content knowledge (such as teaching methods, assessment and evaluation, educational psychology, etc.) to enhance their teaching in classes and laboratories and contribute to their professional development.

Student Motivation

Student motivation is an important factor that significantly impacts student success, and there are several factors affecting motivation. Participants in the workshops highlighted challenges with students' adaptation to face-to-face classroom environments, especially after the distance education format during the pandemic. As a result, students demonstrated low motivation in attending school, and actively engaging in lessons.

It has been noted that the YKS (TYT and AYT) exams greatly affect students' motivation to learn biology subjects, and students tend to neglect topics that are not included in the exam. Therefore, it has been recommended to increase the number of biology questions in the YKS (TYT and AYT) exams. Additionally, providing diverse learning opportunities (out-of-school learning, projects, competitions, etc.) were identified as strategies to enhance student motivation.

Factors affecting the motivation of pre-service teachers include respect for the teaching profession and the financial prospects it offers. It has also been stated that developing a sense of belonging to the profession is also important for prospective teachers. In this regard, it has been suggested enhancing pre-service teachers' professional self-efficacy through certificate programs (out-of-school learning, STEM, etc.) in addition to their undergraduate studies. Language proficiency, which is a teacher competency, is also a requirement for international exchange programs and other international activities. Prioritizing language education from the first grade will increase students' motivation. Pedagogical formation programs, which allow students studying in biology and other departments of Faculty of Science to practice the teaching profession, can negatively affect the motivation of students enrolled in teaching programs.

To increase the motivation of students studying in biology departments of the Faculties of Science, it has been suggested that instructors encourage and support students to participate in activities such as projects and congresses. Integrating

current educational approaches into courses, improving language proficiency, and fostering a sense of belonging were also highlighted to have a positive effect on student motivation. It has been observed that teachers who stay updated with scientific developments share and incorporate these developments into their lessons and assign them as research topics to their students. It has been found that this situation attracts students' attention and motivates them (İpek et al. 2021).

Another important point emphasized during the workshop is that the YKS scores of students enrolling in Biology Departments are not at the desired level. Biologists, who are expected to work in basic science and research and development, should possess higher levels of academic readiness. The focus on filling quotas has resulted in a decline in the academic level of students enrolling in the program.

Environmental Factors

Numerous studies have examined the effect of learning environments (such as laboratory and classroom environments, textbooks) on student achievement and motivation. However, due to the problems in ther scientific content and existing misconceptions, the use of the MoNE textbooks in teaching has been found to cause mislearning and create new problems. It is essential to ensure that the scientific content of the textbooks, which serve as the primary source of instruction for both teachers and students, is up-to-date and accurate. To prevent scientific errors, it is important to utilize up-to-date and scientifically accurate sources or to implement necessary precautions during the writing process of the textbooks, while also seeking feedback from field experts through applying progressive evaluation processes.

When considering environmental factors in the education of pre-service teachers, infrastructure (classroom and laboratory environments), that is, physical environmental factors, take precedence. Classroom and laboratory settings should be designed to meet the requirements and advancements of the present day, thereby supporting pre-service teachers in acquiring 21st-century skills. Research indicates that laboratory practices have a positive impact on students' motivation (Chatterjee et al. 2009; Wright, 2012), as they provide direct experiences related to the nature of science and science, which ultimately enhances academic achievement (Freedman, 1997). However, studies conducted in Türkiye consistently reveal that teachers feel inadequate in laboratory skills and that schools often lack proper laboratory facilities (Öztaş and Özay, 2004; İpek et al. 2021). In addition, integrating various teaching environments, such

as out-of-school learning settings, into the educational process can contribute to the development of pre-service teachers.

The first of the environmental factors that influence pre-service teachers studying in biology programs, as is in biology teaching departments, is stated to be the classroom (including mobile classrooms) and laboratory environments and their quality. Improving environmental factors is important in increasing student motivation and academic achievement (Mendell and Heath, 2005). The second emphasized issue, in order to enhance the quality of the students enrolled in the program, is the inclusion of students who demonstrate a certain level of achievement, rather than solely aiming to fill program quotas.

Some of the issues discussed in the workshop regarding biology education, as mentioned in the literature, are global concerns (teacher competencies, assessment and evaluation, physical competencies, etc.) and solutions to these issues are addressed in various countries. However, other issues specific to our country (pedagogical formation, implementation of the same curriculum in different high school types, university entrance exam, textbooks, etc.) have persisted unsolved for years. Therefore, adopting a different perspective in future studies is vital for finding solutions to these long-standing issues.

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APPENDICES

APPENDIX 1

Workshop Series on Fundamental Science Education -3

CHALLENGES AND SOLUTIONS IN BIOLOGY EDUCATION AT SECONDARY, AND UNDERGRADUATE LEVELS

WORKSHOP PROGRAM

Ankara Grand Mercure Hotel, 23-24 February 2023

23 February 2023	
09.00-09.30	Registration
09.30-10.00	**Opening Speeches** Prof. Dr. M. Akif Kireçci, President of ECOEI Prof. Dr. Semra Mirici, Gazi University, Faculty of Education **'Science Education in the 21st Century'**
10.00-10.45	**Challenges and Solutions in Undergraduate Biology Education Programs** Prof. Dr. Ali Gül, Gazi University, Gazi Faculty of Education
10.45-11.00	Questions and Answers
11.00-11.30	Tea/Coffee Break
11.30-12.30	**My First Year in the Profession** Teacher Neslihan Soysal, Özel Hacettepeliler Eğitim Kurumu Anadolu Lisesi **Teachers' Opinions on High School Biology Curriculum** Teacher Yasemin Horasan, İzmir Anatolian High School Teacher Dr. Aynur Elif Bulut, Ankara Science High School Teacher Kurtuluş Atlı, Nevşehir Şehit Furkan Demir Anatolian High School
12.30- 12.45	Questions and Answers
12.45-13.45	Lunch Break
13.45- 14.15	**Analysis of High School and Middle School Biology Teaching Materials** Prof. Dr. Ertunç Gündüz, Hacettepe University, Faculty of Science Prof. Dr. Mehmet Yılmaz, Gazi University, Gazi Faculty of Education
14.15-14.30	Questions and Answers
14.30-15.00	**Challenges and Solutions in Undergraduate Biology Programs** Prof. Dr. Feray Köçkar, Balıkesir University, Faculty of Science
15.00-15.15	Questions and Answers
15.15-15.45	**Science Education in Elementary Education** Prof. Dr. Füsun Eyidoğan, Başkent University, Faculty of Education

15.45-16.00	Questions and Answers
16.00-16.20	Coffee Break
16.20-16.50	**Challenges and Solutions in Undergraduate Science Education Programs** Assoc. Prof. Dr. Duygu Sönmez, Hacettepe University, Faculty of Education Prof. Dr. Hülya Yılmaz, Ege University, Faculty of Education
16.50-17.05	Questions and Answers
17.05-17.35	**Challenges Related to Pedagogical Formation Education** Prof. Dr. Tahir Atıcı, Gazi University, Gazi Faculty of Education
17.35-17.50	Questions and Answers
17.50-18.20	**Teachers' Opinions on Middle School Science (Biology) Curriculum** Teacher Aylin Güner Kahraman, Ankara Provincial Directorate of National Education Strategy Development Department R&D Unit
18.20-18.30	Questions and Answers

24 February 2023	
09.00-09.30	Preparations for the Day
09.30-12.30	**Challenges and Solutions in Middle School Science (Biology) Teaching Work Group** • *Curriculum Competencies* • *Teacher Competencies* • *Student Motivation* • *Environmental Factors*
09.30-12.30	**Challenges and Solutions in High School Biology Teaching Work Group** • *Curriculum Competencies* • *Teacher Competencies* • *Student Motivation* • *Environmental Factors*
09.30-12.30	**Challenges and Solutions at Undergraduate Biology Education (Teacher Education) Work Group** • *Curriculum Competencies* • *Faculty Member Competencies* • *Student Motivation* • *Environmental Factors*

12.30-14.00	**Lunch Break**
14.00-14.45	**Presentation on Challenges and Solutions in Middle School Science (Biology) Teaching**
14.45-15.00	Questions and Answers
15.00-15.45	**Presentation on Challenges and Solutions in High School Biology Teaching**
15.45-16.00	Questions and Answers
16.00-16.15	Coffee Break
16.15-17.00	**Presentation on Challenges and Solutions at Undergraduate Biology Education (Teacher Education)**
17.15-17.30	Questions and Answers
17.30-18.15	**Presentation on Challenges and Solutions in Undergraduate Biology Programs**
18.15-18.30	Questions and Answers
18.30-19:00	Closing of the Workshop

APPENDIX 2

Workshop Series on Fundamental Sciences Education -3

WORKSHOP ON CHALLENGES AND SOLUTIONS IN BIOLOGY EDUCATION AT SECONDARY AND UNDERGRADUATE LEVELS

WORKSHOP GROUPS

GROUP I: Challenges and Solutions in Middle School Science (Biology) Teaching

1. Assoc. Prof. Dr. Duygu Sönmez (Hacettepe University, Faculty of Education)
2. Prof. Dr. Hülya Yılmaz (Ege University, Faculty of Education)
3. Assoc. Prof. Dr. Ceyhan Çiğdemoğlu (Başkent University)
4. Assoc. Prof. Dr. Ferhat Karakaya (Yozgat Bozok University, Faculty of Education)
5. Dr. Elif Tokgöz (MoNE, Sincan Şehit Abdullah Büyüksoy Science and Art Center)
6. Teacher Aylin Güner Kahraman (MoNE, Ankara Provincial Directorate of National Education Strategy Development Department R&D Unit)
7. Teacher Feride Eda Öztürk (MoNE, Sincan Cumhuriyet Secondary School)
8. Administrator/Teacher Cemil Karagöz (MoNE, Founder of Doku Schools)
9. Teacher Ferdi Bayrak (MoNE, Chamber of Commerce Mamak Secondary School)
10. Erdinç Erdem Bakkal (MoNE, Şırnak Provincial Directorate of National Education R&D Unit)
11. Attendant: Master's Student Seher Akbay

GROUP II: Challenges and Solutions in High School Biology Teaching

1. Prof. Dr. Mehmet Yılmaz (Gazi University, Gazi Faculty of Education)
2. Assoc. Prof. Dr. Nurcan Uzel (Gazi University, Gazi Faculty of Education)

3. Assoc. Prof. Dr. Ümmiye Nur Tüzün (MoNE, Ankara Yenimahalle Science and Art Center)
4. Teacher Yasemin Horasan (MoNE, İzmir Anatolian High School)
5. Teacher Sevilay Kocabaş (MoNE, Sakarya Cevat Ayhan Science High School)
6. Teacher Aynur Elif Bulut (MoNE, Ankara Science High School)
7. Teacher Kurtuluş Atlı (MoNE, Şehit Furkan Demir Anatiolian High School-Nevşehir)
8. Teacher Fatma Mertayak (MoNE, Rize TOBB Science High School)
9. Teacher Huri Şengün Özcan (MoNE, Cumhuriyet Science High School)
10. Teacher Meryem Karagöz (MoNE, Mamak Battalgazi Vocational Technical Anatolian High School)
11. Teacher Öznur Bıçakçı (MoNE, Altındağ Şehit Albay İbrahim Karaoğlanoğlu Primary School)
12. Attendant: Master's Student Canan Bilgili
13. Attendant: Master's Student Ayşe Rumeysa Karacasoy

GROUP III: Challenges and Solutions at Undergraduate Biology Education (Teacher Education) Programs

1. Prof. Dr. Ali Gül (Gazi University, Gazi Faculty of Education)
2. Prof. Dr. Semra Mirici (Gazi University, Gazi Faculty of Education)
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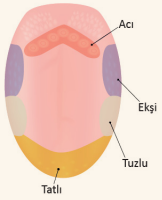
APPENDIX 3

Scientific Examination of Biology Units in Science Textbooks

Erroneous or Controversial Statement	Correct Explanation
"The joints of the vertebrae and the joints between the ribs and the sternum are examples of semi-flexible joints." "The joints between the vertebrae are examples of semi-flexible joints."	The human spine has 33 vertebrae. There are no semi-flexible joints between all of them. The vertebrae in the rump and tail are fully fused and do not move. The joints where the ribs connect to the sternum can flex but do not move. Similarly, between the first two cervical vertebrae (atlas and axis) there is a movable joint that allows the neck to rotate (Marieb et al., 2017: p.253; Gosling et al., 2008: p.397-401) As can be seen, the vertebrae in different parts of the spine have different characteristics. For this reason, it would be more appropriate to give the joints between the dorsal vertebrae and lumbar vertebrae as an example of semi-flexible joints.
Smooth Muscles (White Muscles)	It is scientifically incorrect to refer to smooth muscles as white muscles. White muscles are not smooth muscles but a type of skeletal muscles. Skeletal muscles of this type are called *white muscles* because of containing much less myoglobin than red muscles (Hole, 1993: p.281; Van De Graaff and Fox, 1992: p.270; Seeley et al., 1992: p.292).
"The upper part of the skull of newborn babies consists of a soft cartilaginous tissue."	This statement is scientifically incorrect. It may cause mislearning in students. The soft fontanelle at the top of babies' heads is the area formed by connective tissue where the skull bones have not yet joined with each other (Sadava et al., 2014: p.1020; Hickman et al., 2016: p.636). It would be appropriate to correct the statement in the book in accordance with the explanation.

"Absorption of water, minerals and vitamins takes place in the large intestine."	Nutrients are absorbed in the small intestine. All nutrient molecules from food are absorbed by the villi in the small intestine. The small intestine accounts for about 90 per cent of the absorption of nutrients. Some medicines are absorbed from the stomach. The breakdown products of carbohydrate, protein, fat and nucleic acid digestion, as well as vitamins, electrolytes and water are absorbed in the small intestine by various mechanisms. Most of the remaining water, minerals and vitamins produced by bacteria are absorbed from the large intestine. In this way, the large intestine forms semi-solid faeces (Sadava et al., 2014: p.1081; Hickman, 2016: p.704; Simon et al., 2017: p.483; Hall, 2021: p.828; Marieb, 2017: p.840). In textbooks, a perception has been created that the absorption of minerals and vitamins is only in the large intestine. However, the absorption of vitamins taken with food is carried out in the small intestine. Vitamins absorbed from the large intestine are vitamins produced by the bacteria living there.
"In the chemical digestion of food, enzymes act to initiate and accelerate the chemical reaction."	**An enzyme** is a macromolecule that acts as a catalyst, a chemical agent that accelerates a reaction without being consumed by the reaction. Enzymes do not initiate, but they accelerate reactions (Reece et al, 2013: pp.1048-1049; Nelson and Cox, 2005: p.247).
"In which organ does the final absorption of water, minerals and vitamins take place?"	In this fill-in-the-blank type question, students are expected to write "large intestine". This expression will cause students to learn this concept, which they will hear for the first time in their education life, in the form of incomplete scientific knowledge. More than 90% of absorption takes place in the small intestine. Amino acids, small peptides, vitamins, and other nutrients, including most glucose molecules, are pumped into the epithelial cells in the villi in the opposite direction to their concentration. Vitamins travelling with food to the small intestine are absorbed here. In the large intestine, only vitamins such as K, biotin and folic acid formed by some bacteria are absorbed into the blood (Reece et al., 2013: p.888-889).
"The liquid part of the blood is called blood plasma (serum)."	Blood is a connective tissue consisting of cells suspended in a liquid medium called plasma. Plasma contains water, ions, plasma proteins, nutrients, metabolic wastes, and respiratory gases. Plasma and serum are not synonymous concepts. The term *serum* is the name given to plasma with clotting factors separated (Reece et al., 2013, p.910-911). The cell-free part that remains after blood clotting is called serum (Sadava et al., 2014: p.880). It is expected that the information taught to students, who will learn these concepts for the first time in their education life, should be scientifically correct and not allow for mislearning.

"According to the presence or absence of A and B proteins in the structure (on the red blood cells), there are 4 types of blood groups in humans: A, B, AB and 0 (zero) group." "The type of blood group is determined by the protein structures in the red blood cells."	This statement points to a very common misconception in science and biology textbooks in Türkiye. It is carbohydrates, not proteins on plasma membranes, that determine blood groups. The blood group (phenotype) of an individual can be one of four types: A, B, AB, or O. These letters refer to the two carbohydrates (A and B) that can be found on the surface of red blood cells. A person's blood cells may carry carbohydrate A (blood type A), carbohydrate B (blood type B), and both (blood type AB) or neither (blood type O) (Reece et al., 2013: p.273). Different blood groups in humans (e.g., ABO blood types) derive their specificity from carbohydrate chains (Sadava et al., 2014: p.51; Simon et al., 2017: p.159; Nelson and Cox, 2005: p.374; Rodwell et al., 2018: p.1594).
"Do You Know These? All cells that make up our body need energy. This energy is obtained as a result of the combustion of the nutrients we take, with oxygen in our cells. Do you know that the respiratory system is needed for oxygen to reach our cells?"	This statement points to a very common misconception in science and biology textbooks in Türkiye. Obtaining energy in cellular respiration is not a combustion reaction. It is very important that students, who encounter this concept for the first time in their education life, are introduced to the correct information. What should be emphasised here at the 6th grade level is that oxygen does not enter into a direct combustion reaction with organic nutrients in cellular respiration, that cellular respiration consists of more than two dozen steps and that oxygen also functions towards the end of this process (Simon et al., 2017: p.97; Nelson and Cox, 2005: p.567; Sadava et al., 2014: 169-170).
"The diaphragm flattens when we inhale and domes when we exhale."	The diaphragm does not flatten when we inhale and does not dome when we exhale. This statement should be organised in such a way that students understand the process correctly. During breathing, the diaphragm, which is a membrane made of muscles, moves downwards, and expands the chest cavity. All this expands the volume of your lungs and reduces the air pressure inside to below atmospheric pressure. As a result, air enters through the nostrils and mouth from the outside, where the air pressure is higher, into the lungs, where it is lower. Although it may seem to us that we are inhaling air voluntarily, in fact our lungs are filled with air involuntarily because the air pressure inside them has fallen. During exhalation, the rib and diaphragm muscles relax, reducing the volume of the rib cage. As a result, the air pressure in the lungs increases, pushing the air out of the respiratory system (Simon et al., 2017: p.511; Widmaier et al., 2016: p. 452-453).

"The waste substances released as a result of the breakdown of food are carbon dioxide, water, ammonia, bile, minerals and vitamins B and C, taken in excessive amounts with food."	There are scientific mistakes in this statement within the scope of the excretory system, and learning in this form may cause students to misunderstand the concepts. The breakdown of nutrients can also be considered as digestion (hydrolysis). In this case, the molecules in question are not formed. When the statement is evaluated in the context of excretion; carbon dioxide, water and ammonia are formed when the building units of sugars, fats and proteins are used in cells for energy (Reece et al., 2013: p.180; Sadava et al., p.184-185). The water released in these events is also not considered as waste. Bile is a salt solution secreted from the liver to turn fats into small droplets and to help their digestion and absorption. Most of the bile salts in bile are absorbed back into the body through the small intestine. The liver also sends bilirubin, one of the breakdown products of haemoglobin in old red blood cells, to the small intestine together with bile. This substance is excreted from the body with faeces (Sadava et al., 2014: p.1081). In other words, bile is not an excretory substance as a whole.
"Adrenaline accelerates the beating of the heart, increases blood pressure, and increases the sugar (glucose) content in the blood. It also causes dilated pupils and **goose bumps**." Under the heading of Physical Changes in Adolescence, there is the expression "Hair growth in certain parts of the body".	These functions of the adrenaline hormone are correct. "Goosebumps", which is an idiom in our language, occurs not only when the adrenaline hormone is secreted but also in the cold environment. If a living creature today has feathers, it belongs to the class of birds. If a mammal (in this case a human) is mentioned, there are hairs on the skin (Reece et al., 2013: p.720; Hickman et al., 2016: p. 602; Miller and Harley, 2016: p.322, 410). There are data indicating that giving this idiom to students at this level will lead to learning the erroneous information that mammals have hair on their skin, which will turn into misconceptions in the future (Adıgüzel and Yılmaz, p.2020).
"Sense of Taste". Analyse the picture and tell in which parts of the tongue there are structures sensitive to taste. The tip of the tongue is sensitive to sweet, the sides near the tip to salty, the sides near the back to sour and the back to bitter stimuli. However, each part can perceive other flavours besides the specific taste that it perceives intensely.  	The human tongue has approximately 10,000 taste buds. The taste buds are embedded in the epithelium and most of them are located on the blisters (papillae). The taste buds are distributed in different parts of the tongue. Any part of the tongue with taste buds can perceive any of the five types of flavours. Thus, the "taste map" of the tongue, which is often drawn, is not precise (Reece et al., 2013: p.1102; Sadava et al., 2104: p.970; Miller and Harley, 2016: p.480; Hall, 2021: p.684; Freeman et al., 2014: p.965; Widmaier et al., 2016: p.224). As can be seen from the explanations, it is not scientifically correct to divide language into flavour zones. Mislearning will occur in students who encounter this information for the first time in their education life.

"The liver converts a harmful substance produced by the digestion of proteins into the less harmful urea."	Amino acids are formed as a result of digestion of proteins. Amino acids are not harmful. In this statement, nitrogenous metabolic wastes are intended to be explained, but it is thought that it will cause misunderstanding and mislearning. When amino acids are used as fuel to obtain energy in the cell, ammonia is formed metabolically (Sadava et al., 2014: p.1095). Urea produced in the vertebrate liver is the product of a metabolic cycle that combines ammonia with carbon dioxide (Reece et al., 2013: p.958; Hall, 2021: p.879).
"Chemical bond energy in food is released by digestion arises."	There is a misconception in this statement. Chemical digestion is necessary because animals cannot directly utilise proteins, carbohydrates, nucleic acids, fats, and phospholipids in food (Reece et al., 2013: p.880). Since nutrients are primarily large and complex molecules, they cannot be utilised by animal cells. The body needs to break these nutrients down to make them useful. Eating is the intake of nutrients. Digestion is the breaking down of nutrients into molecules that the body can absorb. Absorption is the uptake of small nutrient molecules by the cells lining the digestive tract (Simon et al., 2017: p. 94, p.475). This process is a hydrolysis, and no energy is obtained. Energy is obtained by cell respiration, oxygen-free respiration, and fermentation processes in cells (Sadava, 2014: p.184).
"Mitosis provides reproduction in unicellular organisms." "In unicellular organisms, mitosis enables the organism to reproduce." "What is the importance of mitosis for unicellular organisms? Explain."	From these statements in the books, it is understood that mitosis is assumed to ensure proliferation in prokaryotic cells. However, proliferation in prokaryotic cells does not occur by mitosis, but by division into two. It is observed that this is a misconception among high school and university students and teachers that the reproduction of bacteria occurs by mitosis. Mitosis is observed only in eukaryotic unicellular organisms. Although the reproduction process in eukaryotes includes mitosis, there is no mitosis process in prokaryotes (Freeman, 2011: p.200; Reece et al., 2013: p.236; Simon, et al., 2017: p.305).
"Plants photosynthesise during the day and respire at night. They consume oxygen in the room during respiration. Therefore, it is not appropriate to keep plants in bedrooms."	In photosynthesis, plants convert light energy into chemical energy stored in organic compounds. Oxygenated respiration continues day and night (Uryy et al., 2022).
"In our striated muscles, oxygenated respiration and anaerobic respiration are also performed. This process, which takes place without the use of oxygen, is called oxygen-free respiration."	Human skeletal muscle cells produce ATP via lactic acid fermentation in the absence of oxygen. At the onset of intense muscle activity, the rate of sugar breakdown to produce ATP exceeds the rate at which the muscle can supply oxygen from the blood. Under these conditions, cells switch from aerobic respiration to fermentation (Reecee et al., 2013: p.178; Simon et al., 2017: p.101).

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"Fungi, living creatures at the bottom of the oceans that allow dough to rise, milk to turn into yoghurt and cheese, breathe without oxygen." "Yeast fungi play a role in making bread from dough, yoghurt and cheese from milk."	Yoghurt is a product obtained by the process of fermentation of milk by some bacteria (Madigan et al., 2019).
Page 127: "Legumes use nitrogen-fixing bacteria in their roots to produce protein. These bacteria take free nitrogen from the air and transfer it to the legume structure."	Legumes and other plants take nitrogen from the soil in the form of ammonium and nitrate with their roots. They first synthesise amino acids and then proteins. Bacteria forming nodules in the roots of legumes convert atmospheric nitrogen (N_2) into ammonia (NH_3). Plants absorb it in the form of ammonium or nitrate (Odum and Barrettt, 2008: p.145-148; Reecee et al., 2013: p.793). As can be seen, free nitrogen-fixing bacteria cause an increase in nitrogenous compounds in the soil. Nitrogen in the air cannot be taken directly into the plant body. For this reason, expressing the statement as "Nitrogen-fixing bacteria living in the roots of legumes convert the free nitrogen of the air into nitrogenous compounds that the plant can take from the soil" will prevent students from misunderstanding.

APPENDIX 4

Scientific Examination of Units in Biology Textbooks

Erroneous or Controversial Statement	Correct Explanation
"Lipids have a polymer structure."	Lipids do not have a polymer structure. A triglyceride contains one molecule of glycerol and three molecules of fatty acids. These structures are not monomers (Urry et al., 2022).
"The most distinctive feature of vertebrates is that they have a spine made of vertebrae that follow each other on the back of their bodies. Because of this structure, organisms in this group are called **vertebrates (chordata)."**	Vertebrate animal and chordata are not the same concepts. Animals belonging to the sub-branches of the chordates (Chordata), tail chordates (Urochordata) and head chordates (Cephalochordata) do not have a backbone (Hickman, et al., 2016: p.498-501).
"Plants produce all the vitamins they need."	Vitamins are essential substances and are not produced by the organism itself (Reece et al., 2013: p.876).
"Vitamin D is also a hormone-acting substance."	This information is completely wrong. The substance that is said to have a hormone effect is not Vitamin D but another substance that is its analogue (Vieth, 2004).
"All vertebrates reproduce through amphigenesis."	This statement is scientifically incorrect. Some lizards, some fish and amphibians can also reproduce by parthenogenesis, a form of monogenetic reproduction (Hickman, et al., 2016: p.496).
"Oxytocin is a hormone secreted only by females".	This statement is scientifically incorrect. In humans, this hormone is secreted in both sexes. The hormones testosterone, prolactin, and oxytocin each appear to influence sexual activity in both males and females (Urry et al, 2022: p.1014).
"Any foreign substance that enters the body is called an antigen".	Substances that cause body cells to produce antibodies are called antigens. For example, there are hundreds of types of drugs used by humans that enter the body, which are foreign to the body, and these are not antigens (Reece et al., 2013: p.935).
Conjugation in Paramecium increases the number of organisms and creates genetic diversity."	Conjugation is an event that provides genetic diversity in some organisms. There is no increase in the number of individuals in conjugation. Therefore, it is not a form of reproduction or multiplication (Sadava et al., 2014: p.260; Reece et al., 2013: p.562).
"Algae photosynthesise during the day and do not respire."	Algae photosynthesise in the presence of light. Cell respiration continues day and night (Simon et al., 2017; Urry et al., 2022).

"Impulses coming from the dendrite are evaluated in the cell body and it is decided whether they will be transmitted to the necessary places or not. If they will be transmitted, the impulse is transferred to the axon".	This statement is scientifically incorrect because it is not the neuron itself that determines the transmission of the impulse from the presynaptic neuron to the postsynaptic neuron, but the magnitude of the stimulus, and the impulse is transmitted if the threshold value is exceeded (Reece et al, 2013; p. 1051; Hole, 1993: pp. 340-341).
"The most commonly known neurotransmitter substances are acetylcholine, norepinephrine, histamine, dopamine, serotonin and glutamate. These chemicals are also called neurohormones".	In the definition given, it is stated that neurotransmitter substances are called neurohormones. This statement is incorrect. Acetylcholine, monoamines, some amino acids or amino acid derivatives and some neuropeptides are used as neurotransmitter substances. Neurohormones are secreted from the endings of nerve cells into the bloodstream and these secreted substances are transported by the blood to the target cell and function as hormones. Examples of such hormones are antidiuretic hormone or oxytocin. Not all neurotransmitter substances are hormones (Reece et al., 2013: p.975).
"Parathormone converts inactive vitamin D, taken from food or synthesised in the skin by sunlight, into active vitamin D in the liver and then in the kidney".	This statement implies that inactive vitamin D is synthesised in the skin. However, the precursor form of vitamin D (provitamin D, 7-dehydrocholesterol) is synthesised from cholesterol by intestinal enzymes and is largely stored in the skin. This substance stored in the skin is converted into vitamin D (cholecalciferol) by ultraviolet radiation. Cholecalciferol is converted to hydroxycholecalciferol in the liver. This substance is converted to dihydroxycholecalciferol (active vitamin D) in the kidneys (Hole, 1993: p.481-482).
"Cellular respiration is the process by which nutrient monomers entering the cells are broken down in the cell with or without oxygen to produce ATP".	This definition may cause mislearning in students. Because oxygen is absolutely used in cellular respiration in human cells; there is no question of not using oxygen. In humans, obtaining energy or producing ATP without the use of oxygen is not oxygen-free respiration but fermentation (Reece et al., 2013: p.177).
"The flower is the reproductive organ of plants that can form seeds."	Not all seed-forming plants have flowers as reproductive organs. Open-seeded plants can form seeds, but their reproductive organs are not flowers but cones (Sadava et al., 2014: p.612; Reece et al., 2013: p.621).
"Plants living in equatorial regions that receive sunlight for less part of the day are called short-day plants."	The definition of short-day and long-day plants is based on the flowering period. Plants that bloom during long daylight periods are called long-day plants; plants that bloom during shorter daylight periods (such as in autumn) are called short-day plants (Sadava et al., 2014: p.804; Reece et al., 2013: p.839).
"In which cases do bacteria reproduce by conjugation?"	This question is scientifically incorrect. Because in this conjugation mechanism, which is seen in unicellular organisms such as bacteria and paramecium, a new individual with recombinant genes emerges by gene transfer. However, the number of individuals does not increase in conjugation (Sadava et al., 2014: pp.261 and 586; Reece et al., 2013: p.573).