REPORT ON CHEMISTRY EDUCATION IN TÜRKİYE: ISSUES, SOLUTIONS, BEST PRACTICES

Series on Fundamental Sciences Education

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ECO
Educational Institute

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

FOREWORD

The following report provides a summary of the outcomes from the two-day "Workshop on Challenges and Solutions in Chemistry Education at Secondary and Undergraduate Levels in Türkiye." The workshop was organized by the Economic Cooperation Organization Educational Institute (ECOEI) and took place on 2-3 March 2023 in Ankara. The reporting team responsible for documenting the workshop's insights and recommendations consisted of researchers from Gazi University, Gazi Faculty of Education, led by Prof. Dr. Yüksel Altun, who also pioneered the framework of the workshop and meticulously curated its sessions. The reporting team included Assoc. Prof. Dr. Ayşe Yalçın Çelik, Assoc. Prof. Dr. Hakkı Kadayıfçı, Assoc. Prof. Dr. Sevinç Nihal Yeşiloğlu and Research Assistant Dilay Dinçdemir.

This was the fourth 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 Chemistry Education at Secondary and Undergraduate Levels in Türkiye" explored innovative teaching methods and provided a platform for educators, researchers, and professionals to come together and discuss the challenges faced by chemistry education at all levels. In this workshop, ECO Educational Institute brought together several academicians from chemistry and chemistry education departments and teachers and administrators from high schools and middle schools, both public and private.

On the inaugural day of the workshop, participants delved into a comprehensive exploration of the prevailing challenges within the field of chemistry education.

Subsequently, on the second day, attendees shared their insights by presenting exemplary approaches and offering policy recommendations specifically tailored to chemistry education. Each presentation session was followed by an interactive Q&A segment, fostering further discussion, encouraging questions from fellow presenters, and facilitating valuable contributions. The workshop concluded with focus group discussions, aimed at gathering diverse perspectives and insights for refining strategies and fostering innovation in chemistry education practices.

I would like to extend my heartfelt appreciation to Prof. Dr. Yüksel Altun for her dedicated contributions to both the coordination of the workshop and the reporting of its outcomes. Her seamless organization and meticulous documentation have been essential to the workshop's success. Additionally, my gratitude extends to the diligent reporting team, Assoc. Prof. Dr. Ayşe Yalçın Çelik, Assoc. Prof. Dr. Hakkı Kadayıfçı, Assoc. Prof. Dr. Sevinç Nihal Yeşiloğlu and Dilay Dinçdemir. Their invaluable efforts in documenting insights and recommendations will play a significant role in enhancing chemistry education at various academic levels in Turkey. I would also like to express my gratitude to all scholars, students, teachers and experts who took part in the workshop for graciously accepting our invitation and sharing their invaluable experience, research, and insights. Their enthusiasm and hard work bring hope and inspiration to our endeavors.

ECOEI acknowledges the pivotal role of chemistry education as a cornerstone of fundamental sciences, fostering critical thinking, problem-solving, and scientific literacy. As we reflect upon the accomplishments of this workshop, we convey our aspirations for the advancement and promotion of fundamental sciences education throughout the ECO region. We hope that this workshop acts as a catalyst for collaborative initiatives, inspiring educators who will shape the upcoming generation of aspiring scientists and researchers and support them in their pursuit of knowledge and discovery.

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

PREFACE

Chemistry education holds vital importance in today's world, where science and technology are advancing rapidly. While influencing many aspects of our daily lives, chemistry, also plays a significant role in several fields, including industry, energy, medicine, and environment. Therefore, chemistry education in Türkiye's educational system is of crucial importance in enabling our students to develop their scientific thinking skills, increase their curiosity, and establish a solid foundation for their future careers.

However, there are several challenges in chemistry education at the secondary and undergraduate levels in Türkiye. This workshop, conducted with the aim of proposing solutions to overcome these challenges and improve chemistry education, is an important step in the fiel.

The workshop provided a platform for experienced chemistry teachers, academics, experts, and students from across the country to come together and discuss and propose solutions to the problems related to chemistry education. The intensive and productive discussions held during the workshop allowed participants to share their rich experiences and learn from one another.

This report encompasses valuable ideas, suggestions, and highlighted issues that emerged during the workshop. It is written with the hope that it will help to gain a better understanding of the current challenges in chemistry education, improve teaching strategies, and generate new ideas to attract more interest in chemistry education.

I would like to express my gratitude to Prof. Dr. M. Akif Kireçci, President of the Economic Cooperation Organization Educational Institute (ECOEI), 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. Ayşe Yalçın Çelik, Assoc. Prof. Dr. Hakkı Kadayıfçı, Assoc. Prof. Dr. Sevinç Nihal Yeşiloğlu and Res. Asst. Dilay Dinçdemir for their contributions to the preparation of the report. We hope that this report provides a roadmap that will assist Türkiye in making progress in the field of chemistry education.

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WORKSHOP ON CHALLENGES AND SOLUTIONS IN CHEMISTRY EDUCATION AT SECONDARY AND UNDERGRADUATE LEVELS IN TÜRKİYE

Ankara, 2-3 March 2023

Invited Speakers

Prof. Dr. Alipaşa AYAS, Bilkent University, Faculty of Education

Prof. Dr. Eylem BAYIR, Trakya University, Faculty of Education

Prof. Dr. Faik KARATAŞ, Trabzon University, Fatih Faculty of Education

Prof. Dr. Nilgün SEÇKEN, Hacettepe University, Faculty of Education

Prof. Dr. Sevgi AYDIN GÜNBATAR, Yüzüncü Yıl University, Faculty of Education

Prof. Dr. Z. Demet KIRBULUT GÜNEŞ, Gazi University, Gazi Faculty of Education

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Assoc. Prof. Dr. Sevil AKAYGÜN, Boğaziçi University, Faculty of Education

Dr. Aysun İNAL, Ministry of National Education, General Directorate of Secondary Education

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Dr. Mehmet BİLGİ, Gebze TUBITAK Science High School

Ali BUĞDAY, Konya Karatay TOKİ Anatolian High School

Özge GÖKTÜRK, Mersin Aydıncık Multi-Program Anatolian High School

Yasemin KESKİN ÇİNKAYA, Ankara Bahçeşehir Educational Institutions

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INTRODUCTION

Chemistry education is an important aspect of modern education, equipping students with the knowledge and skills necessary to thrive in a world that is becoming increasingly complex and preparing them for careers in science, technology, engineering, and mathematics (STEM). Chemistry also forms a solid foundation for various professions as diverse as medicine, engineering, environmental science, and materials science. Furthermore, chemistry teaching prepares students to succeed in many different professions by helping them develop scientific thinking, problem-solving, and critical thinking skills needed to better comprehend the world and tackle future challenges. Additionally, chemistry education fosters an understanding of global issues such as environmental protection, sustainability, and energy efficiency. When scientific and technological solutions are required to address these problems, chemistry plays a pivotal role in finding effective solutions. Thus, chemistry education in the 21st century is an indispensable discipline that empowers students throughout their lives and enhances their career prospects. Qualified chemistry students who contribute to solving global issues become the cornerstones of a sustainable future. Despite its significance, chemistry education faces several challenges, such as lack of student interest and motivation, lack of qualified teachers, outdated curricula, limited access to educational resources and technologies, and inadequate funding (Chai and Kong, 2016; Bennett and Lemoine 2014; Fitriyana et al., 2023; Cardellini, 2012). It has been found that 830 million children worldwide do not have access to a computer at home and 330 million do not have internet access (Özer and Suna, 2020, 179). Moreover, even if all students are provided with access to technology, their levels of utilization may vary, underscoring the importance of digital literacy (Bayındır and Kahraman, 2023).

Educators and researchers have long grappled with these issues to find ways to make chemistry education more engaging, relevant to the needs of the 21st century, and accessible to all students. Globalization, new technologies, migration, international competition, changing markets, and transnational environmental and political challenges have necessitated that students have access to the 21st century education that equips them to survive and thrive in the modern world. Enhancement of students' motivation and interest is based on identifying problems in chemistry education and developing effective solutions (Ayas et al., 1997). Transforming 21st century education goes beyond cultivating thinking skills and content knowledge; it involves preparing all students to thrive and succeed in a competitive world. To equip students to meet the challenges and pressures of the 21st century, schools should adopt a comprehensive yet flexible instructional approach that is focused on content and expands thinking and reasoning abilities. Teaching systems that are open to student input, interdisciplinary in focus and effectively blend non-formal and formal learning are required. In addition, to achieve the desired success, it is essential to instill in students an understanding of the value of science (Millar, 2007).

To address the issues and seek solutions to the issues related to chemistry education, "Workshop on Challenges and Solutions in Chemistry Education at Secondary and Undergraduate Levels in Türkiye" was organized in Ankara on 2-3 March 2023 with the support of the Economic Cooperation Organization Educational Institute (ECOEI), an intergovernmental organization. The workshop brought together academics, teachers, experts, undergraduate and graduate students from across the country to discuss the current state of chemistry education at different levels, as well as to explore strategies for improvement.

The workshop specifically aimed to achieve the following objectives:

- to identify major problems associated with chemistry education curricula at various levels and propose solutions.
- to identify key issues concerning the competencies of instructors (teachers and lecturers) at different levels of chemistry education and propose solutions.
- to identify significant challenges related to student competencies in chemistry education at various levels and propose solutions.
- to address the main problems pertaining to the teaching environment and tangible teaching materials in chemistry education at different levels and develop solutions.
- to present examples of good practices in chemistry education at various levels.
- to compile a comprehensive proceedings book containing the full-text articles of invited speakers, available in both Turkish and English, to be shared with other member countries of the Institute.

During the workshop, participants focused on various topics related to chemistry education, including curriculum design, assessment, teaching methods, and the integration of technology into education. Throughout the workshop, they discussed the current state of chemistry education, identified key issues and challenges, and proposed solutions that could be applied at various levels, from individual classrooms to the national policy level.

This report highlights the primary challenges faced by chemistry education in Türkiye and presents the proposed solutions identified through the evaluation of the presentations made at the workshop, valuable discussions that took place during these presentations incorporating the views of the participants and findings from focus group meeting reports, all aligned with the aforementioned objectives. The report concludes by solution proposals and examples of best practices that can be implemented by chemistry teachers and other stakeholders at different levels.

AN OVERVIEW OF THE TURKISH EDUCATION SYSTEM

The Turkish education system is designed under two main categories: formal and non-formal education, in accordance with the Basic Law on National Education. Formal education comprises pre-school, primary, middle and high schools as well as higher education (university) institutions. While participation in pre-school education is not compulsory in Türkiye, 12 years of education is mandatory for all male and female citizens. The 12 years of compulsory education period consists of four years of primary school (1^{st}, 2^{nd}, 3^{rd}, and 4^{th} grade), four years of middle (5^{th}, 6^{th}, 7^{th}, and 8^{th} grade) and four years of high school education (9^{th}, 10^{th}, 11^{th}, and 12^{th} grade). Upon completion of this last level, each student is awarded a "High School Education Diploma". Students who obtain a high school education diploma can choose to pursue higher education at tertiary institutions (Turkish Education System, 2023).

Pre-School Education: Preschool education covers the optional educational stage for children aged 3 to 5 years who have not yet reached primary school age. The aim of pre-school education is to ensure the physical, mental, and emotional development of children, instill good habits, prepare them for primary education, and promote correct and eloquent Turkish language skills.

Primary Education (Elementary and Middle School): Primary education is a fundamental educational stage that encompasses the compulsory education and training process for children between the ages of 5 and 13. Primary education institutions consist of 4-year elementary schools, 4-year middle schools and *imam-hatip* (religious) middle schools. The primary education aims to provide children with essential basic knowledge, skills, behaviors, and habits necessary to become responsible citizens, develop in accordance with the understanding of national moral values, and prepare them for life and high school education based on their interests, abilities, and talents.

Secondary Education (High School): Upon completion of eight years of elementary and middle schools education, students can enter the high school of their choice based on their score in the central high school entrance exam.

High schools encompass a range of general, vocational, and technical education institutions. In Türkiye, there are various secondary education institutions which provide education at different categories, including Science High Schools, Social Sciences High Schools, Anatolian High Schools, Vocational and Technical Anatolian High Schools, Multi-Program Anatolian High Schools, Anatolian Imam-Hatip High Schools, Fine Arts High Schools, Sports High Schools, Open Education Institutions and Private Schools.

Science High Schools prepare students with exceptional mental abilities and high aptitude in science and mathematics for higher education in those fields. Social Sciences High Schools, on the other hand, aim to train qualified professionals required in the fields of social sciences and literature, and prepare students with high mental performance and a high level of interest and capability in these areas for higher education. Anatolian High Schools are secondary education institutions that aim to provide students with necessary knowledge and skills in science, mathematics, literature, social sciences, and foreign languages, tailored to students' individual abilities and interests. In Multi-program Anatolian High Schools, programs that prepare students for higher education, programs that prepare students for both vocational and higher education, and programs that prepare students for life and work are implemented simultaneously. Anatolian Imam-Hatip High Schools are vocational secondary education institutions that provide the necessary knowledge and skills to fulfil religious services such as imamate and oratory. Anatolian Imam-Hatip High Schools, which take students through central exams, implement science and social sciences programs. Graduates of Vocational and Technical Anatolian High School programs are employed with the title of technician upon entering their respective fields.

In Science High Schools, students are admitted based on central exam scores and are enrolled to numerical (MS, Mathematics-Science) track without the option for field selection. These schools are typically boarding schools that accept both male and female students. Graduates of science high schools often pursue higher education in STEM professions such as medicine, pharmacy, dentistry, and engineering. However, students graduating from these schools are not restricted to these specific fields and can choose higher education programs based on other score types. In Anatolian High Schools, students can choose one of four possible field tracks: TM (Turkish-Mathematics), MS (Mathematics-Science), TSc (Turkish-Social Science) and Lang (Foreign Language). After the second year (10^{th} grade), they choose their specialized tracks and start taking courses in their chosen fields. This system is also applicable to Vocational and Technical Anatolian High Schools. The only difference is that Anatolian High Schools choose their department in the 11^{th} grade, while Vocational High

Schools select their specific department related to their profession after the first year (10^{th} grade). In the Turkish education system, high school graduates gain admission to universities through the nationwide Higher Education Entrance Examination (YGS) and the Undergraduate Placement Examination (LYS).

Higher Education: Higher education institutions provide academic education, offering programs that span at least two years and aim to cultivate highly qualified professionals, and contribute to scientific and technological advancements through research. Universities, faculties, institutes, colleges, vocational schools, conservatories, application, and research centers are all considered higher education institutions.

2.1. Chemistry Education in Middle and High Schools

2.1.1. Chemistry Curriculum

Developing chemistry curricula in Türkiye follows a comprehensive approach. This includes examining the current curricula of various countries, reviewing domestic and international academic studies, gathering the opinions of teachers and administrators through questionnaires, analyzing department reports and reports prepared by faculties of education specialized in relevant fields, and consulting with expert personnel, teachers, and academicians. Thus, the developers aim to adapt the curriculum to the evolving technological, scientific, and social advancements. Furthermore, they strive to implement a science curriculum that emphasizes the use of scientific methods rather than relying solely on memorization-based direct knowledge (Aydoğdu, 1999; Unayağyol, 2009).

In the middle schools, there is no dedicated chemistry course. However, there is a science course offered in grades 5, 6, 7 and 8, which aims to provide students with basic knowledge about astronomy, biology, physics, chemistry, earth, and environmental sciences, as well as science and engineering applications. The science courses follow a 4-hour curriculum, through which basic chemistry concepts are taught. Table 1 provides an overview of the units, course hours, number of learning outcomes and their respective percentages related to chemistry for grades 5 to 8 in middle schools.

Table 1. Chemistry Units in Middle School Science Course Content

Grade	Unit Title	Number of Outcomes	Course Hours	Percentage
Grade 5	Matter and Change	6	26	18,1
Grade 6	Matter and Heat	13	28	19,4
Grade 7	Pure Substances and Mixtures	16	28	19,4
Grade 8	Matter and Industry	17	28	19,4
	TOTAL	**52**	**107**	

Chemistry education in high schools is carried out with a 2-hour curriculum in grades 9 and 10 and a 4-hour curriculum in grades 11 and 12. In 11th and 12th grades, the 4-hour chemistry curriculum is conducted only with students who have selected a science track (see Table 2).

Table 2. 2022-2023 Academic Year Chemistry Course Hours in High School Types

Types of High Schools	Grade 9	Grade 10	Grade 11	Grade 12
Science High Schools	2	2	4 (Compulsory)	4 (Compulsory)
Anatolian High Schools	2	2	4 (Elective)	4 (Elective)
Social Sciences High Schools	2	2	0	0
Vocational and Technical Anatolian High Schools	2	2	0	0
Multi-Program Anatolian High Schools	2	2	4 (Elective)	4 (Elective)
Fine Arts High Schools	2	2	0	0
Sports High Schools	2	2	0	0

The current 2018 chemistry curriculum aims to provide students with knowledge of the basic concepts, principles, models, theories, and laws of chemistry and to learn the development process, nature, and ethical use of scientific knowledge. It also aims to familiarize students with world-renowned scientists who have contributed to science and their works, and to develop the ir ability to use chemistry in different situations such as health, industry, and environment in daily life. It aims to introduce students to technology with its positive and negative aspects and to instill them with the value of chemistry's contributions to social life, economy, and technology. The other aims of the chemistry curriculum include providing students with the ability to conduct experiments and make inferences from the data obtained, providing information about the future of chemistry in terms of career, enabling them to understand the role of chemistry in life, and giving them the opportunity to engage in new studies with original ideas. While implementing the chemistry curriculum, the teachers are expected to follow the guidelines about subjects and learning outcomes to shape the lessons within the framework of laboratories and activities, and to carry out performance studies, experiment designs, projects and activities. Furthermore, they are expected to follow national and international scientific competitions and to motivate students in this direction. How Consequently, the role of teachers in this regard is quite significant. Teachers' inability to follow the innovations in the profession due to reasons such as lack of financial opportunities, competition and motivation affect implementation of an alternative teaching process (Özden, 2007).

The unit titles, number of learning outcomes, foreseen course hours and course hour percentages of the 9th-12th grade high school chemistry curriculum are given in Table 3-Table 6.

Table 3. 9th Grade Chemistry Curriculum

	Unit Title	Number of Outcomes	Course Hour	Percentage
1	Chemistry Science	7	6	8
2	Atom ve Periodic System	5	16	22
3	Interactions between Chemical Species	11	22	31
4	States of Matter	10	20	28
5	Nature and Chemistry	5	8	11
	TOTAL	**38**	**72**	**100**

Table 4. 10th Grade Chemistry Curriculum

	Unit Title	Number of Outcomes	Course Hour	Percentage
1	Basic Laws of Chemistry and Chemical Calculations	4	28	39
2	Mixtures	5	18	25
3	Acids, Bases, and Salts	7	14	19
4	Chemistry in Everywhere	7	12	17
	TOTAL	**23**	**72**	**100**

Table 5. 11th Grade Chemistry Curriculum (Elective Chemistry)

	Unit Title	Number of Outcomes	Course Hour	Percentage
1	Modern Atomic Theory	5	26	18
2	Gases	6	30	21

3	Liquid Solutions and Solubility	6	26	18
4	Energy in Chemical Reactions	4	16	11
5	Chemical Reactions Rate (Chemical Kinetics)	3	14	10
6	Equilibrium in Chemical Reactions	11	32	22
	TOTAL	**35**	**144**	**100**

Table 6. 12th Grade Chemistry Curriculum (Elective Chemistry)

	Unit Title	Number of Outcomes	Course Hour	Percentage
1	Chemistry and Electricity	9	42	29
2	Introduction to Carbon Chemistry	6	36	25
3	Organic Compounds	11	40	28
4	Energy Resources and Scientific Developments	5	26	18
	TOTAL	**31**	**144**	**100**

2.1.2. Course Materials and Physical Conditions

According to 2022 data, there are 345 Science High Schools, 2.887 Anatolian High Schools, 93 Social Sciences High Schools, 2.403 Vocational and Technical Anatolian High Schools, 673 Multi-Program Anatolian High Schools, 101 Fine Arts High Schools, 97 Sports High Schools, totaling 6.599 high schools with 4.818.581 students and 257.350 teachers in Türkiye.

Instructional materials are indispensable components of the learning environments of sciences. The Ministry of National Education (MoNE), Department of Textbooks and Instructional Materials prepares written and electronic instructional materials for both other courses and chemistry. These include interactive textbooks and educational materials, student workbooks, supplementary books, electronic educational content, teacher's guidebooks, program implementation modules and guides (see Figure 1). Interactive textbooks include interactive applications such as audio, video, animation, video questions, matching, interactive assessment tests, and workbooks. The department's website also provides the opportunity to generate, 3D chemical models were transferred to interactive textbooks to facilitate student understanding. In addition, computer-based unlimited dynamic questions through artificial intelligence and to create one's own test from the desired subject achievements.

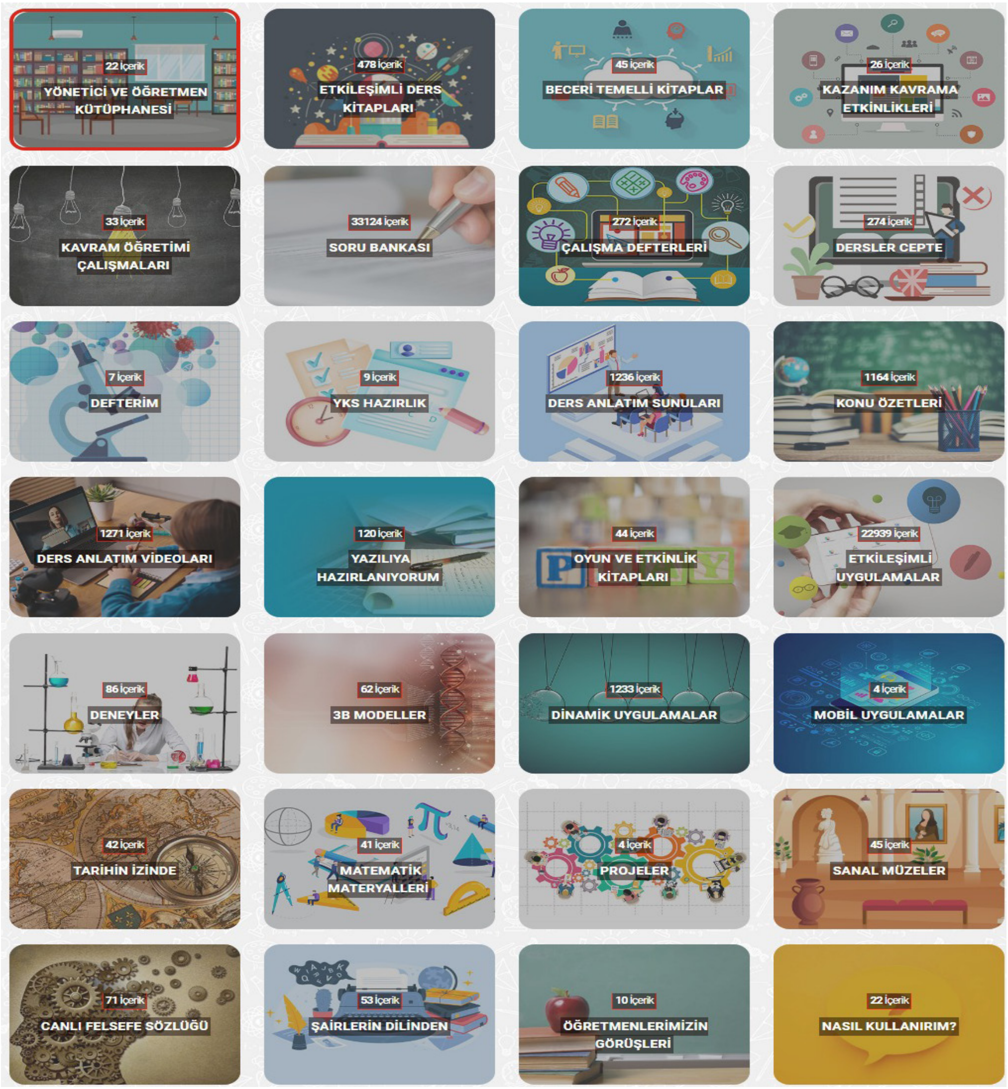

Figure 1. Electronic Materials Prepared by the Ministry of National Education, Department of Textbooks and Instructional Materials (retrieved directly from https://ogmmateryal.eba.gov.tr/#)

Since the beginning of the distance education with the pandemic, various publications, interactive books, dynamic applications, 3D models, experiments, skill-based tests, and achievement comprehension activities, university entrance examination preparation videos, live lessons, and homework assignments have been prepared in the context of Education Informatics Network (*Eğitim Bilişim Ağı* - EBA) and Turkish National Television's EBA Channel.

The physical conditions of some high schools are summarized in Table 7. The number of laboratories, which iare essential for chemistry teaching, is not sufficient when compared to the number of high schools. Moreover, most of the existing laboratories cannot be actively used as much as they should due to reasons such as lack of materials, physical conditions, and teachers' time. While Anatolian High schools have the largest body of students and the biggest number of facilities, science high schools are richer in terms of laboratories, Z libraries, boarding houses and boarding house capacities relative to the number of students.

Table 7. 2022-2023 Academic Year Physical Conditions of High Schools

School	Student	Gym	Library	Boarding House
6.599	4.818.581	2.137	5.716	1.001
Classroom	**Teacher**	**Laboratory**	**Z Library**	**Boarding House Capacity**
196.600	257.350	5.347	817	202.543

2.2. Chemistry Education at the Undergraduate Level

2.2.1. Current State of Chemistry and Chemistry Teaching Undergraduate Programs in Universities

Chemistry undergraduate programs at the Faculties of Science are designed to provide students with a basic knowledge of chemistry, develop their laboratory skills and advance their analytical thinking abilities. These programs aim to train their graduates as qualified chemistry professionals who can successfully pursue careers in industry, research, education, and many other fields. Currently, chemistry undergraduate programs at universities in Türkiye generally offer a comprehensive curriculum. Students are offered basic chemistry courses as well as specialized courses such as organic chemistry, physical chemistry, analytical chemistry, biochemistry, and polymer chemistry. In addition, laboratory experiments and research projects allow students to develop practical skills. As a matter of fact, laboratories, which introduce general outlines of concepts and principles and allow students to construct knowledge on their own, are an environment that brings innovation to science and technology (Aydoğdu, 1999).

Chemistry teaching programs in Türkiye are important educational programs that aim to train qualified teachers with chemistry knowledge. These programs play a critical role in teaching chemistry to high school students, developing scientific thinking skills, and raising the scientific literacy level of future generations. Currently, chemistry teacher education programs in Türkiye offer a variety of opportunities to provide students with a comprehensive chemistry education, develop their pedagogical skills and enrich their classroom experiences. These programs aim to train prospective teachers as qualified chemistry teachers who can effectively transfer their knowledge and skills, motivate their students, and encourage scientific thinking skills.

In Türkiye, 63 public and foundation universities have chemistry departments in the facultyies of science, while only 11 universities have chemistry teaching programs in the facultyies of education. Table 8 shows the number of student quotas for both programs at 11 universities which offer chemistry teaching programs. As can be seen in Table 8, not only the quotas of chemistry departments faculties of science is higher than the quotas of chemistry teaching programs at faculties of education but also there are more chemistry programs at faculties of science. However, in recent years, the chemistry departments at science faculties have not been able to fill their student quotas, which is a looming problem.

Table 8. Quotas and Number of Placed Students in Chemistry and Chemistry Teaching Undergraduate Programs in the Faculties of Science and Faculties of Education; (2022)

	Faculty of Science		Faculty of Education	
University Name	**Quota**	**Number of Placed Students**	**Quota**	**Number of Placed Students**
Atatürk University (4 Years)	26	26	21	10
Balıkesir University (4 Years)	21	21	21	21
Boğaziçi University (English) (4 Years)	67	67	21	21
Çanakkale 18 Mart University (4 Years)	21	21	21	21
Dokuz Eylül University (4 Years)	82	82	21	21
Gazi University (4 Years)	62	62	21	21
Hacettepe University (4 Years)	93	93	21	21
Marmara University (4 Years)	82	82	21	21
Marmara University (TRNC National) (4 Years)	-	-	1	1
Necmettin Erbakan University (4 Years)	-	-	21	21
Orta Doğu Teknik University (English) (4 Years)	82	82	21	21
Van Yüzüncü Yıl University (4 Years)	16	16	21	14
TOTAL	**552**	**552**	**232**	**214**

Table 9 illustrates the number of faculty members in chemistry and chemistry teaching programs of the same universities. The number of faculty members in the Chemistry Teaching Department at the Faculty at Education is considerably less than the number of faculty members in the Chemistry Department of the Faculty of Science. In terms of the number of faculty members, Boğaziçi University and Marmara University have the lowest number of faculty members with 3 faculty members, while Gazi University has the highest number of faculty members with 16 faculty members.

Table 9. Number of Faculty Members in Chemistry Departments and Chemistry Teacher Education Departments in the Faculties of Science and the Faculties of Education; (2022)

University	Faculty of Science	Faculty of Education
	Department of Chemistry, Number of Faculty Members	Department of Chemistry Teaching, Number of Faculty Members
Atatürk University (4 Years)	46	9
Balıkesir University (4 Years)	24	7
Boğaziçi University (English) (4 Years)	34	3
Çanakkale 18 Mart University (4 Years)	26	5
Dokuz Eylül University (4 Years)	31	8
Gazi University (4 Years)	56	16
Hacettepe University (4 Years)	69	12
Marmara University (4 Years)	36	3
Necmettin Erbakan University (4 Years)	-	8
Orta Doğu Teknik University (English) (4 Years)	61	10
Van Yüzüncü Yıl University (4 Years)	27	9
TOTAL	**410**	**90**

2.2.2. Chemistry and Chemistry Teaching Curricula

In Türkiye, chemistry and chemistry teaching undergraduate curricula and course hours vary across universities. For our purposes, the present report focuses on the most commonly used curricula. The Tables 10 and 11 show, the education and field courses in the Chemistry Teaching program of a state university that updated its program in 2018. Chemistry teaching students are required to take and succeed in all of these courses.

Table 10. Education Courses and Course Hours in the Chemistry Teaching Undergraduate Program in a State University (Updated in 2018)

Undergraduate Courses	Theoretical	Practical	Total
Introduction to Education	2	0	2
Educational Psychology	3	0	3
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
Sociology of Education	2	0	2
Philosophy of Education	2	0	2
History of Turkish Education	2	0	2
Research Methods in Education	2	0	2
Chemistry Curriculum	2	0	2
Material Development in Chemistry Education	2	2	4
Special Teaching Methods in Chemistry-I	2	2	4
Special Teaching Methods in Chemistry-II	2	2	4
Special Education and Inclusion	2	0	2
Turkish Education System and School Management	2	0	2
Chemistry Teacher Competencies and Orientation	2	0	2
Assessment and Evaluation in Chemistry Education	2	0	2

Table 11. Compulsory Field Courses and Credits in the Chemistry Teaching Undergraduate Program in a State University (Updated in 2018)

Undergraduate Compulsory Field Courses	Number of Semesters	Theorethical	Practical	Total
General Chemistry	2	4	2	6
General Chemistry Laboratory	2	0	2	2
Laboratory Seafety	1	0	2	2
Analytical Chemistry	2	4	0	4
Analytical Chemistry Laboratory	2	0	4	4
Inorganic Chemistry	2	4	0	4
Organic Chemistry	2	4	0	4

Organic Chemistry Laboratory	2	0	4	4
Physical Chemistry	2	4	0	4
Physical Chemistry Laboratory	1	0	2	2
Biochemistry	1	2	0	2
High School Chemistry Experiments 1	1	2	2	4
TOTAL		**24**	**18**	**42**

Table 12 shows, the education courses and course hours in the Chemistry Teaching program of a state university, which has not yet updated its program and implements the program recommended by the Council of Higher Education (CoHE). These are required courses for all chemistry teaching students at this university.

Table 12. Education Courses and Course Hours in the Chemistry Teaching Undergraduate Program in a State University (Not-Yet-Updated)

Undergraduate Education 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	6
Teaching Practice II	2	6	6
Counseling at Schools	2	0	2
Sociology of Education	2	0	2
Philosophy of Education	2	0	2
History of Turkish Education	2	0	2
Research Methods in Education	2	0	2
Morality and Ethics in Education	2	0	2
Special Education and Inclusion	2	0	2
TOTAL	**30**	**0**	**30**

As seen in Table 11 and Table 12, the courses and course hours in both programs vary significantly. Some courses such as “Chemistry Teacher Competencies and Orientation” and “Material Development in Chemistry Education” in the updated program are not included in the undergraduate program that has not yet updated its program. In addition, the “Educational Psychology” course in both university programs is a 3-hour theoretical course in one university and a 2-hour theoretical course in the other university.

In Table 13, the field courses of chemistry teaching, chemistry and chemical engineering programs are compared. They have quite different curricula, which is expected, since each department educates students for different aims and objectives.

Table 13. 2022-2023 Academic Year Undergraduate Compulsory Field Courses and Course Hours in Chemistry Teacher Education, Chemistry, and Chemical Engineering Departments

Compulsory Field Courses	Chemistry Education		Chemistry Department		Chemical Engineering	
	Number of Semesters	Credits	Number of Semesters	Credits	Number of Semesters	Credits
General Chemistry	2	4+4	2	4+4	2	4+4
General Chemistry Laboratory	1	2	1	3	1	3
Laboratory Safety-Occupational Health and Safety	1	2	1 2	2 1+1	1 2	2 1+1
Analytical Chemistry-	2	3	2	3+3	2	3+3
Electroanalytical Chemistry	1	3	1	2	1	2
Analytical Chemistry Laboratory	2	2+2	2	6+6	2	6+6
Inorganic Chemistry	2	2+2	3	4+4+2	3	4+4+2
Organic Chemistry	2	2+2	3	4+4+4	3	4+4+4
Organic Chemistry Laboratory	2	2+2	2	6+8	2	6+8
Physical chemistry	1	3	4	3+3+3+3	4	3+3+3+3
Physical Chemistry Laboratory	0	0	1	6	1	6
Biochemistry	1	2	1	4	1	4
Biochemistry Laboratory	0	0	1	4	1	4
Chemistry in Daily Life	1	2	Elective	2	Elective	2

2.2.3. Other Undergraduate Programs with Chemistry Instruction

Chemistry courses are compulsory field courses in chemistry departments at faculties of science and chemistry teaching departments at faculties of education, as well as in chemical engineering departments at engineering faculties, and as compulsory elective courses in other departments at faculties of science (such as physics, biology, science departments), pharmacy, medicine, dentistry, all engineering departments under the faculty of engineering, and mathematics and science education department sub-branches. Although varies in universities, there are courses such as General Chemistry and Biochemistry as compulsory elective courses in various programs.

METHODOLOGY

3.1. Structure of the Workshop

The workshop was conducted in two phases. The first phase of the workshop was modeled as a presentation and discussion platform where participants who are experts in their fields, including faculty members, research assistants, administrators, teachers, expert teachers, and undergraduate and graduate students, could identify and develop solutions for the challenges in chemistry education. In the second phase of the workshop, the focus group meetings were held to enable the participants to discuss, share and report their views. The workshop program, which lasted two days in total, is given in Appendix 1.

This workshop report is based on the results obtained from the presentations on the challenges, solutions and good practices in chemistry education at both middle/high school and undergraduate levels, discussions during the presentations, findings obtained through [Form-1 (Appendix-2) and Form-2 (Appendix-3), and the reports of the focus group discussions.

3.2. Selection of Workshop Participants and Workshop Presentation Topics

Participants were selected based on their expertise, experience, and contributions to chemistry education, paying maximum attention to include individuals from different regions, universities, school types and institutions across Türkiye.

The topics and issues to be presented by invited speakers regarding challenges and solutions in chemistry education, as well as the discussions, have been determined through a review of the literature and reports related to chemistry education, as well as through consultations with participants and stakeholders.

3.3. Workshop Participants

To achieve the aforementioned objectives, it was important to provide sufficient time for participants to share and discuss all their knowledge and experiences in depth. Therefore, the number of participants was limited to forty-seven. The participants were informed about the workshop through a Google Form (Google Form Sample is given in Appendix-4) and their consent to participate in the workshop was obtained through this form. They were also expected to determine and inform the topics they wanted to present.

As seen in Table 14, eighteen of the participants were academics, eight were MoNE experts, one was an expert from the Scientific and Technological Research Council of Türkiye (TUBITAK), ten were teachers, and ten were undergraduate and graduate students.

Table 14. Workshop Participants

ACADEMICIANS	EXPERTS (MoNE/TUBITAK)
1. Prof. Dr. Yüksel ALTUN 2. Prof. Dr. Alipaşa AYAS 3. Prof. Dr. Recai İNAM 4. Prof. Dr. Güler EKMEKÇİ 5. Prof. Dr. Nilgün SEÇKEN 6. Prof. Dr. Ali DİŞLİ 7. Prof. Dr. Eylem BAYIR 8. Prof. Dr. Z. Demet KIRBULUT GÜNEŞ 9. Prof. Dr. Sevgi AYDIN GÜNBATAR 10. Prof. Dr. Faik Özgür KARATAŞ 11. Assoc. Prof. Dr. Sevil AKAYGÜN 12. Assoc. Prof. Dr. Halil TÜMAY 13. Assoc. Prof. Dr. Ayşe YALÇIN ÇELİK 14. Assoc. Prof. Dr. Hakkı KADAYIFÇI 15. Assoc. Prof. Dr. S. Nihal YEŞİLOĞLU 16. Asst. Prof. Dr. Funda EKİCİ 17. Res. Asst. Dilay DİNÇDEMİR 18. Res. Asst. Özge LAÇİN	1. Dr. Aysun İNAL 2. Dr. Ebru DEMİR 3. Dr. Emine ŞİMŞEK 4. Dr. Fatma Nur AKIN (TUBITAK) 5. Seda KUZGUN 6. Süheyla DEMİREL YAZICI 7. Leyla SETAN 8. Duygu YAĞMUR 9. Melike ATANIAN YÜNGÜL
TEACHERS	**STUDENTS (PRE-SERVICE TEACHERS AND CHEMISTS)**
1. Assoc. Prof. Dr. Ümmüye Nur TÜZÜN 2. Dr. Fatma Emel IŞIK 3. Dr. Mehmet BİLGİ 4. Dr. Ali BUĞDAY 5. Ayşegül TEKELİ 6. Kevser Gönül KADAYIFÇI 7. Yasemin KESKİN ÇİNKAYA 8. Sibel BAKIR 9. Sultan Burcu TÜRK 10. Özge GÖKTÜRK	1. Nurdan AKDOĞAN 2. Gamze BİLDİRCİN 3. İlhan Deniz TEPE 4. Sude ERGÜN 5. Simge YÜCEL 6. Kübra SÖZEN 7. Hilal Gizem ÖZENÇ 8. Özüm GÖKDUMAN 9. Yağmur ÇETINKAYA 10. Melek Dilara ZORBACI

Table 15 provides some information about the participant profile. When determining the participants of the focus groups, special attention was paid to the fact that they had different backgrounds and perspectives, including academics from different universities, teachers from secondary schools, or science and art centers, experts from the MoNE and TUBITAK, and undergraduate and graduate students.

Table 15. General Information on Participant Profile

	Academic (N=18)		Teacher (N=20)			Student (N=15)			Total
	Faculty of Education	Faculty of Science	MoNE Expert	TUBITAK Expert	Teachers	Doctorate	Master's	Under-graduate	48
Presenter	9	-	-	-	6	-	-	-	15
Focus Group 1	6	-	8	1	9	-	-	1	25
Focus Group 2	9	3	-	-	1	1		8	22

Table 16 provides the regions and provinces of the universities of the academics who participated in the workshop. A total of nineteen academics from seven different universities (Boğaziçi University, Bilkent University, Gazi University, Hacettepe University, Trabzon University, Trakya University, Yüzüncü Yıl University) participated in the workshop. Maximum attention was paid to ensure that the academics were from universities in different regions and provinces. Seventeen of the participating academics were from state universities, while one participant was a faculty member at Bilkent University, a private university.

Table 16. Information on the Regions and Provinces of the Affilliations (Universities) of Workshop Participants

	Number of Academics	State/ Foundation University	The Region	The Province
Boğaziçi University	1	State	Marmara	İstanbul
Bilkent University	1	Private	Central Anatolia	Ankara
Gazi University	9[a]+3[b]	State	Central Anatolia	Ankara
Hacettepe University	1	State	Central Anatolia	Ankara
Trabzon University	1	State	Black Sea	Trabzon
Trakya University	1	State	Marmara	Edirne
Yüzüncü Yıl University	1	State	Eastern Anatolia	Van
Total	**18**			

[a] Faculty of Education (Five academic are members of workshopizing committee)

[b] Faculty of Science

Table 17 presents the affiliations and titles of the academics participating in the workshop. Academics with different academic titles were especially selected and yet special care was taken to ensure that a large percentage of the faculty members consisted of professors (61.1%) who have been specialized in their field for several years.

Table 17. Information on the Affilliations (Universities) and Titles of the Academic Participating in the Workshop

	Boğaziçi University Faculty of Education	Bilkent University Faculty of Education	Gazi University Gazi Faculty of Education	Gazi University Faculty of Science	Hacettepe University Faculty of Education	Trabzon University Fatih Faculty of Education	Trakya University Faculty of Education	Yüzüncü Yıl University Faculty of Education
Prof. Dr.	-	1	3	2	1	1	1	1
Assoc. Prof. Dr.	1	-	4	-	-	-	-	-
Asst. Prof. Dr.	-	-	1	-	-	-	-	-
Res. Asst.	-	-	1	1	-	-	-	-
Total	**1**	**1**	**9**	**3**	**1**	**1**	**1**	**1**

When selecting the invited teachers, special attention was paid to the fact that they were working in different positions (MoNE Expert, TUBITAK Expert, Chemistry Teacher, Science Teacher) or in different types of schools (Anatolian High School, Science High School, Multi-Programme Anatolian High School, Vocational and Technical Anatolian High School, Anatolian Imam-Hatip High School, Science and Art Center or Private High School) and that they studied or had completed postgraduate education. As can be seen in Table 18, a total of nineteen teachers working in different positions participated in the workshop. Some of the teachers invited to the workshop currently work as experts in different general directorates of the MoNE, while others work as chemistry teachers or science teachers in public or private institutions providing formal education or in Science and Art Centers providing supplementary education in addition to formal education. These teachers graduated from the faculties of education or science faculties of various universities. Information about the affiliations of the teachers participating in the workshop and their educational backgrounds is given in Table 18.

Table 18. Affiliations and Last Graduated Education Programs of Teachers Participating in the Workshop (N=20)

Level of Education	MoNE Expert	TUBITAK Senior Expert	Anatolian High School	Science High School	Multi-Program Anatolian High School	Vocational and Technical Anatolian High School	Anatolian İmam-Hatip High School	Science and Art Center	Private High School (College)	Total
Undergra-duate			1							1
Master's	5				1	1			1+1[b]	9
Doctorate	3	1	1	1			1[a]	2		9
Total	**8**	**1**	**2**	**1**	**1**	**1**	**1**	**2**	**2**	**19**

[a] PhD student

[b] Master's student

Information about the undergraduate and graduate students who participated in the workshop is provided in Table 19. When selecting the students, special attention was paid to the fact that they were studying at different levels of chemistry teaching programs at the faculties of education or chemistry programs at the faculties of science. As can be seen from the table, three of the students were doctoral students, two were master's students and nine were undergraduate students at different levels of chemistry teaching. Three of the graduate students were pursuing their master's or doctorate in Chemistry Education at the Institute of Educational Sciences and two of them were pursuing their doctorate at the Institute of Natural and Applied Sciences.

Table 19. Information on Students Participating in the Workshop

Level of Education	Numbers	Grade 1	Grade 2	Grade 3	Grade 4
Undergraduate	9	2	2	3	2
Master's	1[a]+1[b]				
Doctorate	1[a]+1[b]+1				
Total	**14**				

[a] Teacher

[b] Academic (Res. Asst.)

3.4. Data Collection Tools

Three data collection tools were used to identify the challenges in chemistry education at both middle/high school and undergraduate levels and to identify solutions to these challenges. The purpose was to identify the challenges in chemistry education within a certain framework and to reveal different evaluations that may arise from varying expertise and perspectives.

1. Three different data collection tools were used in the keynote speeches and invited presentations on challenges and solutions in chemistry education and examples of good practices and in the discussions held during this process:

a. Presentation summaries and the challenges and solutions expressed in these presentations,

b. Observation notes kept by the organizing committee regarding the discussions and questions and answers during the presentations,

c. Listener notes kept by the participants in Form-1 about the challenges and solutions in chemistry education that they identified for each presentation.

2. Listener notes by the participants in Form-2 about the challenges, their sources, consequences and proposed suggestion for the challenges in chemistry education,

3. Discussion reports prepared by two focus groups, (i) Middle/High School and (ii) Chemistry/Chemistry Teaching Undergraduate group.

3.4.1. Opening Speeches/Invited Presentations and Discussions

The plenary sessions of the first and second day of the workshop, which lasted until noon, included three keynote speeches and a total of eleven presentations by chemistry education experts and active, qualified field teachers. Discussions during and at the end of the presentations provided participants with the opportunity to discuss and share their experiences and ideas on key issues and challenges in chemistry education.

Information about the presentations is provided in Table 20. At the end of each presentation, a discussion environment was created to receive the opinions of all participants on the subject. The full texts of the presentations are available on demand by the ECOEI or in the published full-text book.

Table 20. Workshop Phase One Presentation Topics

Presenter	Presentation Title
Prof. Dr. M. Akif KİREÇCİ *Economic Cooperation Organization Educational Institute*	Why Fundamental Sciences?
Prof. Dr. Yüksel ALTUN *Gazi University, Gazi Faculty of Education*	Teaching of "Chemistry Science" in the 21st Century
Prof. Dr. Alipaşa AYAS *Bilkent University, Faculty of Education* **Dr. Mehmet BİLGİ** *Gebze TUBITAK Science High School*	Good Practice Examples in Chemistry Education: The Case of TUBITAK Science High School
Prof. Dr. Eylem BAYIR *Trakya University, Faculty of Education* **Dr. Fatma Emel IŞIK** *Edirne Şehit Nefize Çetin Özsoy Science and Art Center*	Challenges and Solutions in Chemistry Teaching from the Perspective of Chemistry Teachers: Edirne Example
Assoc. Prof. Dr. Sevil AKAYGÜN *Boğaziçi University, Faculty of Education*	Inadequacy of Chemistry Laboratory Practices at High School Level and Limited Use of Particle Level Demonstrations (Animation & Simulation) in Classes
Assoc. Prof. Dr. Halil TÜMAY *Gazi University, Gazi Faculty of Education*	The Nature of Chemistry and System Approach
Yasemin KESKİN ÇİNKAYA *Ankara Bahçeşehir Educational Institutions*	Designing Chemistry Lessons with Teaching Methods and Techniques to Ensure Permanent and Complete Learning in High School Chemistry Lessons
Dr. Aysun İNAL *MoNE General Directorate of Secondary Education*	Challenges Encountered by Chemistry Teachers in Project-Based Educational Institutions in Secondary Education and Solutions
Dr. Ali BUĞDAY *Konya Karatay TOKİ Anatolian High School*	Challenges Encountered by Chemistry Teachers in Project-Based Educational Institutions in Secondary Education and Solutions
Prof. Dr. Nilgün SEÇKEN *Hacettepe University, Faculty of Education*	An Examination of Challenges in Chemistry Education from the Perspective of Pedagogical Formation
Prof. Dr. Z. Demet KIRBULUT GÜNEŞ *Gazi University, Gazi Faculty of Education*	Anatomy of Student Participation in Active Learning Environments in Undergraduate Chemistry Courses
Prof. Dr. Sevgi AYDIN-GÜNBATAR *Van-Yüzüncü Yıl University, Faculty of Education*	Challenges in Chemistry Teacher Training at Undergraduate Level
Prof. Dr. Faik Özgür KARATAŞ *Trabzon University, Fatih Faculty of Education* **Özge GÖKTÜRK** *Mersin Aydıncık Multi-Program Anatolian High School*	Laboratory Use in Chemistry Teaching

3.4.2. Forms Prepared for Challenges and Solutions in Chemistry Teaching

The audience at the workshop were provided with two different forms to note down their views on the problems and solutions they had identified during the presentations. This initial phase of the workshop lasted one and a half days, concluding after all presentations were delivered and the two forms were filled in by all participants. Attached in this report are Form-1 and Form-2, which were distributed to the participants for completion.

Form 1 was used to document the "challenges" and "solution suggestions" expressed by the audience regarding chemistry education in each presentation and subsequent discussions (Appendix 2).

Form 2 was designed to identify the "problems," "sources of the problem," "consequences of the problem," and "solution suggestions" provided by the audience during the workshop, especially relating to specific themes such as the curriculum, teaching environment, and instructors (Appendix 3).

The data collected from each participant's completed forms were subjected to content analysis. First of all, data presenting similar ideas were grouped under specific concepts and themes. These data were then interpreted as a coherent whole in a way that the reader could understand (Yıldırım and Şimşek, 2006). In the first stage, identified issues and in the second stage, solution proposals put forward for these issues were evaluated through content analysis using pre-established codes determined by the organizing committee. Tables were generated to present the findings of the analysis of the data obtained through forms.

Form 1 captured the problems and solution suggestions proposed during the presentations by the listeners. An organizing committee member analyzed and categorized these problems and solution suggestions for each presentation. In a meeting, the organizing committee finalized the categories and described them accordingly.

Analysis of the data from Form 2 involved listing themes based on an initial analysis of the statements provided by the audience. Forms related to each theme were examined collectively during a meeting of the organizing committee. A shared understanding of the coding and categorization process was established. For other themes, coding and categorization were conducted separately by a member of the organizing committee. The committee convened to finalize the categories, ensuring a unanimous decision on how the findings would be presented.

3.4.3. Focus Group Meeting Reports

During the afternoon of the second day of the workshop, two distinct focus groups were established: one at the middle/high school level and the other at the chemistry teaching/chemistry undergraduate level (see Figure 2). In the establishment of the focus groups, careful consideration was given to the participants' areas of expertise and their voluntary preferences in joining a specific focus group. Each focus group appointed two moderators and one scribe (The list of focus group members is attached as Appendix 5).

For the working sessions, each group was given three hours to discuss four main topics (see Table 21), which were formulated based on a comprehensive literature review. The focus groups were also granted the flexibility to include additional topics or exclude existing ones, as deemed necessary. Following the discussions, each focus group presented their respective reports on the identified problems and proposed solutions in chemistry teaching. At the end of each presentation, a question-and-answer session ensued allowing other participants to share their perspectives (Balbağ, Leblebicier, Karaer, Sarıkahya and Erkan, 2016).

Table 21. Focus Group Discussion Topics and Main Headings

Groups	Discussion Topics	Main Headings
I. Group	Challenges and Solutions in Middle/High School Chemistry Teaching	Curriculum Instructor (faculty member/teacher) Student Learning environment
II. Group	Challenges and Solutions at Chemistry Teaching/Chemistry Undergraduate Programs	

Figure 2. A Visual from the Focus Group Meeting

FINDINGS

This section presents the key themes and findings derived from various sources, including opening speeches, invited presentations, workshop discussions, analysis of participant responses to two forms provided by the organizing committee, and focus group discussions.

4.1. Findings From the Opening Speeches, Invited Presentations, Discussions and Form-1

The findings presented in this section were obtained through the analysis of the following three distinct data collection tools:

a) Summaries of presentations, particularly the problems and solution suggestions expressed in these presentations,

b) Observation notes kept by the organizing committee regarding discussions, questions, and answers during the presentations,

c) Listener notes recorded by the participants on Form-1, capturing the problems and solution suggestions in chemistry education identified for each presentation.

The opening speeches of the workshop, were delivered by Prof. Dr. M. Akif Kireçci, President of the ECOEI, Prof. Dr. Yüksel Altun, Chairman of the Workshop Organizing Committee, and Prof. Dr. Mahmut Selvi, Dean of Gazi University Gazi Faculty of Education.

During his speech, Prof. Dr. M. Akif Kireçci, provided a concise overview of the institute's establishment, its objectives, member countries (Afghanistan, Azerbaijan, Iran, Kyrgyzstan, Pakistan, Tajikistan, and Türkiye), and previous activities of the institute related to Fundamental Sciences Education. He concluded his speech by expressing gratitude to the participants.

Why Fundamental Sciences?

*Prof. Dr. M. Akif KİREÇCİ**

ABSTRACT

Since its establishment in 2017, the Educational Institute of the ECOEI has placed great emphasis on basic sciences education. The basic sciences, encompassing the disciplines of Physics, Chemistry, Biology and Mathematics, form the foundation of scientific discoveries and development of all other branches of science. Thus, providing high-quality education in these disciplines, from primary school to doctorate programs, is the most important lever for scientific and technological progress, as well as human and economic development. In line with this objective, a comparative analysis of mathematics achievements of the institute's member countries participating in the TIMSS and PISA exams was conducted, aimed to guide mathematics education policies. Additionally, a study commissioned by the Institute on Physics Education in Türkiye is currently in the publication process. Moreover, the editing and publication of the papers presented at mathematics workshops are ongoing. Our next goal involves compiling the outcomes of the Biology and Chemistry Education Workshops into a comprehensive report, which will be accessible to decision-makers. Chemistry plays a pivotal role in the advancement of economies and the well-being of humanity. Chemistry education directly impacts economic productivity and sustainable development. Therefore, investing in chemistry education not only enhances a country's prosperity but also improves people's quality of life. Consequently, the Chemistry Education Workshop, akin to the Mathematics and Biology Education Workshops, will yield highly significant outcomes. Future sessions of this workshop series will concentrate on the education of other core sciences, as well as cognitive skills such as creative and critical thinking, and analytical thinking.

** President of the ECOEI*

Prof. Dr. Yüksel Altun, talked about why this workshop was needed, its purpose and objectives, the workshop program and what was expected from the participants, thanking them participants for their support.

Teaching "Science of Chemistry"in the 21st Century

*Prof. Dr. Yüksel ALTUN**

ABSTRACT

Despite its importance of chemistry teaching, as in all other basic science fields, there are many teaching and learning problems related to chemistry teaching. Unfortunately, these problems lead to a gradual decrease in students' interest in chemistry subjects and sectors related to chemistry. Students' lack of interest in chemistry is mostly due to negative perceptions about the difficulties of understanding abstract chemistry concepts and working in chemistry-related fields. In the 21st century, chemistry teaching has undergone significant changes due to advances in technology, changes in pedagogical approaches and societal demands. These changes, which affect many fields, have led to changes in the practices of the science education system in particular and to a redefinition of the skills and competencies necessary for students to adequately participate in and contribute to today's society. Over the last two decades, at least ten international organizations and commissions, governments, private consortia and private institutions have proposed "21st Century Frameworks" and outlined competencies/skills to address the challenges of the twenty-first century. In most of the studies conducted in chemistry teaching, the importance of teaching 21st century skills such as critical thinking, problem solving, collaboration, communication and ICT literacy is more emphasized. In order to ensure that students have access to a rich education that helps them acquire these 21st century skills, four basic components, namely curriculum, learning environment, teacher and assessment, need to be effective and innovative. Incorporating 21st century skills into chemistry courses can of course pose some challenges. These challenges can be overcome if educators are provided with the necessary resources and training and if technology is incorporated into lessons. Through working in collaboration with colleagues, seeking opportunities for professional development, incorporating real-world examples into lessons to help students develop problem-solving skills, and using alternative assessment methods, educators can successfully incorporate 21st century skills into chemistry lessons and prepare their students for success in the modern workplace.

**** Workshop Organizing Committee Chairman, Gazi University, Gazi Faculty of Education, Department of Chemistry Education, Faculty Member***

The last opening speech of the workshop was made by Prof. Dr. Mahmut Selvi, Dean of Gazi University Gazi Faculty of Education.

The Role of Gazi Faculty of Education in Education

Prof. Dr. Mahmut SELVİ*

ABSTRACT

Education plays a crucial role not only in cognitive and physical development but also in fostering effective communication, building strong societal bonds, and driving economic and social progress. However, despite the planned, programmed, and systematic teaching experiences in schools, studies indicate that we sometimes fall short of achieving desired outcomes. The results of international comparison exams such as PISA, TIMMS, and PIRLS highlight potential issues in our curriculum implementation and education system. To thrive and excel in the global race of science and technology, countries should prioritize the foundational sciences—physics, chemistry, biology, and mathematics—and focus on enhancing the quality of education in these disciplines.

Gazi Faculty of Education, as one of Türkiye's foremost teacher training institutions, recently revamped the curricula of 22 departments in 2021. The updated programs were shared with the administrations of approximately 60 faculties of education based on their requests. Notably, the fact that over 27% of more than one million teachers in Türkiye are graduates of Gazi Faculty of Education underscores its crucial role in elevating the quality of teacher training. Furthermore, Gazi Faculty of Education's significance in teacher education is reinforced by its global ranking of 27th in 2023, with a score of 81/100, in the field of Education and Training according to the World Universities Ranking by Subject conducted by the higher education rating organization Quacquarelli Symonds (QS). It continues to hold the top position in Türkiye.

* ***Dean, Gazi University, Gazi Faculty of Education***

After the opening speeches, the workshop commenced with presentations by invited speakers. The following provides summaries of the presentations made by the invited speakers, as well as the key findings derived from the subsequent discussions with the participants.

The first invited presentation, titled "An Overview of Chemistry Education: Chemistry Curricula, Skills, and Integration into the Teaching Process," consisted of two parts. The first part, focused on "Chemistry Curricula," was delivered by Prof. Dr. Alipaşa Ayas. The second part, presented by Dr. Mehmet Bilgi, a chemistry teacher at Gebze TUBITAK Science High School, provided an introduction to the skills-based "Science High School Chemistry Curriculum" implemented at Gebze TUBITAK Science High School. Notably, Dr. Bilgi played an active role in the development of this curriculum.

PART 1: An Overview of Chemistry Education: Chemistry Curricula, Skills, and Their Integration into the Teaching Process

*Prof. Dr. Alipaşa AYAS**

ABSTRACT

In Türkiye, curriculum changes are frequently made, and unfortunately, programs are often altered without assessing the impact of the new curricula. The chemistry education curriculum, divided into basic and advanced levels, underwent revisions in 2013 and 2018 to keep up with the changes. The 2013 update aimed to incorporate the nature of science, understanding scientific knowledge, science process skills (SPS), science-technology-society-environment-economy, life skills, attitudes, and values, as well as psychomotor skills. In the 2018 revision, 21st century skills and values education were added to the 2013 objectives. The chemistry curriculum adopts a partially spiral structure with a focus on scientific literacy, aiming to enable students to conduct experiments, make inferences, and draw generalizations. This program strives for active student engagement to enhance both knowledge acquisition and skill development. The curriculum also includes values education alongside skill development. The core problem lies not in the curricula themselves but rather in the challenges faced by implementers who struggle to comprehend and effectively apply the existing curricula. Despite approximately one-third of the 2018 chemistry curriculum outcomes emphasizing experimental work, a major issue in chemistry education is that teachers do not sufficiently incorporate laboratory practices in their lessons. Studies investigating the problems encountered during the implementation of chemistry curricula and proposing solutions highlight the following issues:

- Insufficient time allocation,
- Inadequate laboratory facilities and equipment,
- Limited utilization of laboratory methods by teachers,
- High-pressure environment for both teachers and students due to higher education entrance exams,

- Inadequate teacher preparation in laboratory techniques and alternative teaching methods,
- Misalignment between the expectations of teachers and curriculum developers.

The MoNE has initiated plans transformation to address these challenges, testing them in selected schools, including specialized institutions.

**Bilkent University, Dean, Faculty of Education*

PART 2: Good Practice Examples in Chemistry Education: The Case of TUBITAK Science High School Implementing a Skills-Based Teaching Program

*Dr. Mehmet BİLGİ**

ABSTRACT

The MoNE regularly organizes councils and develops guiding documents to equip individuals with the skills needed for the era and to guide education effectively. Two significant documents, the "19th National Education Council" and the "2023 Education Vision Document for a Stronger Future," play a crucial role in shaping the future of Turkish National Education by emphasizing skills-based education. To realize the objectives outlined in these documents, TUBITAK Science High School was established at TUBITAK's Kocaeli-Gebze Campus through a protocol between the Ministry of Industry and Technology and the MoNE. Starting from the 2021-2022 academic year, the school aims to provide education to the top 1% (90 students) who achieved exceptional results in the high school entrance exam (LGS) and the Central Talent Science Examination conducted by TUBITAK across 23 different centers in our country. It offers scholarships, free education, and compulsory boarding facilities. The science high school aims to reach students who have excelled in science olympiads or national/international project competitions and provide them with education by utilizing the resources and laboratory facilities available within TUBITAK. Unlike a typical science high school, this institution, which has the highest proportion of gifted students in Türkiye, strives to provide students with a comprehensive vision encompassing not only academic but also various developmental areas. To achieve this, a specialized program based on an enriched education model is implemented at the school. The positive aspects contributing to the implementation process, challenges encountered during the pilot phase, and the implemented solutions are summarized in the table below.

Factors Contributing Positively to the Pilot Implementation Process of the Program	Problems Experienced in the Pilot Implementation Process of the Program	Solutions to the Problems Experienced in the Pilot Implementation Process of the Program
Duration: Increasing chemistry lessons from 2 to 4 hours per week in 9th and 10th grades provides sufficient time for the successful implementation of skill-based activities.	**Test anxiety:** Due to its structure, the skills-based program requires an educational activity based on conducting experiments or activities rather than solving tests. However, TYT-AYT (Basic Proficiency Test (TYT), Field Proficiency Tests (AYT) exams are conducted according to the curriculum of other high schools. This has caused anxiety among students and their parents about diploma grades and higher education institution exams.	Efforts were made to overcome the problems in cooperation with the school counseling service.
Student Profile: Implementing the program to a group of gifted and high achieving students increases the success of the program in achieving the desired learning objectives.	**Considering Themselves Experimental Subjects:** The pilot implementation of a different program that is not implemented in other high school programs caused students to consider themselves experimental subjects.	Efforts were made to overcome the problems in cooperation with the school counseling service.
Teacher profile: Involving the teachers in the entire process of preparing the skills-based chemistry curriculum the teachers, to be very familiar with the a good curriculum, which literate eliminates several possible negativities during the implementation of the program.	**Different Curriculum from Other Science High Schools:** Students did not have a good command of the curriculum in terms of subject order, etc.	The teachers who were involved in the program preparation, also took part in introduction of the program to the students to overcome their bias.
Class size: The implementation of a skills-based curriculum in classes with fewer students (22-23 students) allows students to take a more active role in experiments/activities.	**Dense Curriculum:** As students compared themselves to their peers in different schools, they began to question the challenges posed by a rigorous curriculum, which included 9 hours of classes and 3 hours of study hall each day.	Students were informed that the curriculum not only helps students learn but also develops their skills and abilities, and thus is useful not only for their academic life but also for their future professional life and personal development.

Laboratory and technical equipment: Laboratories having the opportunity for students to work in groups of three at 8 separate tables, laboratory equipment provided by TUBITAK, such as laboratory materials, laptops for educational purposes and strong internet infrastructure, the ability to conduct research through academic databases such as ULAKBIM, and ease of access to all institutes and laboratory facilities within TUBITAK facilitate the implementation of the skills-based curriculum.	**Student profile**: • Not being prone to group work due to having high leadership qualities and a self-centered personality caused problems for students in TUBITAK Science High School. • Being generally gifted or having high avcademic achievements resulted in students' rushing in educational activities and underestimating the activities planned for the acquisition of some basic skills.	• In the first months of the academic year, students were advised to work in groups and perform acti-vities by assuming certain roles withing the group. • In such situations, students were frequently reminded that they had to perform the activities stipulated in the curriculum and that they could not gain higher level skills without gaining these basic skills.
Boarding Program: Students can have the opportunity to repeat and reinforce the activities with their group friends in the boarding house where they stay after the classes are over.		

** Gebze TUBITAK Science High School, Chemistry Teacher*

After the two presentations, the discussions commenced with questions and suggestions. An academic from Gazi University proposed that chemistry courses should be designed and implemented as a blend of laboratory work and classroom instruction. Another academic from a different university expressed concerns about the proliferation of skill-based high schools, such as Gebze Science High School, and suggested that they should "remain unique" to maintain their quality. Additionally, it was emphasized that the students nurtured in Gebze TUBITAK Science High School would play a crucial role in driving advancements in various fields of science and technology in Türkiye, underscoring the significance of their education.

;It was also pointed out that the chemistry teachers, like many other subject teachers, often fail to make an effort to understand and interpret the underlying philosophy of the curriculum. This lack of understanding may hinder students from fully grasping scientific knowledge and skills, thus emphasizing the need for teachers to carefully examine the curriculum and select the most appropriate teaching methods for their students. Moreover, it was highlighted that teachers should provide engaging examples and experiments, relate the topics to real-life situations, and enable students to comprehend chemistry better. To address these and other curriculum-related challenges, it was suggested that pre-service and in-service training programs should be meticulously designed by thoroughly analyzing the needs of teachers and students. Furthermore, it was emphasized that curriculum development processes should involve not only academicians and curriculum experts but also teachers, taking their perspectives and opinions into account.

Table 22 presents the findings of the analysis conducted on the problems and suggested solutions from the participants' Form-1 responses specific to this presentation.

Table 22. Analysis Results of the Audience Notes in Form-1 During the Presentation Titled "An Overview of Chemistry Education: Chemistry Curricula, Skills, and Their Integration into the Teaching Process"

Specified Challenge	Proposed Solution
Teachers not adhering to the curriculum and not limiting the subjects while teaching chemistry lessons	Teachers can be provided with systematic in-service training on learning outcomes.
Chemistry curriculum being intensive and heavy in terms of course hours	Chemistry lessons should be designed as theoretical + practical in order to make the lessons student-centered. For example, it can be structured as 4+2 or 3+3.
Grade 9 curriculum being easier and more verbal than grades 10, 11 and 12 and not being suitable for experimentation	In Grade 9, "the process of chemistry becoming a science (Unit 1)" can be simplified and explained with laboratory materials - experiments in relation to daily life.
11th grade chemistry curriculum being very intensive	In Grade 11, the number of theoretical and practical hours could be increased, or the program could be slightly lightened. Topics could be distributed across the 9th and 10th grade curriculum.
Activities not being neither up to date nor rich	The number of activities and experiments in all grade programs should be updated and increased.
The communication problem between CoHE and MoNE causing problems in identifying needs and finding solutions	MoNE and CoHE should discuss and make decisions together on issues of mutual interest.
Low number of Teaching Practice hours in Chemistry Teaching programs	Teaching practice course hours can be increased.
Division of the high school chemistry curriculum into two as basic level/ advanced level	-

Teachers' understanding and implementation of the program	In-service trainings should be provided for teachers to better understand and implement the philosophy and content of the curriculum
Teachers' not adopting the content (curriculum)	Teachers should be taught what and how to teach rather than the lesson plan.
Science high school curriculum being difficult	Experienced teachers can mentor inexperienced teachers
Teacher resistance in implementing the programs	Different curricula should be implemented in different types of schools
Incompatibility of curriculum content and intensity with class hours	The curriculum can be extended or decreased according to the level. Different curricula can be implemented in different types of schools.
Teachers' feeling of inadequacy in the implementation of the skill-based curriculum implemented at TUBITAK Science High School, Assigning teachers with the same qualifications to different types of schools	Teachers can be recruited to these schools through exams or academics should be allowed to teach in high schools.

The second invited presentation of the workshop was titled "Challenges and Solutions in Chemistry Teaching from the Perspective of Chemistry Teachers: Edirne Sample" and was presented by Prof. Dr. Eylem Bayır and Teacher Dr. Fatma Emel Işık.

Challenges and Solutions in Chemistry Teaching from the Perspective of Chemistry Teachers: Edirne Sample

Prof. Dr. Eylem BAYIR[*] and Teacher Dr. Fatma Emel IŞIK[**]

ABSTRACT

This study aims to identify the challenges and potential solutions encountered by science teachers in middle schools, chemistry teachers in high schools, and chemistry teaching faculty members in the faculty of education in Edirne province. The data was gathered through interviews and open-ended written questions. The identified problems and proposed solutions focused on various aspects including the curriculum, students, physical facilities, textbooks, the teachers themselves, difficult subjects/concepts, class hours, exams, and the learning capabilities of pre-service teachers. Faculty members mainly expressed concerns about the insufficient course hours in the curriculum, the absence of laboratory courses, and inadequate student preparedness. On the other hand, high school teachers highlighted issues related to the density and irregularity of the course content, the lack of tailored content for different school types,

physical facility constraints such as material shortages and crowded classrooms, as well as student-related challenges and textbook limitations. Secondary school teachers generally reported problems with curriculum coherence, insufficient class hours, physical facility issues, challenging subjects, and textbooks.

***Trakya University, Faculty of Education**

****Edirne, Şehit Nefize Çetin Özsoy Science and Art Center**

During the discussion session, the participants emphasized the need for student-centered education and skill development in high schools. It was pointed out that the current books and experiments are not suitable for achieving these goals, and therefore, in-service training programs should be provided to teachers. One academic expressed concerns about the suggestion to lighten the high school curriculum, arguing that it could potentially lower the quality of education, particularly in terms of teachers. Another academic proposed implementing different programs tailored to the specific types of high schools. Furthermore, participants suggested that school administrations should receive support through school-family cooperation. They also recommended conducting content analysis of provincial and district council minutes annually to identify specific needs and conducting macro-level studies to address broader issues and solutions.

Table 23 presents the analysis results, outlining the problems identified and the suggested solutions from the participants' Form-1 responses specific to this presentation:

Table 23. Analysis Results of the Audience Notes in Form-1 During the Presentation Titled "Challenges and Solutions in Chemistry Teaching from the Perspective of Chemistry Teachers: Edirne Example"

Specified Challenges	Proposed Solutions
• Difficulty in understanding abstract topics (interactions between chemical species) in classrooms • Deficiencies in mathematical operation skills in mole concept and chemical calculations in the classes • Difficulty in understanding gases, aqueous solution equilibria in classes • Inadequate equipment at the science and art centers • Inadequate content of textbooks • Insufficient class hours • Recruiting teachers from other faculties than the faculties of education • Combining "Organic and Analytical Chemistry" courses at undergradate science teaching programs • Inadequate physical conditions • Not associating the subjects with current life • Insufficiency of laboratory courses, facilities and hours • Enrolling in universities with incomplete information from high school • Lack of sufficient laboratories in high schools • Coordination between MoNE and CoHE • Lack of laboratory experience in secondary school chemistry classes • Instructors experiencing difficulty in open-ended questions • The insufficient time allocated in the curriculum for additional practices for the teachers • Giving less importance to the last units in the curriculum • Lack of course hours in teacher training programs • Lack of laboratories in teacher training programs • Reluctant participation of teachers in seminars • Low PISA and TIMSS averages except for 2019 • Problem of purchasing consumables and chemical materials • Classroom and curriculum density • Following the same curriculum in all high school types.	• Field selection after the ninth grade • Work and guide books • Increasing the number of experiments in textbooks • Expanding the content of simulations and virtual laboratories in EBA platform • Increasing laboratory course hours in faculties • Separation of "Organic and Analytical Chemistry" courses in the undergraduate science teaching program • Including daily life connections in textbooks • Establishing equipped laboratories in every high school • A classroom environment that is not crowded and where the teacher can take care of every student • Including digital technology in books • Relating the subjects to daily life • Introduction of laboratory courses • Laboratories being a separate course in high school • Increasing the number of class hours in high schools • Inspection of high school test books • Implementation of different curricula according to high schooltypes • Giving students the opportunity to design experiments • Mitigation of the curriculum • Organizing the curriculum to include a laboratory course • Providing the teachers with additional time to put their own work into action • Budget allocation to departments for consumables • Lessons for teaching specific chemistry topics • Increasing practical teacher training • Separation of practical and theoretical courses • Adequate teacher recruitment

The third presentation of the workshop was delivered by Associate Professor Dr. Sevil Akaygün, titled "Inadequacy of Chemistry Laboratory Practices at High School Level and Limited Use of Particle Level Demonstrations (Animation & Simulation) in Classes."

Inadequacy of Chemistry Laboratory Practices at High School Level and Limited Use of Particle Level Demonstrations (Animation & Simulation) in Classes

Assoc. Prof. Dr. Sevil AKAYGÜN*

ABSTRACT

Chemical concepts encompass three levels: observable level, particle level, and symbolic level, and it is crucial to establish connections between these levels in concept teaching. Laboratory practices serve as the most effective method for teaching the observable level. Moreover, laboratory practices play a pivotal role in achieving various chemistry teaching objectives. However, there are certain challenges when it comes to teaching the observable level. Based on data gathered from several teachers, it was discovered that approximately three-quarters of the teachers did not conduct laboratory practices during the last fall semester. Pre-service teachers also observed a lack of sufficient laboratory practices in high schools. Furthermore, it was determined that there were significantly fewer laboratory practices in the final year of high school compared to other grades. Infrastructure issues such as a lack of laboratories and materials, student-related problems like overcrowded classrooms and classroom management, and shortcomings such as inadequate class hours and experiment books were identified as the reasons for the insufficiency of laboratory practices. To address these issues, suggestions include well-equipped laboratories, knowledge and awareness enhancement, chemistry practice courses, experiment books, collaboration with universities and the MoNE, and in-service training programs. Animation-simulation applications are the most effective method for teaching the particle level. It was revealed that approximately half of the teachers utilized these applications in the last semester, although their usage decreased in the 12th grade. Pre-service teachers also noted limited usage. The reasons for the low frequency of use can be attributed to infrastructure problems related to internet and smart boards, the potential for creating misconceptions among students, the lack of appropriate representations or materials in Turkish, and teachers' insufficient knowledge, skills, and awareness. Solutions include strengthening the technological infrastructure, enhancing knowledge and awareness, providing support for materials and interactive books, fostering

collaboration with universities and the MoNE, and offering training programs for educators.

** Boğaziçi University, Faculty of Education*

Table 24 presents the analysis results of the participants' identified problems and suggested solutions in Form-1, specifically related to this presentation:

Table 24. Analysis Results of the Audience Notes in Form-1 During the Presentation Titled "Inadequacy of Chemistry Laboratory Practices at High School Level and Limited Use of Particle Level Demonstrations (Animation & Simulation) in Classes"

Specified Challenges	Proposed Solutions
• Inability to integrate the animations into the subject matter • Inability to move from the observ level to the particle and symbolic level • Failure to take experimental/laboratory safety precautions • Inability to integrate experiments into the course • Insufficient class time • Integration of access to other available sites such as EBA into the course • Lack of effective and sufficient materials • Imbalance in the conditions of different types of high schools • Fewer laboratory applications because of possible harm by the chemical substances • Inadequacy of laboratory course durations • Lack of a laboratory or lack of up-to-date materials in the laboratory • Intensive curriculum • Teachers' competencies in technology • Teachers not receiving in-service training on this subject • Teachers feeling inadequate in conducting experiments • Teachers' reservations about using the laboratory • Teachers' negative attitudes towards the laboratory • Crowded classrooms • Less use of representations related to particle structure • Lack of appropriate digital representations	• Solving infrastructure problems in the use of animation and simulation • Creating guidelines for experiments and activities • Establishment of an equipped laboratory • Increasing drama and modeling activities • Realization of EBA content virtual laboratory applications • Training teachers with laboratory skills • Material support and interactive books • Being aware of misconceptions that may occur in students • Increasing students' knowledge and awareness • Adding a chemistry application course to the curriculum • Teaching abstract concepts of chemistry in the laboratory • Using animations for teaching submicroscopic level • Developing and strengthening technological infrastructure • Including high school experiments in university education • University and MoNE cooperation

The fourth presentation of the workshop, titled "The Nature of Chemistry and the Systems Approach," was delivered by Associate Professor Dr. Halil Tümay.

The Nature of Chemistry and the Systems Approach

Assoc. Prof. Dr. Halil TÜMAY*

ABSTRACT

Chemistry, deals with complex and dynamic systems. It is crucial to help students understand this inherent nature of chemistry. Unfortunately, students often develop a static perspective instead of adopting a systems approach. As a result, they tend to make generalizations when explaining chemistry-related phenomena. While generalizations can be helpful in certain cases, they may not always lead to accurate conclusions. When students encounter situations that do not conform to generalizations, they struggle to provide meaningful explanations. This raises concerns about the depth of their understanding in chemistry. Therefore, it is essential to teach students about systems thinking. Systems thinking involves recognizing that a system consists of interconnected components with emergent properties. This study introduces the systems thinking cycle in the context of chemistry.

*** Gazi University, Gazi Faculty of Education, Faculty Member***

In the discussions following the presentation, one participant, an academic, suggested that the systems approach in chemistry might be challenging for some students, requiring an advanced level of understanding. To address this and other learning difficulties, it was proposed that curricula could be tailored to students' levels, offering "basic level and advanced level programs." Another participant, a teacher and current doctoral student who had studied the systems approach extensively, shared their observation that low academic achievement does not necessarily indicate intellectual incompetence, asserting that all students can grasp this approach given the right support. A biology teacher, attending the workshop as a guest, recommended integrating the systems approach into Nature of Science (NOS) courses, as it remains a relatively new topic at the national level. Several teachers in the workshop expressed their concerns about the exam-oriented education system in our country, which they believed hindered students' comprehension of the systems approach and encouraged generalizations in learning chemistry. Another teacher, working in the MoNE, argued that presentation-based teaching methods and techniques were incongruent with the systems approach. Consequently, they proposed abandoning presentation-based methods and techniques in favor of more aligned approaches. It was also stressed that curricula and textbooks could be restructured to better incorporate the systems approach.

Table 25 provides an overview of the participants' analysis of problems and suggested solutions in Form-1 specifically related to this presentation:

Table 25. Analysis Results of the Audience Notes in Form-1 During the Presentation Titled "The Nature of Chemistry and System Approach"

Specified Challenges	Proposed Solutions
• Not giving enough importance to the process of creating scientific knowledge • Accepting chemical heuristics and generalizations as absolute rules of thumb • Formation of wrong concepts by students as a result of teaching chemistry by overgeneralization • Students' inability to apply the knowledge learned in different questions due to generalizations • Not being aware of the problems arising from the nature of chemistry	• It is necessary to be aware of the nature of chemistry and the systems approach. For this, the curriculum and textbooks can be designed according to the systems approach. • Pre-service teachers need to be taught the reasons for generalizations and exceptions in chemistry. Therefore, the systems approach should be integrated into undergraduate courses. • Retrospective descriptions should be used. • When teaching chemistry, it is important to avoid overgeneralizing. It is necessary to know the limitations of generalization. • Teachers should be given in-service training on the "systems approach".

The fifth presentation of the workshop was delivered by Chemistry Teacher Dr. Yasemin Keskin Çinkaya, titled "Designing Chemistry Lessons with Teaching Methods and Techniques to Ensure Permanent and Complete Learning in High School Chemistry Lessons."

Designing Chemistry Lessons with Teaching Methods and Techniques to Ensure Permanent and Complete Learning in High School Chemistry Lessons

Yasemin Keskin ÇİNKAYA*

ABSTRACT

In instructional design models, the educational process requires careful planning, identification, and design of materials to be utilized, and evaluation of the entire process using appropriate evaluation scales and criteria. The traditional model where the teacher is at the center and the student plays a passive role as a mere listener has lost its relevance in today's educational context. The effectiveness of the learning environment and the teaching methods and techniques employed

significantly influence the teaching and learning process, complementing the skills, attributes, and dedication of both the teacher and the learner.

Türkiye's low science literacy scores in international assessments like PISA are noteworthy. This situation can be attributed to factors such as students' inability to achieve a comprehensive understanding, apply their knowledge to real-life situations, solve problems, and engage in analytical and interdisciplinary thinking. It was observed that students with high academic achievements in a private school struggled to comprehend the questions posed in PISA exams. Moreover, many learning outcomes in the chemistry curriculum lend themselves to connections with everyday life, making them suitable for enhancing chemistry lessons through various teaching methods and techniques. These outcomes align with the types of questions found in PISA exams. However, the recommended class hours for chemistry are insufficient for effectively implementing these teaching methods and techniques. Additionally, experienced teachers in private schools are often assigned to classes focusing on YKS exams, limiting their ability to utilize teaching methods and techniques extensively.

Bahçeşehir Educational Institutions, Chemistry Teacher

During the post-presentation discussions, participants stressed the importance of regularly reviewing exam questions from a measurement and evaluation standpoint. An academic attendee highlighted the numerous errors he found in the chemistry materials of a private school where he was a parent, emphasizing the need for audits of publications from private schools and institutions. It was recommended that teachers have access to a greater number of exemplary teaching methods and techniques and that they actively share these practices with one another.

Table 26 presents the findings of the analysis, outlining the identified problems and suggested solutions from participants in Form-1 regarding this presentation:

Table 26. Analysis Results of the Audience Notes in Form-1 During the Presentation Titled "Designing Chemistry Lessons with Teaching Methods and Techniques to Ensure Permanent and Complete Learning in High School Chemistry Lessons"

Specified Challenges	Proposed Solutions
• Presentation-based teaching as a dominant method in secondary education and undergraduate education • Inadequacy of the traditional classroom model for new methods • Not using different teaching methods and techniques • Restriction of the use of different teaching methods and techniques by the exam-oriented teaching • Despite the spiral structure in the curriculum, students not being reminded of prior knowledge • Teachers not believing in the contribution of new methods and techniques to students • Limitation of the use of methods and techniques due to difficulties with time and classroom management • Lack of methodology, technical knowledge and experience limiting their use • Lack of dissemination and knowledge of tried and tested methods and techniques specific to chemistry teaching	• Good practices need to be increased so that different methods and techniques are used by teachers. • Teachers need to be equipped to apply new methods and techniques • Course hours should be planned as theoretical and practical • Teachers need in-service training in chemistry-specific methods and techniques.

The sixth invited presentation of the workshop focused on the "Challenges Encountered by Chemistry Teachers in Project-Based Educational Institutions in Secondary Education and Solutions" and was delivered by Dr. Aysun İnal, a chemistry teacher with experience in project schools. İnal has been working in a highly sought-after vocational high school in Ankara since its establishment, which is also a project school. In her presentation, İnal addressed the issues faced by students and teachers in project schools. A summary of the presentation is provided below.

Challenges Encountered by Chemistry Teachers in Project-Based Educational Institutions in Secondary Education and Solutions

Dr. Aysun İNAL*

ABSTRACT

Project-based educational institutions admit students based on their scores in the centralized system (High School Entrance Exam [LGS]). In vocational high schools, students receive general education in the 9th grade. At the end of the

9th grade, they are assigned to fields within the Anatolian Vocational programs, which encompass both general knowledge courses and profession-specific knowledge and skills. The primary objective of vocational high schools is to train intermediate and technical staff. Instead of emphasizing a scientific perspective, vocational high schools prioritize skill development. Consequently, vocational high school students are trained in a master-apprentice relationship, following their mentors' guidance. It is therefore inappropriate to subject students to a single type of examination, even across different school types. Different schools serve different purposes. For instance, vocational high schools aim to cultivate competent intermediate staff. The centralized exam system puts different school types at a disadvantage. Furthermore, relying solely on LGS results for student selection in project schools is a flawed practice. Students face difficulties in certain subjects within project schools due to the nature of the coursework, which requires manual or specialized skills. Consequently, student selection for project schools should involve interviews in addition to the central exam. Additionally, students in project schools often prioritize preparation for the final-grade central exam, perceiving project-based studies as time-consuming and therefore not actively participating in such projects. To address this issue, I propose that projects/activities undertaken by students during their high school education should be credited. Similarly, there are deficiencies in the selection process for teachers in project schools. School principals submit petitions or recommend teachers to the MoNE for selection, which is carried out by a commission at the MoNE through interviews. However, there is no evaluation of whether the teacher possesses the necessary professional competence and experience to serve in a project school. Consequently, teachers lacking project management skills or experience may be reluctant to take on projects or avoid them altogether. To overcome this problem, the MoNE organizes continuous in-service trainings. Unfortunately, many of these trainings are not adequately planned to meet the specific needs and objectives. Furthermore, teachers in project schools face heavy workloads, including after-hours and weekend duties and responsibilities. However, this additional workload does not provide economic benefits to teachers. Therefore, it is recommended to provide additional economic support as a means of motivating teachers in project schools to invest more in their work.

MoNE, Education Expert

Following the presentations, a chemistry teacher from another project school shared that he had encountered similar issues. Another participant inquired about the support provided by TUBITAK for these projects. Dr. İnal responded by sharing his experience of conducting several TUBITAK projects at the project school. She mentioned that the school administrators considered such support as a valuable resource and actively sought opportunities to engage in TUBITAK projects. However, she acknowledged that the project process did not always proceed smoothly, and highlighted challenges faced when collaborating with external organizations that have long-term commitments. These circumstances often make it difficult to carry out projects with external support.

The problems and solution suggestions discussed during the presentation are summarized in Table 27.

Table 27. Analysis Results of the Audience Notes in Form-1 During the Presentation Titled "Challenges Encountered by Chemistry Teachers in Project-Based Educational Institutions in Secondary Education and Solutions"

Specified Challenges	Proposed Solutions
Absent or if any, inadequate and outdated laboratories,	Fully equipped laboratories should be established in all schools including the project schools.
Inadequate and ill-equipped laboratories	Every school should have a suitable laboratory environment.
Lack of materials/equipment	Enhance collaborations between universities and schools to increase material availability.
Reluctance to engage in projects due to YKS	Revising the YKS exam system to encourage students in project schools to conduct projects.
Difficulty in combining academic achievement with the project process (for students)	Modify YKS to motivate project involvement while maintaining academic success
Lack of adequate material and moral support, isolation of the teachers	Material and moral support should be provided to teachers and students.
Difficulty finding resources for the project	Schools can benefit from the budget provided by TUBITAK for conducting projects.
Not allocating a share for teachers in the project budget	Teachers working in project schools should be given incentive payment or project budget.
The difficulty of carrying out both the lessons and the project together for the continuation of academic success brings extra workload to the teacher.	In-service training should be planned according to the targets.
Teachers' difficulty in making projects	Teachers working in project schools should be given incentive payments or project budget
Intensive and heavy working hours	Enable all teachers trained in the field of chemistry in undergraduate education to conduct advanced studies.
Undergraduate chemistry education is not provided equally and under the same conditions/programs in universities, differences in quality	-

The seventh invited presentation of the study featured a presentation by chemistry teacher Ali Buğday titled "Challenges and Solutions in Chemistry Education". A brief summary of the presentation is provided below.

Challenges and Solutions in Chemistry Education

Head Teacher Ali BUĞDAY*

ABSTRACT

Chemistry and Chemistry Technology courses are integral parts of secondary education institutions, serving as the foundation for all sciences. A solid understanding of this subject paves the way for easier comprehension and grasp of other scientific branches. With today's technological advancements, students' interest in science is heightened, as recent scientific developments in our country instill immense excitement and curiosity among them. It is crucial to channel this excitement in the right way and guide their efforts in the correct direction, without dampening their knowledge or diminishing their enthusiasm. However, there is a lack of sufficient initiatives to further nurture their interest and curiosity. To direct students towards this field, enhance their knowledge and skills, and foster their enjoyment of science, it is essential to prioritize skill development alongside knowledge acquisition. The suggestions put forth will contribute to enhancing the quality of education. Challenges in chemistry education arise from the curriculum, physical conditions, students, parents, administrators, teachers, and the centralized examination system. These challenges, along with proposed solutions, are summarized in the table below.

Source of the Challenge	**Challenges**	**Suggestions**
Curriculum-related	Not suitable for all student levels	The curriculum should be more activity-based. Project-based learning should be emphasized.
Related to physical conditions	There are no laboratories in schools, or they are not sufficient and up to date. Not suitable for collaborative learning environments	Necessary infrastructure and material support should be provided for schools. If necessary, unused, or surplus materials should be shared with other schools. Universities should provide support in terms of materials.
Parents-related	Schools are seen as institutions that prepares students for exams.	

Administrators-related	School budget is not used for the necessary equipment and infrastructure of the school. Learning environments are not organised in accordance with occupational health and safety principles. Administrators do not have a STEM mindset.	A part of the funds should be allocated for laboratory equipment. Laboratories should be organised according to occupational health and safety principles. Administrators should support and motivate teachers in project and research activities, and their work should be taken into consideration.
Teacher-related	Poor field knowledge Teachers do not have a good command of the curriculum. Teachers do not know to how to manage a project. Teachers have diminished motivation for their profession.	Effective and systematic in-service trainings should be organised. The teaching profession should be valued.
Related to the central exam system	Skill assessment can not be realized. A single test type is not appropriate.	The central examination system should be revised and exams measuring different skills and knowledge should be conducted for different school types and occupational groups.

Konya Karatay TOKI Anatolian High School, Chemistry Teacher

During the discussion session, a participant raised a question, asking why schools are unable to acquire laboratory equipment due to a lack of funds. Buğday responded by stating that schools do receive a budget, but school principals often allocate it to other expenses. Furthermore, Buğday observed that some teachers approach their textbooks with enthusiasm and excitement, while others handle them with indifference. He emphasized the impact this can have on the classroom, as students may not engage with the lesson if the teacher lacks enthusiasm. Buğday reiterated the importance of requiring teachers to participate in regular in-service trainings to foster openness to innovation and change and highlighted the need for periodic assessments of teacher competencies.

The problems and solution suggestions discussed during the presentation are summarized in Table 28.

Table 28. Analysis Results of the Audience Notes in Form-1 During the Presentation Titled "Challenges and Solutions in Chemistry Education"

Specified Challenges	Proposed Solutions
Despite the experimental nature of chemistry, the failure to integrate experiments into the course.	Schools should have fully equipped laboratories.
Teachers lacking sufficient knowledge in fields such as science, technology, and engineering.	Teachers should be supported through in-service trainings.
Absence or insufficiency of up-to-date laboratory materials in schools.	Branch managers should visit schools and identify unused materials or surplus materials and direct them to other schools.
Laboratories/classrooms not being suitable for students to work in teams.	-
The laboratories not having the physical conditions to arouse the students' feeling of research.	-
The stipulation of the school environment as a place of learning.	Students learn everywhere.
Lack of activity-based education.	Project-based learning should be emphasized.
Parents seeing the school as a classroom.	Placing emphasis on project-based/activity-based education in education programmes.
Challenges arising from curricula.	Performance and project work should be encouraged.
	Activities should be basic. Instead of visual activities, activities students perform should be planned.
School administrators not having STEM mindset.	Administrators should attach importance to the project laboratory.

The eighth invited presentation of the workshop was titled "An Examination of Challenges in Chemistry Education from the Perspective of Pedagogical Formation" and was delivered by Prof. Dr. Nilgün Seçken.

An Examination of Challenges in Chemistry Education from the Perspective of Pedagogical Formation

Prof. Dr. Nilgün SEÇKEN*

ABSTRACT

The effectiveness of an education system is evidenced by its ability to train individuals with the necessary quality and quantity to meet the needs of society. Pedagogy, defined as "the science and art of teaching children," encompasses understanding the importance, impact, and value of education, and guiding towards attainment of desired goals. In other words, pedagogy

involves thoughtful consideration of the act of education. While pedagogy was once limited to imparting metaphysical, moral, and religious ideas, it gained a scientific character in the 19^{th} century. Pedagogical education encompasses various aspects such as individual, spiritual, social, and institutional dimensions. Effective storytelling and information delivery are closely linked to pedagogy, as it is connected to the methods employed by teachers. Pedagogical formation offers individuals the opportunity to teach in institutions related to their fields after completing the necessary courses and trainings, even without graduating from a faculty of education. In the Republican era, various approaches were attempted to train teachers for primary and secondary education institutions, yet the demand for qualified teachers remained unmet. Consequently, alternative methods such as distance education, substitute teaching, reserve officer teaching, accelerated teacher training programs, and the appointment of non-education graduates as teachers were explored. Although pedagogical education was initially provided to individuals outside the field of education due to the shortage of teachers, many educators have since joined the system through this practice. Today, numerous graduates from faculties of Arts and Sciences benefit from pedagogical formation education. Each year, a significant number of students, nearing the quotas of their respective departments, graduate as teachers after completing 28 weeks of formation training. It is important to note that teacher education encompasses not only practical knowledge, pedagogical skills, and techniques. The problems identified and the suggested solutions by the participants are summarized in the table below:

Sources	Challenges	Solutions
Implementation of the Curriculum	The appointment of graduates of departments other than education faculties as teachers for many reasons from past to present.	• Students who want to become teachers from faculties other than the Faculty of Education should be placed in the Faculty of Education through inter-programme transfer or Central Placement Score. • The opportunity to obtain the diploma of Faculty of Education through double major programmes should be provided to different faculties. • Teacher training programmes should be updated from time to time in the light of the needs of the time and scientific developments.
	Practices such as teacher training by letter, formation education, classroom teaching certificate education.	
	Few student quotas in faculties of education undergraduate programs and large number of non-education graduates becoming teachers through pedagogical formation.	
	The difference in the conditions under which chemistry education undergraduates and students enrolled in certificate programmes compete.	
	The fact that pedagogical formation programmes damage the education system process.	
	Graduated teachers having employment problems.	
Adequecy of the Curriculum	The course hours of chemistry education programmes are too few compared to chemistry departments and engineering.	• Teachers needed by the country should be trained by the Faculties of Education. • Programme updates should be agreed with the faculty members of Faculties of Education.
	The adequacy of the qualifications of graduated teachers.	

***Hacettepe University, Faculty of Education, Faculty Member**

During the discussions following the presentation, the importance of conducting a needs analysis in the development of teacher education programs and processes was emphasized. Seçken highlighted that without such an analysis, initiatives would result in a wast of human resources and funds, and demotivate students. It was also pointed out that pegagogical formation creates a sense of hopelessness for those who pursue teaching as a career, and the problem of unemployment for unassigned teachers would gradually worsen. Furthermore, Seçken raised a significant question regarding the quantitative need for formation education, asking, "Can graduates of chemistry education undergraduate programs compete on equal footing with students enrolled in certificate programs?" One undergraduate student expressed the opinion that while chemistry departments and chemical engineering departments are allowed to teach chemistry, graduates of chemistry teaching programs are not qualified to apply to jobs as chemists or chemical engineers. for these professions. Additionally, a few participants shared their views on the hours of analytical chemistry laboratory courses, stating that in the chemistry teaching department, it is taught for two semesters (2 hours each semester), while in the chemistry department, it is taught for two semesters (6 hours each semester). This situation extends to other courses such as physical chemistry laboratory and organic chemistry laboratory. Seçken cautioned that the implementation of the pedagogical formation certificate could disrupt the education system that has been developed over many years.

Table 29 presents the analysis of the problems and solution suggestions provided by the participants in Form-1 specific to this presentation.

Table 29. Analysis Results of the Audience Notes in Form-1 During the Presentation Titled "An Examination of Challenges in Chemistry Education from the Perspective of Pedagogical Formation"

Specified Challenges	Proposed Solutions
The in adequacy of pedagogical formation programmes in teacher training.	Chemistry teachers should be trained by faculties of education.
Limited time allocated for laboratory applications.	More time should be allocated to laboratory applications in the curriculum.
The in adequacy of the 2018 CoHE programme implemented in all faculties of education.	All programmes should be renewed by taking the opinions of field experts.
Few courses related to field education in the curriculum.	Universities should make more original decisions in terms of programmes.
Inability of students graduated from chemistry education undergraduate programmes and certificate programmes to compete on equal terms.	Pedagogical formation programmes should be abolished or restricted.
Training more teachers than needed.	Richer teaching programmes should be developed.
While the quota of faculties of education is kept low, the quota of faculties of science, which can receive pedagogical formation, is high.	The quota of faculties of education should be increased and only faculties of education should train teachers.
	The teaching profession should be taken seriously and emphasized sufficiently.
Pedagogical formation being given to too many fields.	The number of student quotas in chemistry teaching undergraduate programs should be increased.
Excess number of unassigned teachers.	Teachers should be trained only by faculties of education.

Apart from chemistry teaching, graduates of chemistry, chemical engineering and some faculties become teachers in a very short time by receiving pedagogical formation.	Instead of appointing teachers from the quotas of faculties of science or chemical engineering, the quota allocated to these faculties should be transferred to faculties of education and pedagogical formation should be removed from these faculties.
Lack of strategic planning	Strategic planning should be made according to the number of needs and graduates. The quota of Faculties of Education should be increased. Double major programme should be implemented.
Approximately 250 people per year obtain a chemistry teaching certificate in 28 weeks	Instead of giving pegagogical formation training to chemistry department and chemical engineering, the quota of faculties of education should be increased.
Training too many teacher candidates through pedagogical formation programme	
Decrease in the chance of appointment of graduates of the faculties of education	

The ninth invited presentation of the study was given by Prof. Dr. Zübeyde Demet Kırbulut Güneş, who spoke on the topic of "Anatomy of Student Participation in Active Learning Environments in Undergraduate Chemistry Courses." A brief summary of the presentation is provided below.

Anatomy of Student Participation in Active Learning Environments in Undergraduate Chemistry Courses

Prof. Dr. Zübeyde Demet KIRBULUT GÜNEŞ*

ABSTRACT

Active learning can be defined in various ways. It involves creating environments where students go beyond traditional teaching methods and actively engage in making sense of information. In contrast, passive learning relies on students simply listening and taking notes through traditional approaches. Constructivism plays a crucial role in the process of knowledge construction for individuals. Students may utilize cognitive or social constructivist perspectives as they construct knowledge. Active learning not only empowers students to gain autonomy but also allows them to interact directly with teachers, peers, field practices, data, models, and experiences. Environments with high levels of student participation facilitate positive experiences in active learning. However, it is important to note that not every environment with active student participation can be considered an active learning environment.

Based on the results of a study conducted by Güneş, it was found that activities focused on understanding are the most commonly used, while those involving analysis are used the least. Furthermore, activities at the recall level demonstrate lower student participation, knowledge construction, and group work. To address these findings, it is recommended to incorporate more activities at the analysis level into the learning process. While Center for Assessment, Selection and Placement (ÖSYM) exams prioritize analysis, there is insufficient emphasis on comprehension. Moreover, in terms of knowledge dynamics, knowledge construction is the least encountered, while knowledge sharing is the most encountered. Therefore, in the learning process, factors such as cooperative learning environments, group work to make sense of information, and a communicative approach all play significant roles in promoting effective student participation. It is essential for teachers to be aware of these factors. The problems and suggested solutions discussed during the presentation are summarized in the table below:

Sources	Challenges	Solutions
Implementation of the Curriculum	• When considering all learning environments, activities at the level of comprehension are used the most and activities at the level of analysis are used the least. • The activities organised at the recall level involve less student participation, structuring knowledge and group work.	• In the learning process, co-operative learning environments, making sense of information through group work, and communicative approach should be taken into consideration. • Differences of attributes among students should be taken into consideration by the teacher. • Activities at the level of analysis should be included in the learning process.
Adequecy of the Curriculum	In the content of the Student Selection and Placement Center (ÖSYM) exams, more attention is paid to analysis, but not enough attention is paid to comprehension.	

Gazi University, Gazi Faculty of Education, Faculty Member

Following the presentation, Dr. Mehmet Bilgi, a chemistry teacher at TUBITAK schools and workshop participant, responded to the question, "Should the task of forming a group in a class where almost all students are leaders be left to the students?" by stating, "It should be done by the teacher, taking into consideration group dynamics." Güneş highlighted that the learning process is complex and influenced by numerous factors. Furthermore, Güneş supported Taber's assertion that the same approach cannot yield identical results in every class, stating, "Students are not like a solution that can be prepared at a desired concentration or magnesium strips that can be cut into equal sizes." Additionally, Prof. Dr. Güler Ekmekçi, another workshop participant, expressed that "Not every teaching activity is suitable for every chemistry topic."

Table 30 presents the results of the analysis of the participants' problems and solution suggestions specific to this presentation, as documented in Form-1.

Table 30. Analysis Results of the Audience Notes in Form-1 During the Presentation Titled "Anatomy of Student Participation in Active Learning Environments in Undergraduate Chemistry Courses"

Challenges	Proposed Solutions
Organising the activities at maximum comprehension and minimum analysis levels.	Activities should be carried out at the analytical level, reviewing factors such as the learning environment, group positions, the teacher's ability, etc.
Excessive teaching programme load.	Adequate time and class level should be provided.
Teacher-centred education practices that do not make the student active.	Student-centred education should be introduced.
	Students should be made to feel themselves in the lesson.
Learning by structuring knowledge.	Activities at the level of analysis should be used where appropriate and necessary.
Accepting every environment with active participation of the student as an active learning environment.	Model-based reasoning should be encouraged.
Lack of time for active learning in chemistry classes.	Attention should be paid to the time allocated for the activity, classroom organisation and the distribution of groups.
	In the content of the textbooks, more opportunities should be provided at the comprehension level, taking into account the adequacy of time.
Adequacy of learning environments.	The dynamics of the class and the differences of each student should be well known and the right active learning environments should be provided.
Attributes of the learning environment and classroom organisation.	difference between class dynamics should be taken into consideration.

Creating environments where students can be mentally active.	Collaborative social knowledge process should be provided.
Following a course process based on classical knowledge transfer.	For effective student participation, teaching material, learning environment, time allocated to the activity and teacher factor should be balanced.
Teacher authoritarianism.	Whether students construct knowledge or not should be carefully monitored and commented.
Active participation of pre-service teachers in the learning environment.	Chemical thinking should be transferred.
	There should be transfers not only at the level of analysis but also at the level of knowledge.
	Learning environment should be organised according to group dynamics.
	Students should be made more willing and motivated.
	They should be encouraged to reasoning.

The tenth presentation of the study was delivered by Prof. Dr. Sevgi Aydın Günbatar, titled "Challenges in Chemistry Teacher Training at Undergraduate Level."

Challenges in Chemistry Teacher Training at Undergraduate Level

Prof. Dr. Sevgi AYDIN GÜNBATAR*

ABSTRACT

Pedagogical content knowledge is a unique combination of subject knowledge and pedagogical knowledge that enables effective teaching to students. It is crucial for prospective chemistry teachers to attain a sufficient level of pedagogical content knowledge upon graduating from the faculty. Drawing on data obtained from graduated teachers, this study presents the identified shortcomings of the chemistry teacher education program and offers solutions from the teachers' perspective. The analysis focuses on the categories of content knowledge, field education, teaching practice, and pedagogy courses.

Teachers emphasized the need for more conceptual teaching approaches in certain field courses and the importance of enhancing understanding of abstract topics through appropriate methods. They pointed out that applying teaching methods and techniques learned during field education courses in high school settings is challenging due to student dynamics, objectives, infrastructure

limitations, and time constraints. To address this challenge, they recommended that teaching activities at universities be designed with the conditions and time constraints of our country's schools in mind, with practical teaching experiences provided to pre-service teachers.

Teachers also highlighted the lack of practical opportunities, particularly in the special teaching methods course, in high schools. They suggested the inclusion of a course on chemistry curricula in the faculty and recommended that field educators teach this course. To bridge the gap between the levels of chemistry learned at the university and those taught in high schools, they proposed incorporating courses such as "High School Chemistry Experiments" and "Misconceptions" into the program.

Regarding the teaching practicum course, teachers expressed the need to provide candidates with more teaching opportunities, as the current observation and teaching periods in high schools are limited. They suggested longer internship experiences through collaborations with the MoNE. Moreover, they emphasized the importance of closer monitoring and feedback from academic supervisors during the internship period.

Teachers identified a lack of familiarity with the regulations and rules applied in high schools among pre-service teachers. They recommended introducing these aspects at the faculty level and seeking assistance from high school administrations. To enhance effective communication and encourage critical thinking among candidates, they proposed incorporating micro-teaching activities into the curriculum, particularly for increasing their experience and communication skills.

Teachers noted that strategies learned in the classroom management course, one of the pedagogy courses, are not always effective with Generation Z high school students. They faced challenges in classroom management at the high school level. As courses such as measurement and evaluation, curriculum, and instructional programs are distant from the field of chemistry, teachers stressed the importance of involving chemistry field educators in teaching these courses and promoting collaboration whenever possible.

Teachers also encountered difficulties in utilizing instructional technologies, implementing effective distance education, teaching in non-classroom and non-laboratory environments, applying chemistry in specialized contexts, managing projects, and gaining familiarity with different types of high schools. They recommended incorporating relevant courses into the undergraduate program to address these challenges appropriately.

Van Yüzüncü Yıl University, Faculty of Education

During the discussion section, an academic highlighted the differences between the current program and the 1997 program, where courses involving faculty-school cooperation were spread over four years. The need for close collaboration between teachers, the MoNE, and academics was emphasized, along with the recognition of the problem of academics being detached from the classroom/school environment. It was suggested that addressing high school problems should be incorporated into undergraduate education, and the importance of training teachers for different high schools was emphasized. The implementation of courses such as classroom management in high schools was also discussed. Additionally, the lack of motivation among high school students to engage in projects was raised. An academic shared a personal anecdote related to material design courses in the field of chemistry. The problem of determining who will teach pedagogical content knowledge courses during curriculum changes was highlighted, emphasizing the importance of fostering interaction between field educators and educational scientists.

Table 31 presents the analysis results of the problems and solution suggestions provided by participants in Form-1 specific to this presentation.

Table 31. Analysis Results of the Audience Notes in Form-1 During the Presentation Titled "Challenges in Chemistry Teacher Training at Undergraduate Level"

Specified Challenges	Proposed Solutions
• Academic being far from the high school classroom environment. • Lack of training for science and art centre chemistry teachers. • Lack of time for activity-based teaching • Failure to train teachers for different types of high schools • High number of graduates with those who take pegagogic al formation training • Graduating more teachers than needed but not being able to employ them • Not giving enough importance to conceptual teaching • Inadequacy of undergraduate project preparation course • Instructional difference between undergraduate chemistry and high school chemistry • Lack of curriculum knowledge • Teaching courses such as instructional technologies, material design, measurement and evaluation in education at general and theoretical level. • Lack of pedagogical field knowledge • Education in different environments other than classroom and laboratory • Transfer of abstract subjects without using methods and technology • Inadequacy of the duration and effectiveness of the teaching practice course • Assigning fewer tasks to candidate teachers in teaching practice • Distance chemistry teaching • The university not preparing high school students for professional life. • Inadequacy of the CoHE programme and inability to expand it.	• Academics using effective teaching methods, techniques and technology appropriate to the courses and subjects • Increasing academics' experience of high school environment and their studies for high schools • Some pedagogy courses being taught by academic who are field educators. • Interaction between educational scientists • Teacher training for different types of high schools and out-of-school settings. • Granting formation only to faculties of education • Practical teaching of activities and lessons to prospective teachers by considering the real work environment • Attaching more importance to concepts in undergraduate courses • Providing micro-teaching experiences • Preparation of different curricula according to school types • Providing pre-service teachers with the opportunity to make more presentations/ practical activities in teaching practice • Having a course for prospective teachers to examine the curriculum • Preparation of guidebooks with activities for teachers • Preparation of teaching practice guides and introduction of regulations • Extending the teaching practice, expanding its content, and making more practice for the candidates • University, MoNE and CoHE co-operation • Developing shorter-term activities for high school level in universities and teaching them to prospective teachers

The final presentation of the workshop, titled "Laboratory Use in Chemistry Education," was divided into two parts. The first part featured a presentation by Prof. Dr. Faik Karataş, who discussed the challenges associated with laboratory use in chemistry teaching. In the second part, Özge Göktürk, a teacher from the Science and Art Center, addressed the issues encountered in science and art centers regarding laboratory usage.

PART 1: Laboratory Use in Chemistry Education

Prof. Dr. Faik KARATAŞ*

ABSTRACT

In chemistry education, concepts are explained and predicted at three levels: macro, particle, and symbolic. Students learn about observable and concrete aspects of matter and changes in matter at the macro level, particularly in chemistry laboratories. Chemical changes and certain concepts (e.g., physical states of reactants and products, reaction conditions) are represented using symbols in chemical equations. The explanation of macro and symbolic representation is usually related to interactions at the particle level. Chemistry laboratories not only facilitate understanding of the macro level of chemistry but also provide opportunities for students to test their conceptual knowledge, collaborate, interact with experimental materials, learn through trial and error, and analyze experimental data to comprehend chemistry. However, there are some challenges related to laboratory use and learning. This study examines the problems encountered in laboratory applications, addressing various themes such as teaching-learning approaches, curriculum, physical conditions, personnel, and research on laboratory use. Some solution suggestions are presented for these problems. The problems and solution suggestions are summarized in the table below.

<table>
<tr><th>Problems related to the use of laboratory in chemistry teaching</th><th>Solutions</th></tr>
<tr><td>Learning approach:
• Confirmatory laboratory approach
• Closed-ended experiments
• Focus on basic skills (less interest in causal and empirical skills)
• Limited research and enquiry</td><td rowspan="6">• Professional development (continuing education) activities
• Use of virtual and remote access laboratories: Although the investment cost of virtual laboratories is high, they are favourable in terms of accessibility and cost in the long term.</td></tr>
<tr><td>Curriculum:
• No or limited scientifically prepared laboratory programme
• Outdated laboratory manuals
• Limited assessment and evaluation
• Unclear and ambiguous learning/teaching objectives</td></tr>
<tr><td>Physical Conditions:
• Suitability of laboratories
• Marble worktop
• Problems in design
• Suitability and adequacy of equipment
• Although available, devices, tools and equipment being limited in number compared to the number of students.
• Limited number or absence of current, IT-compliant probes and data reading devices.</td></tr>
<tr><td>Materials and Maintenance:
• Difficulty in replacing consumed materials
• Lack of immediate maintenance services in case of malfunction</td></tr>
<tr><td>Personnel:
• The technician does cleaning and stock keeping rather than basic laboratory preparations.
• One lecturer attending the laboratory courses.
• Limitations in following current technologies
• Weak pedagogical content knowledge about laboratory approaches, measurement and evaluation etc.</td></tr>
<tr><td>Research:
• Limited chemistry education research related to the chemistry laboratory and its use at the university level</td></tr>
</table>

Trabzon University, Faculty Member

PART 2: Challenges in Chemistry Laboratories at Science and Art Centers (BILSEM)

Özge GÖKTÜRK*

ABSTRACT

The concept of “gifted individuals” is defined in the MoNE Science and Art Centers (BILSEM) Directive as individuals who learn faster than their peers,

demonstrate creativity, leadership capacity, and possess special academic talents. They have the ability to understand abstract ideas and prefer independent work in their fields of interest, performing at a high level. Students enrolled in BILSEM participate in training programs that include adaptation, support education, individual talent recognition, special talent development, and project production and management. Upon program completion, students receive a "Program Completion Certificate" from the BILSEM directorate. The Individual Talents Recognition Program (BYFP) aims to identify students' interests and talents in specific areas, while the Special Talents Development Program (ÖYGP) focuses on developing high-level thinking skills and deepening knowledge in the field. In the case of chemistry, this process allows students to explore chemistry through BYFP, while teachers identify students' interests and abilities, providing guidance in the field. Chemistry laboratories in BILSEMs play a crucial role in these processes. However, certain problems arise in BILSEM chemistry laboratory applications. This study discusses the problems based on personal experiences, focusing on themes such as teachers, students, and physical conditions. Solution suggestions are provided for some of these problems. The problems and solution suggestions are summarized in the table below:

<table>
<tr><th>BILSEM Chemistry Laboratory Problems</th><th>Proposed Solutions</th></tr>
<tr><td>Physical conditions:
• Physical unsuitability of laboratories (no ventilation, no separate area for chemicals, no sink).</td><td rowspan="5">Mobile laboratories can be established. Mobile laboratories are laboratories where all the equipment and expert personnel required for experiments are delivered to students by a vehicle (truck, lorry, caravan, etc.) and intensive face-to-face experiments are carried out. Applications that can attract students' interest about writing an experiment report can be used. For example, https://labflow.com</td></tr>
<tr><td>Lack of materials:
• Lack of chemicals and materials or inability to replace the chemicals used</td></tr>
<tr><td>Unsuitable laboratory environment for group work</td></tr>
<tr><td>Student:
• Students failing to show the same interest in chemistry because of no specialisation in BYFP groups yet,
• Failure to achieve the purpose of the experiment due to the fact that they had done chemistry experiments in the support group or in their schools before, realisation of wrong learning, unwillingness to do the experiments stating, "I have done this before"
• Unwillingness to participate in experiments due to fear of harm
• Not being able to participate in successive experiments due to not attending the BILSEM programme regularly
• Wasting the material
• Students avoiding organising the preparation for the experiment and the working environment after the experiment
• Not willing to write the experiment report</td></tr>
<tr><td>Teacher:
• Since there are few chemistry teachers who can work actively due to working conditions, science teachers conducting chemistry lessons.
• Teacher's giving the chemistry activity book to the students and having them do uncontrolled experiments,
• Students' failure to reach the targeted goals,
• Due to safety concerns, the teacher's performing the experiment as a demonstration experiment himself/herself instead of having the student do the experiment,
• Not having the students write an experiment report,
• The teacher's hesitancy to conduct experiments due to anxiety (can I achieve the same result in practice as in theory? Will the students be harmed by chemicals?)
• Due to not having done experiments before, the teachers not knowing how to reach a conclusion
• Leaving the experiments only by doing or having them done, not being open to alternative ways or trials (open-ended experiments),
• Sticking to the chemistry activity book,
• Not being able to carry out studies to project experiments,
• Not favouring interdisciplinary work.</td></tr>
<tr><td colspan="2">*Mersin Aydıncık Multi-Program Anatolian High School, Expert Teacher</td></tr>
</table>

In the discussions following the presentations, it was noted that teachers working in BILSEM face challenges due to their evening working hours and inclusion of Saturdays. To prevent students who participate in both Try-and-Build workshops and BILSEM activities from encountering the same activities, it was suggested to differentiate the activities. Workshop participants, who were faculty members, expressed that, teachers working in BILSEM expressed a desire for support and access to university laboratories, but the specific needs were not clear. Regarding chemistry course materials, it was recommended for the Course Instrument Making Center to produce more specific and diverse materials, particularly for institutions like BILSEMs, and deliver them to BILSEMs.

4.2. Findings From the Analysis of Form-2 on Challenges and Solution Suggestions in Chemistry Education

Form-2, developed by the workshop organizing committee as a data collection tool, asked participants to identify the problems hindering chemistry education, the causes/sources of each problem, the resulting effects, and their solution suggestions. The analysis of data collected through Form-2 revealed that the problems related to chemistry education were categorized into four themes: curriculum, instructors, teaching environment/teaching materials, and students. Although the problems differed between the middle/high school and undergraduate levels, the analysis showed that participants' responses were grouped under the same themes. Therefore, the problems, sources, consequences, and solution suggestions for each theme are presented by categorizing them according to the education level (Table 32-Table 39).

4.2.1. Findings Related to Curriculum

Table 32. Findings Related to the Theme of Middle/High School Level Curriculum

CHALLENGES	SOURCES (S) AND CONSEQUENCES (C) OF CHALLENGES	PROPOSED SOLUTIONS
Execution of middle/high school chemistry curriculum • Difficulty in adapting the curriculum to the course environment • Lack of cooperation between different institutions • Differences in student level in each school and within the same school	S Teaching the same curriculum in all school types S Teacher's inadequacy in program adaptation (due to the lack of a guidebook) S Synchronized progression of chemistry and other courses S Lack of interaction between CoHE and MoNE S The curriculum is heavy and intensive compared to vocational high schools C Inadequate education C Failure to ensure a sustainable program	• Guidebooks should be used again. • Infrastructure must be improved. • Course hours and priorities should be reorganized. • Pedagogical courses such as assessment and evaluation should be made field-specific.
The adequacy of the secondary school chemistry curriculum • Being based on scientific thinking • Topics addressing current problems • Implementation of a uniform curriculum that does not change according to school types	**Lack of scientific characteristic** S Not aiming to learn the nature of science S Not targeting scientific thinking skills S Uniform exam requirement S Failure to concretize abstract concepts S Low use of translated books S Low use of modeling S Insufficient number of activities in the books S Course material limitations related to distance education S Not giving enough space to particle level representations S Insufficient space for field knowledge in the secondary school curriculum S Having the same level of textbooks in every school S Assessment questions remain simple according to the level of the exam S Textbooks are written in a boring language S Textbooks include few elements for digital competence S Not covering the last topics related to daily life in the books S Not adopting a constructivist approach S Requiring all students to be on equal footing in YKS C Students do not value science C Decline in the quality of education C The realization of rote learning. C Low interest in science C Textbooks are considered inadequate C Raising students who cannot think at the three-dimensional molecular level C Confusion in terms of the questions in the exam C Low interest in the course C Increased orientation to other resources C The subjects are heavy for students studying in vocational high schools but not satisfactory for students studying in science high schools	• The Nature of Science course should be integrated into the secondary education curriculum. • Scientific infrastructure should be developed for the secondary education curriculum. • More experiments should be included. • Domestic and foreign resources should be included. • The number of technological course materials should be increased. • The number of activities should be increased. • EBA should be enriched. • Models adapted to the course should be developed. • Questions asked in the exams should be added to the books. • The visuals in the books should be of interest to students. • QR codes should be added to textbooks for digital competence. • Current topics should be in the curriculum. • Students should be guided to the fields appropriate to their interests and skills, paving the way for appropriate university selection or profession. • The use of foreign resources recognized in the field should be expanded.

Table 33. Findings Related to the Theme of Undergraduate Level Chemistry Teaching/ Chemistry Programs Curriculum

CHALLENGES	SOURCES (S) AND CONSEQUENCES (C) OF CHALLENGES	PROPOSED SOLUTIONS
Execution of the Undergraduate Curriculum • The curriculum being heavy and intensive according to the course hours • Timeliness of the activities in the program • Undergraduate courses such as Assessment and Evaluation, Material Design, Program Development being taught by field educators	S Incorrect design of the curriculum S Insufficient time allocated to field courses in the program S Frequent change of the program S Lack of harmonization between CoHE and MoNE C Emphasizing theoretical knowledge and leaving no time for practices C Students graduate without adequate field knowledge C Failure to achieve the outcomes C Failure of students to achieve program outcomes C Failure of the student to develop well in the relevant subjects	• Course hours in the programs should be increased. • The process of curriculum simplification should be reduced. • There should be activity designs appropriate to the achievements. • Scientific thinking should start from the basics.
Adequacy of the undergraduate curriculum • Cooperation between different institutions • Restricted Program • Adequacy of field course hours • Number of undergraduate courses, especially laboratory courses in the field • Adequacy of Teaching Practice course and internship opportunities • Undergraduate courses including topics related to current life	S Lack of sufficient interaction between educational institutions S CoHE's program restriction S Inadequacy of internship courses S Inadequate and unreflective teaching hours C Failure of internship courses to fulfill their purpose C Inadequate inclusion of courses such as physical chemistry laboratory in the program C Training of teachers with poor knowledge of the field C Inadequate teachers in terms of teaching practice C Training teachers without considering their qualifications C Lack of well-trained chemistry teachers	• Teachers should have a say in the undergraduate program development process. • Internship courses should be provided starting from the 1st grade. • A solid infrastructure should be provided in chemistry education. • Elective courses should be made compulsory as main courses. • Courses such as school experience and teaching practice should be given gradually from the beginning of the program. • There should be courses to develop TPCK (Technological Pedagogical Content Knowledge) to meet the needs of the age. • Field and laboratory course hours should be increased.

4.2.2. Findings Related to Instructors (Lecturers/Teachers)

Table 34. Findings Related to the Theme of Middle/High School/Teachers

CHALLENGES	SOURCES (S) AND CONSEQUENCES (C) OF CHALLENGES	PROPOSED SOLUTIONS
Teachers' competencies in conducting research and project preparation • Teachers having an idea about eTwinning • Teachers being innovative, collaborative and having a good command of current literature • Teachers' project perspective	S Lack of ethical permission for teachers to work at the university	• Ethical permissions for teachers by universities • Opening new undergraduate courses such as polymer, nanotechnology, forensic medicine etc. • Developing systems to encourage project work
Working conditions of teachers • Suitability of working conditions for teachers • Teachers updating themselves • Parents' demand for exam-oriented education • Teachers receiving the necessary support from the school administration	S The burden of a heavy program S Difficulty in control due to crowded classrooms S Lack of necessary financial and moral support S Lack of in-service training in the field C The teacher feels financially and emotionally alone in the struggle for life	• Improving the living conditions of teachers • Providing in-service training in the field • Raising awareness of parents about teaching objectives • School administration should pay more attention to teachers' ideas
General competencies of teachers • Teachers' competencies to provide training at BILSEM • Teachers' competencies • Teaching department scores	S Lack of effective in-service training for teachers' needs S Teacher training programs, especially the undergraduate program prepared by YÖK, are not sufficient S More graduates than needed to be able to teach decreasing the quality C Teachers do not respect their own profession	• Creating a digital competence area specific to BILSEM • Analyzing the needs of teachers and the problems mentioned in the reports and providing in-service trainings for specific solutions to specific problems • Removal of the formation trainings • Emphasizing field education • High scores of students admitted to education faculties • Increasing in-service trainings • Balanced need for teachers and graduates
Teachers' professional perceptions, attitudes and communication • Teachers' love for the profession • Teachers' willingness to participate in seminars • Interaction and synchronization between branches	S Feeling financially and emotionally alone in the struggle for survival S Seminars do not provide the intended contributions to teachers S Failure to carry out simultaneous studies with other branches	• Improving the living conditions of teachers • Leaving the choice of seminar to the teacher • Improvement in in-service training for teachers
Teachers' teaching and assessment competencies • Teachers' use of different assessment and evaluation approaches • Teachers' teaching chemistry practices in out-of-school settings		• Opening related courses for prospective teachers • Providing relevant in-service training for teachers

Teachers' competencies in using technology and distance education • Teachers integrating technology into their lessons • Teachers updating themselves • Teachers' TPACK competence • Teachers' distance chemistry teaching	S Lack of appropriate digital competence of teachers S Teachers cannot follow the technology or cannot do so due to financial reasons S Problems in the integration of ICT use into the course, lack of planning S Teachers' inability to keep up with technology C Classical and more boring teaching C Decreased motivation of students C Failure to attract children's attention C Difficulty in visualizing abstract information C Lack of understanding of the subject C Planning distance online courses	• In-service training on ICT use at field level • Introducing simple devices and gaining skills in their use • Training and awareness raising for teachers on distance education • Development of online assessment techniques and materials • Providing training on concrete examples for the use of technology in teaching

Table 35. Finding Related to the Undergraduate Level Chemistry Teaching/Chemistry Instructors

CHALLENGES	SOURCES (S) AND CONSEQUENCES (C) OF CHALLENGES	PROPOSED SOLUTIONS
• **General and academic competencies of teaching staff**	S Lack of merit S Lack of periodic trainings	• Creating a competitive environment • Reinstatement of the associate professorship oral exam • Providing in-service training to academic staff in accordance with their needs
• **Instructors' competencies to train pre-service teachers** • Teacher training competencies of academic staff • Teaching competence of teaching staff in the faculty of science • Instructors' use of traditional teaching methods • Instructors teaching laboratory courses in the style of a cookbook • Instructors' competencies in laboratory teaching skills • TPCK skills of lecturers • Effective guidance of pre-service teachers by lecturers	S Insufficient number of class hours S Faculty members being competent only in their own field C Failure to train qualified teacher candidates C Raising teachers who cannot acquire 21st century skills such as questioning, researching, etc.	• Providing pedagogical perspective to science faculty lecturers • Participation in workshops • Realization of in-service trainings • Adequate budget allocation for education • Increasing laboratory course hours • To gain knowledge and skills in the use of basic devices used in chemistry laboratory • Increasing the environments where academic staff can cooperate with MoNE and providing teaching opportunities in MoNE environment • Developing TPCK skills of lecturers • Faculty members should be competent enough to master interdisciplinary studies in fields other than their own field • Gaining measurement and evaluation methods and techniques with online chemistry teaching
• **Instructors' competencies in using technology and distance education** • Instructors' competencies in using technology • Instructors'distance education skills		• Gaining measurement and evaluation methods and techniques with online chemistry teaching

4.2.3. Findings Related to Learning Environment

Table 36. Findings Related to the Theme of Middle/High School Level Learning Environment

CHALLENGES	SOURCES (S) AND CONSEQUENCES (C) OF CHALLENGES	PROPOSED SOLUTIONS
Physical environment conditions (classrooms and laboratories) • Not being suitable for 21st century skills • Class size	S Lack of different classroom designs for different types of schools S Infrastructure inadequacies C A noisy learning environment C Difficulty in classroom management C Students do not fully grasp the subject	• Designing different school buildings according to needs • Class sizes should be reduced - Adequate number of school buildings should be built to meet the needs • Design chemistry classrooms where laboratory and classroom are together
Duration • Insufficient time for laboratory practices	S Lack of laboratory course hours	• An additional laboratory course hour should be included in the curriculum • Laboratory courses can be shifted to other classes according to the intensity of the curriculum at the class level
Need for course materials/ reference books • Insufficient laboratory materials and equipment • Insufficient technological equipment • Inadequacy of course materials in distance education • Qualitative inadequacy of textbooks • Inadequate models • No teacher guidebooks	S Failure to spend school funds according to need S Not teaching the same book in every school type S The language of the textbooks is not suitable for students S Assessment and evaluation questions in textbooks do not match with YGS exam questions S Not enough activities in the textbooks C The publishing boom and teachers' struggle to choose sources	• Spending school funds according to teachers' needs • Schools cooperate with university laboratories • Facilitating the supply of laboratory materials • Bringing back teacher's guidebooks • Open access course materials on the Web can be translated into Turkish. • Providing access to online applications, scientific books and articles with QR codes • Increasing the number of WEB 2.0 tools (animation and simulation) used in chemistry teaching • Textbooks can be diversified by translating foreign books into Turkish • There should be separate questions for each subject, not for the whole unit.
Teaching methods and techniques • Dominance of classical methods (such as presentation technique, conducting experiments in a cookbook style) • Not being suitable for 21st century skills • Lack of active participation/ limited learning environment • Traditional experiment report format/challenges in report writing	S Learning-teaching habits S Inadequacies in mathematical processing S Cognitive differences of the student S Teacher's time management S Teacher's field knowledge C Students cannot visualize the abstract concepts of chemistry in their minds C There is rote learning C 21st century skills cannot be developed C The student finds writing an experiment report boring.	• Individual differences of students should be taken into consideration • Classrooms should be designed as science classrooms according to branches. • A laboratory approach with open-ended experiments based on research and inquiry should be developed • Applications for daily life should be made • In-service trainings should be organized for teachers • The book content of laboratory courses should be diversified • Encourage the use of different techniques such as V diagrams in writing an experiment report

Student psychology (such as perception/anxiety/self-confidence) • Anxiety of being harmed by instruments, devices and chemicals in the laboratory • Self-confidence problem		• Laboratory safety needs to be updated taking into account occupational safety
• **Out-of-school learning opportunities (projects, field trips-observations, science museums, etc.)** • Insufficient or none	S Lack of support from the school administration S Teachers' unwillingness to take responsibility S Students' undesirable behaviors in out-of-school environments S Not encouraged to do projects	• Teachers should be encouraged • Schools should be funded • Activities should be organized in out-of-school learning environments

Table 37. Findings Related to Undergraduate Level Chemistry Teaching/Chemistry Programs Learning Environment

CHALLENGES	SOURCES (S) AND CONSEQUENCES (C) OF CHALLENGES	PROPOSED SOLUTIONS
Physical environment conditions (classrooms and laboratories) • Not being suitable for 21st century skills	S Infrastructure inadequacies	• Redesigning laboratories and classrooms in universities
Duration • Insufficient time for lectures or laboratory practices	S Reducing undergraduate program course credits	• Grading the credits of the courses and laboratory courses according to the needs of the departments • Keeping laboratories open for use by students for extracurricular opportunities
Need for course materials/reference book • Insufficient laboratory equipment and equipment • Insufficient technological equipment		• Improvement of laboratory equipment
Teaching methods and techniques • Dominance of classical methods (such as presentation technique, conducting experiments in a cookbook style) • Not being suitable for 21st century skills • Lack of active participation/limited learning environment • Traditional experiment report format/ challenges in report writing	S Pedagogical content knowledge of the instructor S Lack of time of the instructor	• In-service trainings should be organized for academic staff • Undergraduate classrooms should be designed to support collaborative learning environments
Teacher candidate psychology (such as perception/anxiety/self-confidence) • Anxiety of being harmed by instruments, devices and chemicals in the laboratory		• Practices that will increase pre-service teachers' laboratory self-efficacy should be increased especially for secondary education.

4.2.4. Findings Related to Students

Table 38. Findings Related to the Theme of Middle/High School Level Students

CHALLENGES	SOURCES (S) AND CONSEQUENCES (C) OF CHALLENGES	PROPOSED SOLUTIONS
Students being reluctant to interact in class	S Not valuing the lesson C No meaningful learning takes place	• Provide learning environments and opportunities for students to be more active • Learning environment should be planned according to group dynamics
Negative student attitudes towards the courses	S Students' inability to transfer what they have learned S Large class size S Generation Z's learning style is very different S Having misconceptions C Lack of interest in class activities C Low student sufficiency	• Enriching the courses with various teaching methods • Increasing the number of schools to reduce class size • In-service trainings should be planned for teachers • Opportunity for technology and social interaction
Readiness • Different learning competencies of students studying in different types of schools • Students' inability to perform simple mathematical operations	S Differences in student competencies and individual differences S Lack of math processing skills S Failure to support the processing skills needed in science lessons with mathematics lessons C Students are never at the same level C Lack of interest in class activities C Seeing chemistry as a difficult subject due to lack of mathematical processing skills	• Different teaching should be provided according to school types • Students should be directed to universities according to their skills and interests • Ensure mathematical literacy at all levels of education for basic mathematics subjects
Low interest and motivation	S Students focusing only on the YKS exam S Insufficient readiness of students entering secondary education (reading comprehension or mathematical processing skills) S Preference for traditional methods/approaches S Inadequate integration of technology into lessons C The student is passive C Student's lack of interest C Lack of meaningful learning	• Projects/activities carried out at school should be reflected as points in YKS (For students who are placed in the field, students' skills should also be taken into consideration according to the type of school. • Curricula should be diversified according to school type and the YKS exam should be restructured according to these programs • Enriching the courses with various teaching methods, realizing in-service trainings for this purpose • Enabling interactive lessons
Lack of participation in project work • Students' unwillingness to participate in project work • Not valuing project work	S Current exam system S Students are TYT/AYT-oriented C Failure to realize qualified projects even in project school	• Reflecting the activities (projects or other scientific studies) as points in YKS (for students placed in the field)

Table 39. Findings Related to Undergraduate Level Chemistry Teaching/Chemistry Students

CHALLENGES	SOURCES (S) AND CONSEQUENCES (C) OF CHALLENGES	PROPOSED SOLUTIONS
Failure in the realisation of meaningful learning	S Teacher-centered teaching (lessons do not attract student interest) S Students' inability to transfer what they have learned S Lack of interest in class activities S Low student competence	• Should allocate time for activities (to ensure student participation) • Opportunity for technology and social interaction
Low level of interest and motivation	S Insufficient integration of technology into lessons S Passivity of the student S Career anxiety/problem of not being appointed C Wrong career choice C Moving away from science C Student apathy C Lack of meaningful learning	• Should allocate time for activities (to ensure student participation) • Opportunity for technology and social interaction • Enriching the courses with various teaching methods • Planning in-service trainings • Interactive lessons • Increasing the value given to the profession

4.3. Findings from Focus Group Meetings

During the afternoon of the second day of the workshop, after all presentations and discussions had concluded, participants engaged in focus group meetings. The participants were divided into two groups: (i) secondary and (ii) chemistry teaching/chemistry undergraduate focus groups. Each group prepared a report based on the participants' presentations, subsequent discussions, and their individual experiences. The reports highlighted the problems at the respective education levels and provided solution suggestions. The workshop organizing committee analyzed the reports and classified the findings according to the four previously identified themes (curriculum, instructor/teacher, students, and teaching environment/teaching materials), as presented in Table 40 and Table 41.

4.3.1. Findings From the Secondary Level Focus Group Meeting

The majority of participants in the focus group discussing problems in chemistry education at the middle/high school level were teachers. These teachers conveyed the problems they had experienced or observed, as well as their suggested solutions, in the report. Effective communication among the group members was ensured during the report preparation, allowing for a clear expression of the identified problems and solution suggestions. The findings obtained from the analysis of the report are presented in Table 40.

Table 40. Findings Obtained from the Analysis of Focus Group Meeting Reports Related to the Challenges and Suggestions in Secondary/High School Chemistry Education

Themes	Sub-Themes	Challenges	Proposed Solutions
Curriculum-Related Challenges	Curriculum	The curricula's containing a sufficient number of activities that are aligned with the learning outcomes.	Activities in curricula should be enriched. Various activities should be prepared for each outcome with a systematic and planned study.
		The compatibility of the instructional program with performance and project-based studies.	The curriculum should be project-based and encourage project work.
		The clarity of concise learning outcome statements that are open to interpretation and the explanatory power of the book author's comments.	Explanation of learning outcomes should be more descriptive. The curriculum should not be open to interpretation varying according to the author.
		The need for the reports of teachers, academics, and institutions reviewed by the Board of Education and Discipline to be solution-oriented.	Opinions received from schoolteachers should be taken into consideration. School, district, and provincial minutes should be read and supported.
		The program literacy of teachers.	The curriculum should be examined by teachers, curriculum changes and curriculum expressions should be fully comprehended by teachers.
		The mastery of the subject matter by the representatives and teachers explaining the renewed curriculum.	Teachers and academicians who have a good command of the curriculum should provide detailed information about the renewed curriculum through in-service trainings.
		The alignment between the instructional program and class hours.	The curriculum should be organised according to the grade level and student levels.
		The requirement for the teaching of the curriculum with the same subject and content in all school types.	School types should be created by diversifying schools according to academic achievement levels and programmes specific to these school types should be prepared.
		The curriculum implemented being more dense and tough compared to the course hours in vocational high schools while creating time problem in other types of schools.	Schools should be diversified according to their academic achievement according to the Gauss curve. The curriculum should be expanded according to the degree of difficulty in Science and Anatolian high schools.
	Extracurricular Opportunities (Project, excursion etc.)	Its perception as a loss of time due to the YKS.	Parents should be informed about educational trips.
		The alignment between the curriculum and field trips to external environments (such as CERN and subatomic particles).	Teachers and programme developers who take active roles in out-of-school activities should come together.
	Use of Technology	Adequacy of content.	EBA should be enriched.
			Teachers should be provided with the necessary support and training for the use of virtual laboratories.

<table>
<tr><td rowspan="22">Challenges Related to the Learning/ Teaching Environment</td><td rowspan="4">Textbook and Other Concrete Course Materials</td><td>The alignment between the subject content in textbooks and the questions asked in university entrance exams, as well as the adequacy of the assessment and evaluation sections in textbooks.</td><td>At the end of each chapter, assessment and evaluation should be made to reinforce the acquisitions, and at the end of the unit, studies and activities for YKS should be included.</td></tr>
<tr><td>Adequacy of laboratory facilities for conducting experiments mentioned in textbooks.</td><td>Equipped laboratories should be established in schools.</td></tr>
<tr><td>The presence of outdated information and scientifically erroneous content in textbooks.</td><td>Scientific knowledge should be updated and free from scientific errors. In this context, co-operation should be made with academicians.</td></tr>
<tr><td>The ability of visuals in textbooks to create perceptions towards different approaches.</td><td>It is suggested that the visuals in the textbooks should be free from ideological, sexist, etc. approaches.</td></tr>
<tr><td rowspan="3">Learning Environment</td><td>Distraction in students due to overcrowded classrooms.</td><td>Class sizes should be reviewed.</td></tr>
<tr><td>Adequacy of laboratories expected to be used for practical achievements.</td><td>Laboratory equipment and completion of material deficiencies should be given importance.</td></tr>
<tr><td>Insufficiency of the educational environment in terms of 21st-century skills and lack of appropriate physical infrastructure.</td><td>Education and training environments that appeal to all senses of students should be created.</td></tr>
<tr><td rowspan="4">Connections of Chemistry (Other disciplines, daily life, society, environment, industry, etc.)</td><td>Adequacy of teachers in managing interdisciplinary interactions.</td><td>In-service training should be provided for programme requirements and teachers should be open to improve themselves through in-service training.</td></tr>
<tr><td>Lack of communication among teachers.</td><td>Necessary environments should be provided for teachers to improve themselves by communicating with each other about interdisciplinary interactions.</td></tr>
<tr><td rowspan="2">Teacher qualifications and availability of resources regarding community-environment relationships.</td><td>Interdisciplinary interaction should be provided by transforming daily-life situations into activities. The dimensions of these situations should be evaluated correctly and transformed into classroom activities.</td></tr>
<tr><td>Effective communication environments such as EBA should be provided where teachers can communicate across disciplines.</td></tr>
<tr><td>Use of Technology</td><td>Problems with internet access.</td><td>Deficiencies in internet access in all schools should be identified and necessary support should be provided.</td></tr>
<tr><td rowspan="6">Laboratory and Experiment</td><td>Insufficient laboratory facilities in every school.</td><td>Laboratories should be opened in schools.</td></tr>
<tr><td rowspan="2">Insufficiency of physical infrastructure in school laboratories.</td><td>School laboratories should be enriched in terms of equipment.</td></tr>
<tr><td>A part of the funds given to schools should be allocated to laboratories.</td></tr>
<tr><td>Teachers' competence in utilizing laboratory equipment.</td><td>Teachers should be given laboratory training through well-prepared in-service trainings based on changing curriculum and activities.</td></tr>
<tr><td>Procurement of materials for school laboratories.</td><td>Laboratory and laboratory equipment needs analyses should be carried out in schools on an annual basis and deficiencies should be eliminated.</td></tr>
<tr><td>Management and disposal of chemical waste.</td><td>Arrangements should be made for the management and safety of chemical wastes.</td></tr>
<tr><td rowspan="2">Extracurricular Opportunities (Project, excursion etc.)</td><td>Limited financial resources (school, parents, school-parent association, sponsors) leading to restricted participation of students in educational trips (such as CERN, university laboratories).</td><td>For places that cannot be visited, videos should be shown, and teleconferences meetings should be conducted with the relevant people.</td></tr>
<tr><td>The adequacy of the opportunities offered by the school for project studies.</td><td>Schools should raise funds from universities and sponsors for project work.</td></tr>
</table>

Instructor-Related Challenges	**Instructor Competencies**	Adequacy of the number of effective in-service trainings for teacher needs.	Specific solutions should be produced by analysing teachers' needs and the problems mentioned in the reports and in-service trainings should be provided in this direction.
	Use of Technology	Adequacy of pedagogical and technological field knowledge.	Training on the use of technology in education should be provided through concrete examples.
		Teachers' following the technology and being open to development.	It should be ensured that a certain number of teachers receive in-service training at certain intervals.
			Teachers' competence should be measured at certain intervals.
	Extracurricular Opportunities (Project, excursion etc.)	The effect of legislative obligations on the realisation of trips.	The MoNE and school management should take responsibility instead of teachers taking the initiative.
		Teachers' knowledge and skill level to carry out projects such as TUBITAK, Olympiad, etc.	In-service trainings should be provided by universities and the MoNE.
Student-Related Challenges	**Secondary Level Student Competencies**	The problem of failure in university exams due to differences in students' readiness levels.	Students should be correctly assessed and guided according to their abilities and interests.
			Different education should be provided according to school types.
		Taking into account the individual differences of students.	Parent trainings should be organised for parents.
			Different plans should be made for vocational high school students who may be orientated towards professional groups and it should not be aimed for all students to take the university exam.
		Students' prejudice against chemistry due to their inadequate reading, comprehension, and mathematics skills from secondary education.	Skill competences of students in secondary education should be taken into consideration when assigning them to school types.
	Student Motivation and Interest	The level of interest in chemistry course activities due to the reality of the YKS exam.	It should be ensured that the activities/projects carried out by students have an impact on the YKS score.
	Use of Technology	Students' ability to master technology more.	Similar to private schools, students' use of phones and technology should be controlled in all public schools.

4.3.2. Findings From the Undergraduate Level Focus Group Meeting

The focus group addressing problems in chemistry education at the undergraduate level consisted of academicis working in the department of chemistry education at the faculty of education or in the department of chemistry at the faculty of science, as well as undergraduate and graduate students from both faculties. The working group took into consideration the perspectives of their respective faculties and reported the problems they had experienced or observed, along with the suggested solutions. Effective communication among the group members was ensured during the report preparation. The problems and solution suggestions were expressed in a manner that encompassed the common and distinct challenges faced by both faculties. The findings obtained from the analysis of the report are presented in Table 41.

Table 41. Findings Obtained from the Analysis of Focus Group Meeting Reports Related to the Challenges and Suggestions in Undergraduate Level Chemistry Education

<table>
<tr><th>Themes</th><th>Sub-Themes</th><th>Challenges</th><th>Proposed Solutions</th></tr>
<tr><td rowspan="17">Curricular Challenges</td><td rowspan="15">Curriculum</td><td rowspan="2">Sufficiency of laboratory and field courses in the curriculum (lack of physical chemistry laboratory, organic chemistry laboratory, instrumental analysis laboratory).</td><td>Field laboratory courses should be added.</td></tr>
<tr><td>Organic physical chemistry laboratories should be opened.</td></tr>
<tr><td>Implementation of different curriculum in science faculties, varying from university to university.</td><td>A uniform curriculum with a clear framework should be implemented in science faculties in order to eliminate the difficulty of adjustment and to provide equal opportunity.</td></tr>
<tr><td rowspan="4">The level of relevance of curricula to current issues of global interest.</td><td>Assessment and evaluation, curriculum development and material design courses in the faculties of education should be revised as field-specific and taught by field educators.</td></tr>
<tr><td>Up-to-date courses intertwined with technology should be provided.</td></tr>
<tr><td>Education courses on sustainability and environmental chemistry should be added.</td></tr>
<tr><td>Courses on innovation should be added to the curriculum.</td></tr>
<tr><td>Consideration of individual differences in curriculum design.</td><td>Individual differences such as student readiness, etc. should be taken into account when designing the curriculum.</td></tr>
<tr><td>Sufficiency of teaching practice course hours.</td><td>Starting from the 1st grade, teaching practice courses should be included in the curriculum in different periods.</td></tr>
<tr><td>Practical realization of laboratory courses in the distance education process.</td><td>Recognizing their importance, applied courses should be conducted face-to-face in science and education faculties in the online process.</td></tr>
<tr><td>The remuneration of teacher candidates in teaching practice.</td><td>As in other branches, prospective teachers who participate in teaching practice should be paid.</td></tr>
<tr><td>Updating the programs carried out in science faculties without seeing the outcomes in terms of content.</td><td>The curriculum applied in science faculties should be prevented from being updated without seeing the outcomes in terms of content.</td></tr>
<tr><td rowspan="4">Conducting pedagogical formation education.</td><td>For those without a teaching program in higher education programs, certificate programs should be carried out taking into account the needs.</td></tr>
<tr><td>The large number of teachers as a result of formation education and the problems of assignment should be eliminated through employment.</td></tr>
<tr><td>Interviews in appointments should be abolished or, if they are to continue, special field competencies should be taken into account.</td></tr>
<tr><td>Pedagogical formation education should be conducted according to the need for teachers in the country.</td></tr>
<tr><td rowspan="2">Use of Technology</td><td rowspan="2">Conducting distance education process and online assessment.</td><td>Courses related to distance education as elective courses should be organized with BÖTE and added to the program.</td></tr>
<tr><td>Online assessment materials should be developed.</td></tr>
</table>

Problems Related to the Learning/ Teaching Environment	Textbook and Other Course Materials	Sufficiency of materials that can be used in the distance education process.	Local and foreign web link, Z book and QR code applications and interactive applications should be included in the program.
			Short activities applied in the world should be adapted and used in our country.
			Using books used in the world such as Skoog-West as textbooks and increasing the number of similar books can help the Turkish language to be used in science.
		Sufficiency of concrete materials related to the course.	Lessons should be supported with concrete materials.
			Animation and simulation demonstrations in chemistry should be increased by adapting them to the process.
	Teaching Environment	The opportunity for active participation in the learning environment.	Time should be increased to create time for active participation.
		The suitability and limits of learning environments for group work.	Out-of-school learning environments should be increased and improved.
		Encouraging student participation and support in terms of metacognitive skill development.	Collaborative learning environments should be created.
	Teaching Methods and Techniques	The use of mostly confirmatory laboratory approach in the laboratory.	Methods and techniques unique to each field should be followed in chemistry in higher education.
			A laboratory approach based on research and inquiry and open-ended experiments should be developed.
		Integration of methods and techniques related to the topics into the course.	Instructors should be trained in current methods and techniques.
	Connections of Chemistry (Other disciplines, daily life, society, environment, industry, etc.)	The frequency with which sustainability and environmental education topics are included in the curriculum.	Sources in foreign languages on chemistry, technology and society should be adapted into Turkish.
		The level of interaction between field experts from different departments such as Chemistry Education, Chemistry Department and Chemical Engineering.	Chemistry courses, basic chemistry textbooks and trainings of departments such as physics, medicine, engineering, etc. should be organized by chemistry field experts.
	Use of Technology	Conducting distance education process and online evaluation.	In this process, simple devices should be introduced, demonstrated and used in external environments.
	Laboratory and Experiment	Differences in the experiment sheets used by different universities and their adequacy.	Practices that increase the self-efficacy of prospective teachers about laboratory for secondary education should be emphasized.
			A program for applied chemistry experiments should be developed in cooperation with BÖTE.
			Uniform laboratory experiment books should be prepared.
		Preparation of the experiment report with specific techniques.	Information about different report writing techniques such as V diagram should be provided.
		Laboratory conditions and adequacy of application.	High school chemistry experiments course should be developed and renewed in an inquiry-based way.
			University laboratories should be renewed according to current conditions.
			Necessary precautions regarding laboratory safety should be taken and integrated into the process.

Instructor-Related Problems	Instructor Competencies	Lack of instructor motivation.	In-service trainings should be provided in line with the needs of academic staff.
		Recruitment of lecturers.	Merit should be taken into account in the recruitment of academic staff.
			Oral exams for associate professorship should be brought back.
		Instructors' level of mastery of technological applications, different teaching and methods.	Units such as ÖGEM, which will provide analysis of students and lecturers at the university center, should be increased and activated.
		Cooperation between instructors and MoNE.	Environments should be created to increase the cooperation between academic staff and MoNE.
			Faculty members should work as teachers at the MoNE in order to experience the field during the postgraduate education process.
Student-Related Problems	Undergraduate Student Competencies	Inadequacy of students' research skills.	Field and non-field elective courses should be enriched.
			Project supports such as STAR TUBITAK-2247C should be increased for students.

DISCUSSION AND RECOMMENDATIONS

This section of the workshop report prepared with an academic approachprovides a brief and analysis of kshop data collection tools. The authors of the report present an analysis based on the scientific literature on the workshop subject in an effort to provide the reader with information based on solid scientific grounds.

Chemistry education for secondary school students in Türkiye plays a vital role in fostering their interest in fundamental sciences and engineering and preparing them for successful careers in related fields. The decline in the number of students choosing chemistry as a major or future career has become a growing concern in chemistry education and related industries worldwide (Fitriyana et al., 2023; Osborne and Collins, 2000; Woldeamanuel, 2014; Taber, 2019; Kiarie, 2016; Coll et al., 2006; Treagust et al., 2000).

The evaluations and conclusions regarding the problems in chemistry education in Türkiye, as well as proposed solutions, are categorized under the four main headings for secondary/high school and undergraduate education levels:

1. Chemistry curriculum
2. Instructor (lecturer/teacher)
3. Learning environment/teaching materials
4. Student

5.1. Challenges and Solutions in Chemistry Education at Secondary Level

5.1.1. Chemistry Curriculum

For 21st century learning, the curriculum stands as a vital instructional component that offers various teaching and learning approaches (Kopnina, 2020; Meyer and Norman, 2020). Just like in other fundamental sciences, issues with the chemistry curriculum hinder students and chemistry teachers from achieving their goals. In this section, we discuss the problems highlighted in the workshop findings regarding the curricula at the secondary and undergraduate levels (chemistry teaching/chemistry department), along with solution suggestions.

1. Few Practice-oriented Learning Outcomes in the Chemistry Curriculum

In science courses that involve practical application like chemistry, inadequate utilization of laboratories can lead to significant issues in teaching the subjects. While theoretical knowledge is crucial, it alone is insufficient. Hence, it is vital for students to experience and comprehend what they learn through their senses during the learning process.

Based on the assessment of workshop data, the following potential problems are identified in relation to this issue:

Forgetting Learned Knowledge Quickly: If conceptual knowledge remains unapplied, its retention in the mind will be brief. Conversely, information acquired through practical application tends to be retained for longer periods. Therefore, in the learning process, it is crucial for students to engage their senses and experience what they learn (Gardner, 1983). For instance, while verbal explanations or videos may suffice for auditory or visual learners to comprehend a chemistry experiment, a more lasting understanding is achieved through hands-on experience, actively engaging with experimental tools, and receiving guidance from the teacher. This approach caters to students with diverse intelligence and enhances the quality of learning.

Difficulty in Learning Abstract Concepts: Chemistry encompasses abstract concepts, and a lack of practical exposure deprives students of the opportunity to grasp these concepts concretely. Consequently, students may encounter difficulties in comprehending chemistry topics and rely solely on memorization-based learning approaches (Woldeamanuel, 2014; Johnstone, 2000; Sirhan, 2007; Tsaparlis, 2016).

Inadequate Focus on Real-World Applications in the Chemistry Curriculum: Chemistry offers practical applications to real-world problems. Therefore, neglecting this aspect can hinder students from utilizing their knowledge to solve daily life issues, impeding the development of scientific literacy, technological proficiency, and scientific process skills. Addressing this issue is critical for effective chemistry education (Özden, 2007).

Inadequacy in Equipping Students with 21st Century Skills: Insufficient practical engagement in chemistry teaching inhibits the development of crucial skills such as scientific process skills, problem-solving strategies, experiment design skills, and analytical thinking skills among students (Freeman et al., 2014; Omiko et al., 2017; Dede, 2010).

Decreased Student Motivation: Insufficient practical experience in chemistry teaching also diminishes students' motivation. Students often seek real-life applications of chemistry and may lose interest if they are not provided with ample opportunities for hands-on practice. Moreover, without practical learning experiences, students struggle to think in multidimensional ways and establish connections between concepts, which can lead to difficulties in subsequent levels of education and negative perceptions of school and chemistry courses.

Based on the comprehensive evaluation of workshop findings related to these problems, the following solution suggestions were proposed:

Laboratory Experiments and Practical Applications: The chemistry curriculum should prioritize laboratory experiments and practical applications, enabling students to experientially explore the fundamental principles of chemistry. Through hands-on experiments and practical activities, students can engage with chemistry topics tangibly and enhance their problem-solving skills.

Integration of Different Learning Methods: To address application-related challenges in chemistry education, incorporating active learning methods like problem-based learning and project-based learning is recommended. Students should be assigned projects that involve solving real-world problems, with a particular emphasis on the practical applications of chemistry. This approach allows students to witness the real-life relevance of chemistry and improves their problem-solving abilities (Morra, 2018).

Emphasis on Real-World Applications in the Curriculum: The chemistry curriculum should underscore the practical applications of chemistry in daily life and the real world. Demonstrating how chemistry operates in practice gives topics greater meaning and boosts student motivation. Examples showcasing the use of chemistry in environmental, industrial, or medical contexts can be explored to help students understand its applications.

2. Demanding and Intensive Chemistry Curriculum

Ensuring the chemistry curriculum aligns appropriately with the allotted class hours is crucial for effective and efficient learning of chemistry knowledge by students. It is important to match the chemistry curriculum to the designated class hours in order to facilitate successful comprehension of chemistry concepts and the development of relevant skills. In light of this, the following issues arising from the evaluation of workshop data and their respective impacts are discussed below:

Challenges in Depth of Learning: A demanding curriculum leaves students with insufficient time. Consequently, teachers and students may struggle to dedicate ample time to practice and thoroughly cover topics. This can hinder students' ability to grasp concepts in-depth and internalize the subject matter.

Limited Opportunities for Experimentation and Practice: A burdensome chemistry curriculum can restrict the availability of opportunities for experimentation and practical exercises. The intensive nature of the curriculum might prevent teachers from allocating sufficient time for laboratory work, depriving students of valuable chances to enhance their practical skills through experimentation.

Student Fatigue and Loss of Motivation: An excessively intensive chemistry curriculum can lead to student fatigue and demotivation. The constant rush from one topic to another and the pressure of consecutive exams can render the learning process monotonous and arduous. Consequently, students may lose interest and experience a decline in motivation.

Based on the evaluation of workshop findings regarding these issues, the following suggestions for solutions have been proposed:

Curriculum Reevaluation: The chemistry curriculum should be reassessed to avoid exceeding students' capacity within the given course hours. Achieving a more balanced distribution of topics and reducing the intensity would enable students to delve deeper into subjects and develop a thorough understanding.

Identification of Priority Topics: It is crucial to identify key topics in the curriculum. Prioritizing these topics allows students to focus on the essential aspects and attain a profound comprehension. By enhancing their understanding of pivotal concepts, students can establish a solid foundation in chemistry.

Flexibility and Adaptability: Introducing flexibility in the curriculum empowers teachers to adopt an approach that aligns better with students' needs and interests. Teachers can make necessary adjustments to the pace of instruction, speeding up or slowing down certain processes as required. This flexibility facilitates improved understanding of topics and enhances students' adaptability to the learning process.

Provision of Support Programs: Support programs can be established to aid students who struggle with an intensive chemistry curriculum. Additional course materials, teacher support, or student mentoring programs can be made available to address individual needs and support students in overcoming challenges.

3. Inadequacy of Skill-related Learning Outcomes in the Chemistry Curriculum

The chemistry curriculum plays a crucial role not only in imparting students with fundamental principles and concepts of chemistry but also in equipping them with essential skills and fostering scientific thinking. However, the lack of emphasis on skill-related outcomes in the chemistry curriculum can give rise to various issues.

Based on the evaluation of workshop data, the following noteworthy problems associated with this issue are identified:

Insufficient Development of Scientific Process Skills: If the chemistry curriculum fails to adequately cultivate students' scientific process skills, they may not only acquire knowledge of chemistry but also miss out on learning essential scientific methods and research skills. This deficiency may result in a lack of vital skills like scientific thinking, experimental design, data analysis, and concluding.

Neglect of 21st Century Skills: When the chemistry curriculum does not sufficiently prioritize 21st century skills such as critical thinking, problem-solving, communication, collaboration, and creativity, students' opportunities to develop these skills become limited. This limitation may hinder students from acquiring skills essential for solving complex problems, collaborating effectively, and generating innovative solutions in the modern world (González-Pérez and Ramírez-Montoya, 2022; Holme vd., 2010; Mbajiorgu and Reid, 2006).

In light of the workshop findings, the following suggestions for solutions have been proposed:

Focus on Scientific Process Skills: The chemistry curriculum should be designed to actively foster students' scientific process skills. Practical experiences, such as laboratory experiments and projects, should emphasize the various steps involved in scientific inquiry, including experimental design, data collection and analysis, and drawing valid conclusions. Furthermore, students should be provided with opportunities to develop research skills and analytical thinking through activities like reading and critically evaluating scientific articles.

Enhanced Integration of 21st Century Skills: The chemistry curriculum should place greater emphasis on the integration of 21st century skills. It should include a wide range of activities aimed at developing students' critical thinking, problem-solving, communication, collaboration, and creativity. Group projects, discussions, presentations, and research-based tasks that promote collaboration and communication should be integrated into the curriculum. Additionally, leveraging technology and digital tools is crucial in supporting students' acquisition of 21^{st} century skills.

Teacher Training and Support: Teachers should receive comprehensive training and support in teaching science process skills and fostering 21^{st} century skills. They should be equipped with the necessary knowledge and methods to effectively teach these skills. Ongoing professional development opportunities and collaborative platforms can aid teachers in further developing and implementing these skills effectively.

4. Teachers' Limited Knowledge of the Chemistry Curriculum

Inadequate familiarity with the chemistry curriculum by teachers can lead to significant issues in chemistry instruction, as well as in other subjects.

In this context, the problems identified through the workshop evaluation, along with their effects, are outlined below:

Incomplete Understanding of the Curriculum: Teachers may engage in lesson planning and implementation without fully grasping the curriculum. Consequently, they may present the objectives and learning outcomes of the chemistry curriculum to students in an incomplete or inaccurate manner.

Inadequate Comprehension of the Content: When teachers have an insufficient understanding of the chemistry curriculum's content, they may convey incomplete or incorrect information to students. This hinders students' ability to grasp the fundamental concepts and engage in in-depth learning.

Program Implementation: Insufficient proficiency in the curriculum leads to ineffective implementation by teachers. As a result, teachers may fail to carry out the activities, projects, or experiments prescribed by the curriculum in a complete or satisfactory manner.

Based on the evaluation of all the workshop findings, the following solutions have been proposed to address these issues:

Teacher Training (In-service Training): Teachers should receive comprehensive training and guidance on the fundamental principles, objectives, and content of the curriculum. They should develop a thorough understanding of the curriculum's learning outcomes and align their lesson plans accordingly.

Regular Evaluation and Updating of Curricula and Feedback: The MoNE, along with teachers, academics, and all relevant stakeholders, should regularly evaluate and update curricula. Taking into account feedback and experiences from teachers and students, programs should be improved and adapted to reflect current scientific developments. Student feedback is particularly valuable in tailoring the program to better meet student needs.

Collaboration and Knowledge Sharing: Encouraging collaboration and information sharing among teachers is essential. Through sharing their experiences and best practices, teachers can enhance their knowledge and implement the curriculum more effectively.

Provision of Supportive Resources: Teachers should be provided with resources to support curriculum implementation. These resources may include guidebooks, sample lesson plans, experiments, and activities. By utilizing such resources, teachers can enhance the effectiveness of program implementation.

5. Fragmented Approach to Biology, Physics, Chemistry, and Mathematics Curricula

Biology, Physics, Chemistry, and Mathematics are disciplines that are closely interconnected. Treating them as independent curricula can lead to challenges in teaching the basic sciences.

In light of this, the problems identified through the workshop evaluation, along with their effects, are outlined below:

Loss of Content Cohesion: Independent curricula can hinder students' ability to grasp the interrelationships between these fundamental science subjects. Consequently, students may struggle to comprehend the conceptual connections and interactions among them.

Diminished Motivation to Learn: Repeated coverage of the same topics across different science courses can negatively impact students' motivation. This can result in a decline in their overall interest in science.

Shortcomings in Application: Independent curricula fail to illustrate how the fundamental sciences merge and are practically applied in real-life contexts.

Based on the evaluation of the workshop findings, the following solutions have been proposed to address these issues:

Adopting an Interdisciplinary Approach: Biology, Physics, Chemistry, and Mathematics curricula should embrace interdisciplinary approaches. Common topics and concepts should be identified, and the connections among these disciplines should be explicitly highlighted to students. This will enable students to comprehend how the basic sciences intertwine and interact with one another.

Collaborative Projects and Activities: Students should engage in joint projects and activities that incorporate biology, physics, chemistry, and mathematics. These projects will allow students to witness and establish connections between the basic sciences. For instance, an environmental science project could involve biological processes, chemical reactions, and physical phenomena.

Teacher Collaboration and Training: Teachers of biology, physics, chemistry, and mathematics should embrace interdisciplinary approaches and collaborate to demonstrate these connections to students. This collaboration ensures a cohesive learning experience that showcases the interrelationships among the basic sciences.

6. The Use of the Same Chemistry Curriculum Across All Achool Cypes

Utilizing a uniform chemistry curriculum across different school types can present certain challenges and limitations. In light of this, the problems identified through the workshop evaluation, along with their effects, are outlined below:

Neglecting Student Differences: Students enrolled in various school types, such as science high schools, vocational high schools, and Anatolian high schools, possess distinct interests, learning needs, abilities, and career aspirations. Consequently, a standardized program may not adequately cater to the diverse requirements of each school type. Employing a uniform curriculum fails to acknowledge the unique differences among students.

Diminished Student Motivation: Given that students in different school types may have varying interests and goals, employing the same curriculum may expose them to subjects that are either uninteresting or irrelevant to their career aspirations, resulting in decreased motivation. Moreover, students' motivation to study topics included in the Science High School program but not assessed in the Higher Education Institutions Examination (Basic Proficiency Test (TYT), Field Proficiency Tests (AYT)) significantly declines. Additionally, the limited number of science (Biology, Physics, Chemistry) questions in the Basic

Proficiency Test (TYT) and Field Proficiency Tests (AYT) hampers effective measurement and evaluation processes.

Based on the evaluation of the workshop findings, the following solutions have been proposed to address these issues:

Customization According to School Types: The chemistry curriculum should be tailored to suit different school types, considering unique learning objectives, content, and practices for each. This approach ensures a more relevant chemistry teaching experience that aligns with students' interests and goals.

Modifying Content and Questions of the Higher Education Institutions Examination: Expanding the number of university entrance exam questions and aligning them with the content covered in the chemistry curricula of all school types can mitigate the negative impact on student motivation.

Flexibility and Elective Courses: Introducing flexibility in the curriculum and offering elective courses provide students with the opportunity to select chemistry subjects based on their individual interests and abilities. For example, science high school students can be offered advanced chemistry courses, while vocational high school students can explore courses that emphasize the industrial applications of chemistry.

Collaboration and Resource Sharing: Fostering collaboration and resource sharing among chemistry teachers across different school types should be promoted. Sharing experiences and best practices will facilitate the development and implementation of effective programs. Through mutual support, teachers can create materials and teaching strategies that better cater to the needs of students in diverse school types.

7. The Lack of Cooperation Between Institutions

Insufficient collaboration between institutions, particularly universities and industry organizations, in teaching chemistry to high school students can lead to various issues. The significant problems and their impacts, as identified through the workshop evaluation, are outlined below:

Lack of Real-World Context: The absence of collaboration with external institutions, such as universities and industry organizations, in chemistry education can limit students' exposure to real-world applications of the subject. As a result, students may miss out on the opportunity to apply their theoretical knowledge in practical settings and struggle to understand the relevance of chemistry in everyday life.

Neglecting Career Opportunities: Institutions like universities and industry organizations can provide valuable information about career pathways and related professions to students. However, the lack of collaboration with these institutions may hinder students from exploring diverse career options and making informed decisions about their future.

Insufficient Practical Experiences: University laboratories and industry organizations offer invaluable practical experiences and applications in chemistry. However, the scarcity of collaborations deprives high school students of such opportunities to gain hands-on experience. Consequently, students may face difficulties in developing laboratory skills and experiential learning.

Challenges in Staying Updated with Current Developments: The absence of collaboration with external institutions in chemistry education can make it challenging for teachers and students to keep up with the latest developments in the field. Universities, research centers, and industry organizations possess up-to-date information on new discoveries, technological advancements, and innovative applications in chemistry. However, effectively disseminating this information to schools and integrating it into chemistry teaching can be a hurdle.

Based on the evaluation of the workshop findings, the following solutions have been proposed to address these problems:

Establishment of Collaboration Networks: Collaborative networks can be established between schools, universities, and industry organizations. These networks facilitate the sharing of knowledge and resources, providing opportunities to integrate real-world applications into chemistry teaching. Teachers can benefit from these networks by organizing field visits, inviting expert speakers, and facilitating mentorship programs for students.

Internship and Practicum Opportunities: Chemistry students should be offered internships or practicum projects in collaboration with universities, research centers, and industry organizations. These opportunities allow students to experience real-world applications of chemistry and enhance their professional skills. Moreover, internships and practicums aid students in exploring potential career paths.

Seminars and Workshops: Universities and industry organizations can organize seminars and workshops specifically for high school students. These events inform students about developments in the field of chemistry, career opportunities, and related professions. Students have the chance to interact with experts, ask questions, and deepen their understanding of the subject.

Virtual Collaboration and Online Resources: Leveraging technology, students can engage in virtual collaboration and access online resources provided by different institutions. Webinars, virtual laboratories, online educational materials, and resources can facilitate chemistry learning and practical experiences. This approach enables inter-institutional collaboration and resource sharing, enriching students' chemistry education beyond physical boundaries.

Continuous Professional Development for Teachers: Teachers should be offered continuous professional development opportunities to stay updated with the latest developments in chemistry and effectively transfer this knowledge to their students. Seminars, conferences, workshops, and other educational activities help teachers maintain their knowledge and skills. By doing so, they can convey the most current knowledge and practices to their students.

8. Inadequate Implementation of Measurement and Evaluation Processes in the Chemistry Curriculum

The effective implementation of measurement and evaluation methods in the chemistry curriculum is crucial for accurately assessing and enhancing students' learning. Assessment and evaluation serve as powerful tools to gauge students' knowledge, skills, and abilities, monitor their progress, and guide the educational process. The workshop findings shed light on the following problems and their impacts:

Insufficient Realistic Assessment of Student Performance: Ineffectively implementing measurement and evaluation methods in the chemistry curriculum may result in a lack of realistic assessment of student performance. Relying solely on one type of assessment tool, such as written exams or multiple-choice tests, can make it challenging to determine whether students truly comprehend chemistry topics or can successfully apply their skills.

Lack of Formative Assessment: Formative assessment aims to monitor students' progress during the learning process and provide feedback. However, the absence of formative assessment in the chemistry curriculum can hinder the measurement and development of students' current knowledge and skills.

Neglecting Student Differences: Each student possesses unique learning styles, interests, and abilities. Neglecting these individual differences in the chemistry curriculum may prevent students from being assessed based on their specific needs. Consequently, students may not have the opportunity to fully realize their potential, leading to a decrease in motivation.

Based on the evaluation of all workshop findings regarding these issues, the following solution suggestions were put forth:

Utilize Diverse Assessment Methods: Incorporate various assessment methods into the chemistry curriculum, such as exams, projects, laboratory work, presentations, performance tasks, and portfolios. This diverse range of assessment tools better captures students' different skills and learning styles, enabling a more accurate evaluation of their actual performance.

Highlighting the Significance of Formative Assessment: Emphasize the importance of formative assessment in the chemistry curriculum. Provide students with regular feedback throughout the learning process, and utilize this feedback to monitor their progress and adapt teaching strategies accordingly. Formative assessment serves as a vital tool for measuring and nurturing students' current knowledge and skills.

Adopting an Individualized Assessment Approach: Embrace an individualized assessment approach that takes into account student differences. Employ assessment methods that align with students' interests, abilities, and learning styles. Offer personalized feedback and support to help students reach their learning goals and unlock their full potential.

Encouraging Student Collaboration and Self-Assessment: Promote student collaboration and self-assessment methods. Allow students to evaluate each other's work and reflect on their learning progress. This fosters self-confidence, active engagement, and ownership of the learning process.

5.1.2. Instructor (Lecturer/Teacher)

1. Teachers' Research and Project Preparation Competencies

Science teachers face challenges when it comes to developing projects (Timur and Çetin, 2017). In the workshop, it was highlighted that chemistry teachers specifically encounter difficulties in preparing and managing projects, such as eTwinning. It was suggested that offering courses on current chemistry topics like polymers and nanotechnology during pre-service and undergraduate education, as well as encouraging teachers engaged in project work, would help address this issue.

2. Teachers' Working Conditions

Working conditions play a crucial role in chemistry teachers' job satisfaction (Otrar and Öztürk, 2013). Inappropriate working conditions were raised as another problem in the workshop. The heavy curriculum, overcrowded classrooms, inadequate material and moral support, and insufficient in-service training in the field contribute to negative working conditions. Additionally, parents' demands for exam-oriented education and inadequate support from school administration exacerbate these challenges. Under such circumstances, teachers struggle to keep themselves updated and may feel isolated. Improving teachers' living conditions, providing in-service training tailored to their needs, raising parents' awareness about educational goals, and considering teachers' opinions more seriously regarding school administration are suggested approaches to enhance working conditions.

3. Teachers' General Competencies

It was noted that there are concerns about teachers' general competencies, particularly in teaching at the Science and Art Centers (BILSEM) and the scores of teaching graduates. Insufficient effective in-service training aligned with teachers' needs, inadequate teacher training programs (particularly in undergraduate programs designed by the CoHE), and an excess of teaching graduates relative to demand can undermine teacher competence. Such issues may impact teachers' professional esteem. Ensuring that students admitted to education faculties have high scores, balancing the supply and demand for teachers, establishing a digital competency area specific to BILSEM, analyzing teacher needs and the problems identified in reports, and providing tailored in-service training can contribute to solving these problems. These solutions are aligned with the Chemistry Teacher Special Field Competencies defined by the MoNE (MoNE, 2011).

4. Teachers' Professional Perceptions, Attitudes, and Communication

Professional perceptions of science teachers are vital to their competencies (Hacıömeroğlu and Şahin-Taşkın, 2010). For chemistry teachers, who were the focus of the workshop, feeling financially and spiritually isolated in their professional journey, unfulfilling seminar experiences, and lack of collaboration with other disciplines can influence their professional perception, attitude, and communication. As a solution, improving teachers' living conditions and providing material and moral support are important. Regarding seminars, organizing programs that facilitate professional growth and allowing teachers to choose seminars aligned with their interests and needs can be beneficial.

5. Teachers' Teaching and Evaluation Competencies

Teachers expressed difficulties in teaching and implementing diverse assessment and evaluation approaches, particularly in out-of-school settings. Offering relevant courses during pre-service and in-service education can help alleviate these problems. This approach contributes to the realization of chemistry teacher competencies set by the MoNE (MoNE, 2011).

6. Teachers' Competencies in Using Technology and Distance Education

In the modern age, teachers' utilization of technology is crucial for students to construct their knowledge (Gilakjani, Lai-Mei and Ismail, 2013). Additionally, distance education has become an integral part of formal education, especially during and after the COVID-19 pandemic. Teachers' lack of digital competencies, inability to keep up with technology due to financial constraints, and challenges in accessing technology hinder their effectiveness in utilizing technology and distance education. These problems can lead to traditional and uninspiring lessons, low student motivation, difficulty in capturing interest, struggles in visualizing abstract information, limited comprehension of subject matter, and challenges in planning online distance courses. To address these issues, teachers can be supported through in-service training focused on integrating information and communication technology (ICT) effectively into their lessons. Additionally, developing proficiency in using basic devices, providing distance education training to teachers, and creating online assessment techniques and materials should be considered. Furthermore, training on technology integration in teaching using concrete examples is also valuable.

5.1.3. Learning Environment/Teaching Materials

The learning environment is a comprehensive and interconnected concept that encompasses both the context in which learning occurs and the learning itself. It can be likened to an ecosystem that includes learning activities and outcomes (OECD, 2013).

Traditionally, the learning environment was limited to lectures and laboratory sessions conducted within the school building. However, advancements in technology and evolving educational perspectives have resulted in diverse learning environments (Kinshuk et al., 2016). Students now have the opportunity to learn in various settings and have different experiences. For instance, virtual learning environments (O'Leary and Ramsden, 2002) provide online interactions where students and instructors engage in different activities. In these environments, students can access course materials, participate in interactive activities, conduct experiments in virtual labs, and communicate with peers and teachers online.

Virtual learning environments facilitate education without geographical or physical constraints, allowing students to progress at their own pace.

Out-of-school learning environments refer to informal learning settings (Cors et al., 2018) where students have the chance to learn outside the traditional classroom. Museums, libraries, nature parks, art galleries, and historical sites are examples of places that offer unique learning experiences. Such environments support concrete and real-life experiences, enabling students to gain contextual and practical knowledge.

Below, the problems identified in the workshop findings regarding the learning environment are outlined, along with suggested solutions.

1. Problems Related to Physical Environment Conditions

The workshop findings indicate that the physical conditions of classrooms and laboratories, as well as overcrowded classes, are not conducive to the development of 21st century skills. The root causes of these problems include the absence of diverse classroom designs suitable for different types of schools and inadequate infrastructure. These issues have several negative effects. For example, the lack of standardized classroom designs limits flexibility and adaptability in learning environments. Traditional desk arrangements in classrooms restrict student interactions and hinder the development of 21st century skills, such as collaboration, communication and critical thinking (İsmailoğlu and Zorlu, 2018). Insufficient resources and equipment in laboratories, workshops, and other learning spaces (e.g., Akın, Adıgüzel, and Aytaş 2022) may deprive students of experiential and practice-based learning opportunities, hampering their development of 21st century skills and impacting their future success.

A noisy learning environment, resulting from crowded classrooms, physical conditions, and infrastructure inadequacies can distract students and impede their focus during the learning process (Tuncer, Bal, Özüt and Köse, 2012). Moreover, inappropriate classroom organization and resource scarcity can lead to challenges in classroom management and hinder effective teaching. Students may also struggle to fully grasp the subject matter due to these problems.

To address these issues, a review of the physical environment within the education system is necessary. Creating flexible and adaptable classroom designs for different types of schools and addressing infrastructure deficiencies are crucial steps. Providing suitable learning environments for students is essential to foster the development of 21st century skills and enhance student success (Yakup, 2022).

2. Insufficient Time Allocated for Laboratory Practices

The workshop identified the lack of dedicated class hours for laboratory work as the primary reason for inadequate time allocated to practical experiments. This can prevent students from benefiting from experiential and practice-based learning opportunities. Laboratory practices are vital for students to understand the interconnectedness of theory and experiment by experiencing them firsthand (Yeşiloğlu and Köseoğlu 2020). However, the current education programs allocate insufficient time to laboratory studies. The absence of dedicated class hours specifically for laboratory work can hinder students from fully experiencing and comprehending laboratory experiments in depth. The consequences of this situation are significant. Students may not adequately develop their scientific and analytical thinking skills, as they lack opportunities to practice and understand the interconnectedness of theory and experiment. They may also struggle to grasp the nature of science and its epistemology (Yeşiloğlu and Köseoğlu, 2020). Moreover, experiments and observations conducted in laboratories provide students with a profound understanding of science and related disciplines. However, limited time may prevent students from benefiting from these opportunities.

Laboratory practices are crucial for helping students understand the scientific method, develop research skills (Hodson, 1996), and increase their interest in science. Therefore, allocating sufficient time for laboratory practices (Uluçınar, Cansaran, and Karaca, 2004) is essential to address this deficiency in students' education. Providing more time for laboratory applications through curriculum revisions allows students to fully embrace experiential learning opportunities. Additionally, teachers should receive the necessary support and resources to effectively plan and manage laboratory work.

3. Problems Related to the Need for Course Materials and Resources

Insufficient laboratory materials and equipment, a lack of technological resources, inadequate course materials for distance education, poor textbook quality (e.g., inappropriate language, insufficient activities, misalignment with assessment and evaluation questions), insufficient models, and the absence of teacher guidebooks were identified as problems related to course materials and resources. These problems stem from insufficient school funding and improper allocation, as well as the use of different textbooks across schools.

The lack of laboratory equipment and resources limits students' practical experiences and may dampen their interest in science. Insufficient technological resources can hinder students' development of digital skills and their access to information. Inadequate course materials for distance education (Gülhan and Tümay, 2023) can impede effective learning at home. Poor textbook quality can significantly impact learning environments, encompassing content, presentation, and materials (e.g., Gültekin and Nakiboğlu, 2015). Incomplete, inaccurate, or difficult-to-understand information in textbooks may hinder students' comprehensive understanding of the subject matter, reducing learning efficiency and promoting superficial memorization instead of deep comprehension. Boring or uninteresting textbooks can also lead to disengagement and loss of interest in the subject. Textbooks should provide opportunities for questioning, analyzing, and synthesizing new ideas, but qualitatively inadequate textbooks may hinder the development of these skills, transforming students into passive recipients of information. Insufficient models can pose challenges in visualizing abstract subjects, while the lack of teacher guidebooks can hinder effective lesson planning and management. The use of different textbooks in each school type, textbooks not written in language suitable for students' level, assessment and evaluation questions in textbooks not aligning with standardized exam questions, and insufficient activities in textbooks contribute to the proliferation of publications, making it challenging for teachers to select appropriate resources.

These problems adversely affect the quality of education and students' potential to develop 21st century skills. To address this, it is crucial to allocate school funds according to educational needs and update laboratory materials, technological resources and course materials. Textbooks should be enhanced qualitatively, adopting a student-centered approach and incorporating interactive content. The provision of teacher guidebooks will support the teaching process. Meeting the need for course materials and resources in secondary and high school education will enable students to learn more effectively and better prepare for their future.

4. Problems Related to Teaching Methods and Techniques

The learning model adopted by teachers and their choice of teaching methods along with the implementation of corresponding activities, play a significant role in creating a conducive learning environment (Kaplan, 2011). Problems related to teaching methods and techniques identified in the workshop include the prevalence of traditional methods (e.g., lecture-based instruction, cookbook-style experiments) that are incompatible with 21st century skills, limited active participation or engagement, a restricted learning environment, and challenges in the traditional experiment report format or the report writing process. Relying heavily on traditional methods can manifest as classroom presentations, textbook-based information transmission and simple experiment demonstrations. Such methods often result in passive knowledge acquisition by students (Marlowe and Page, 2005), hindering effective student engagement and their ability to take control of their own learning process. The traditional experiment report format typically requires students to follow a standardized structure, which can limit creativity and critical thinking. Additionally, the report writing process may be challenging for students, becoming a tedious task in the learning process (Burand and Ogba, 2013). Factors contributing to these problems related to learning and teaching methodologies include entrenched teaching habits, students' inadequate mathematical processing skills, cognitive differences among students, teachers' time management, and teachers' content knowledge. This situation impedes students' visualization of abstract chemistry concepts, promotes rote learning, and hampers the development of 21st century skills. Active participation by students and meaningful learning processes are constrained by these problems.

To overcome these challenges, the workshop participants suggested that teachers should encourage student engagement and enrich learning environments through innovative teaching methods and techniques. Interactive learning materials and experiments should be developed to bridge abstract chemistry concepts with real-world examples, allowing students to apply 21st century skills. The format of experiment reports should be revised to provide more effective opportunities for students to exercise their creative thinking and communication skills. For example, a more creative format, such as a letter from a research team, could replace the standard experiment report (Burand and Ogba, 2013).

These suggestions align with the principles outlined in OECD reports (2023) for creating "innovative learning environments" that support 21st century competencies. These principles include placing learning and participation at the core, promoting social and collaborative learning, considering students' motivations and emotions, acknowledging individual differences, maintaining high standards and expectations while managing workloads effectively, employing assessments aligned with learning objectives, and fostering horizontal connectivity across activities and subjects within and beyond the school.

5. Students' Anxiety and Lack of Self-Confidence When Working With Tools, Equipment, and Chemicals in the Laboratory

Students' anxiety about potential harm and their lack of self-confidence when engaging with laboratory tools, equipment, and chemicals can adversely affect the learning process. These concerns may make students feel insecure and discouraged, hampering active participation in laboratory experiments, and hindering their ability to gain practical experience.

To address these issues, strategies should be implemented to ensure students' safety and foster their self-confidence in the laboratory environment. Firstly, teachers should provide detailed safety training to students, covering the proper use of laboratory equipment, handling of chemicals, and adherence to safety procedures (Hill and Finster, 2016). Starting with simple and safe experiments can help students build confidence initially. Over time, the complexity and risk level of experiments can be gradually increased, allowing students to develop skills and learn risk management. Addressing student psychology and creating a safe learning environment in the laboratory can enhance students' self-confidence, leading to more active participation in laboratory experiments. This, in turn, facilitates the development of scientific thinking skills and maximizes the benefits derived from the learning process.

6. Inadequate or Nonexistent Out-of-school Learning Opportunities, Such as Projects, Field Trips, Observations, and Science Museums

Insufficient or absent out-of-school learning opportunities limit students' learning experiences. Experiential learning opportunities enable students to explore and gain a deeper understanding of the real world (Barron and Bell, 2015). Inadequate out-of-school learning opportunities restrict students to a limited perspective within the confines of the classroom environment, hindering their comprehensive understanding of subjects, the development of problem-solving skills, and the expression of creativity.

The main reasons for this problem may include a lack of emphasis and support from school administration, teachers' reluctance to take an active role, and challenges in managing student behavior. Additionally, students may not be encouraged to undertake projects, and the importance of experiential learning opportunities may not be emphasized. Project work and out-of-school trips provide students with opportunities for research, problem-solving, and showcasing their creativity. However, without adequate encouragement and support for such activities, students may miss out on these valuable experiences. Overcoming this problem requires collaboration and support among school administration, teachers, and students. Placing greater emphasis on out-of-school learning opportunities, directing resources towards these endeavors, and encouraging students to engage in projects can enrich learning experiences, fostering deeper and more interactive learning.

5.1.4. Student

1. Lack of Engagement in the Classroom

This issue arises from their lack of appreciation for the lesson, which hinders meaningful learning. The proposed solution to increase student interest and motivation emphasizes creating engaging learning environments. Students should be provided with interactive and participatory learning environments where they can be more active. Additionally, the learning environment should be designed based on group dynamics, offering opportunities for students to collaborate, work together, and discuss. This situation fosters increased interest and participation in the course, supporting meaningful learning processes (Hampden-Thompson and Bennett, 2013).

2. The Problem of Students' Negative Attitudes Towards Lessons

This problem has multiple causes. The primary reason is their difficulty in transferring learned knowledge, making it challenging to apply their knowledge to real-life situations and hindering meaningful learning. Additionally, large class sizes can limit individual attention and interaction opportunities, reducing interest in the lesson. The unique learning styles of Generation Z also affect attitudes towards lessons, as they prefer interactive, technology-based, and socially interactive learning environments. Furthermore, students' misconceptions negatively impact their interest and proficiency levels (Assem, Nartey, Appiah, and Aidoo, 2023). The suggested solution to address these problems involves enriching lessons with various teaching methods (Sugano and Mamolo, 2021). Offering different learning experiences can enhance students' interest in the course, while measures such as reducing class size by increasing the number of schools, providing in-service training for teachers, and facilitating social interaction with technology aim to improve learning environments.

3. Readiness Problem

This refers to the variations in students' learning competencies across different types of schools and their inability to perform basic mathematical operations. The primary reason for this problem is the differences in students' competencies and individual characteristics. Additionally, students' lack of mathematical processing skills and the absence of support for these skills in mathematics courses for science-related subjects contribute to the problem. As a result, students being at different levels lead to challenges in areas such as university exams. The problem of readiness negatively affects students' interest in course activities, making subjects like chemistry difficult due to the inability to perform mathematical operations (Gultepe, Celik, and Kilic, 2013). The recommended approach to address this problem suggests providing differentiated education based on school types. Furthermore, analyzing students' abilities and interests accurately and guiding them appropriately, as well as teaching fundamental mathematical subjects for mathematical literacy at all levels of education, can improve students' readiness and their ability to perform mathematical operations.

4. Low Interest and Motivation for Learning

Several factors contribute to this problem. The primary reason is students' sole focus on the university entrance exam (İğci, 2023; Özden, 2007), resulting in reduced interest in other courses and a lack of meaningful learning. Additionally, students' inadequate readiness when transitioning to secondary education diminishes their motivation to learn, as they may lack essential skills such as reading comprehension or mathematics. Teachers' reliance on traditional teaching methods and a failure to integrate technology are also factors influencing low interest and motivation. Consequently, students become passive, show apathy, and meaningful learning processes do not occur. The suggested approach to tackle this problem involves enriching lessons with various teaching methods, integrating school activities (such as projects or school-based awards) into the university entrance exam score calculation (for students entering related fields), considering students' skills based on school type, diversifying the curriculum accordingly, and restructuring the university entrance exam to align with these programs. Additionally, providing interactive lessons is a crucial step in increasing student interest and motivation.

5. Lack of Participation in Project Work

Teachers face the challenge of students' reluctance to engage in project studies and their lack of appreciation for these assignments. The source of this problem lies in the current exam system, with students primarily focusing on exam preparation for standardized tests (Özden, 2007). This focus on exams leads students to undervalue project work and exhibit reluctance to participate. Consequently, students prioritize exam success and neglect project work. The proposed solution to address this problem suggests assigning points to activities, particularly project work, in the university entrance exam. This approach would enhance the value of project work for students entering related fields, increasing their motivation and willingness to participate. By assigning points to activities in the university entrance exam, students would perceive project work as a more significant and valuable learning experience, thereby fostering their participation and facilitating meaningful learning.

In conclusion, the main problem among high school students is their low interest and motivation for learning, which stems from various factors. The primary factor is their excessive focus on the university entrance exam, disregarding other subjects. Furthermore, students' inadequate readiness during the transition to secondary education contributes to the problem. The consequences include reduced interest in course activities, a lack of meaningful learning, and decreased academic performance. The recommended approach to address this problem is to make lessons more interactive and practical to increase students' interest and motivation. Additionally, accurate analysis of students' abilities and interests, appropriate guidance, and adopting a teaching approach that supports overall learning rather than solely exam-oriented learning are essential.

5.2. Challenges and Solutions in Chemistry Teaching/Chemistry Programs at the Undergraduate Level

5.2.1. Curricula

Chemistry undergraduate programs in faculties of science are designed to equip students with fundamental chemistry knowledge, laboratory skills, and analytical thinking abilities. These programs aim to produce qualified chemistry professionals who can excel in various fields such as industry, research, and education. Similarly, chemistry teaching programs in Türkiye offer diverse opportunities to provide comprehensive chemistry education, enhance pedagogical knowledge and skills, and enrich classroom experiences. The curricula play a crucial role in achieving these goals. However, both chemistry teaching and chemistry undergraduate programs face several challenges in their curricula. In this section, the workshop findings related to the curricula of chemistry teaching and chemistry undergraduate programs in science faculties are discussed, along with solution suggestions.

1. Outdated Activities/Experiments/Information in Chemistry Teaching and Chemistry Undergraduate Programs

The activities, experiments, and information used in chemistry teaching and chemistry undergraduate programs should be current and adaptable to the advancements in the field of chemistry. These programs are vital in imparting scientific knowledge and practical applications of chemistry. It is imperative that the activities, experiments, and information employed in these programs are up-to-date to enable students to connect with the real world and stay abreast of the latest developments. The problems identified through the evaluation of workshop data, along with their respective impacts, are outlined below:

Lack of Knowledge: Outdated activities, experiments, and information hinder students from staying informed about the latest developments. Chemistry is an ever-evolving science, with new information emerging through current research. Engaging students with outdated or inaccurate content can lead to incomplete or faulty understanding.

Decreased Student Motivation: Outdated activities can result in reduced student motivation. It is crucial for students to interact with current issues, intriguing applications, and perceive themselves as active participants in ongoing scientific debates. However, the absence of such opportunities can dampen students' interest and motivation, fostering a negative attitude towards chemistry.

Lagging Practical Skills: Chemistry teaching and chemistry degree programs aim to develop students' practical skills. Outdated activities and experiments may impede students from acquainting themselves with real-world applications and contemporary laboratory techniques. Consequently, students may face difficulties in practical skill development upon graduation.

Limitation of Professional Development: Outdated activities may curtail the professional development of chemistry teachers and undergraduate students. Chemistry teachers must stay updated by following current scientific research and effectively convey the latest information to their students. Similarly, undergraduate students should be prepared for their careers with contemporary activities and laboratory practices. However, a lack of currency in curricula can limit opportunities for professional growth.

Based on the evaluation of workshop findings, the following solution suggestions have been proposed:

Reviewing Current Resources and Research: Utilizing reliable and up-to-date sources is crucial in ensuring that the activities and information in chemistry teaching and chemistry undergraduate programs remain current. Teachers and faculty members can access the latest information by following academic journals, research articles, and other reputable sources, incorporating them into course materials. Additionally, providing students with access to up-to-date resources can enhance their motivation and facilitate access to current information.

Industry Collaboration and Internship Programs: Collaboration between chemistry teaching and chemistry undergraduate programs and industrial sectors can contribute to the development of activities and experiments that incorporate current knowledge and practices. Establishing internship programs in collaboration with industrial organizations allows students to experience contemporary laboratory techniques and gain insight into industrial operations.

Continuous Professional Development: Chemistry teachers and faculty members can stay up to date by engaging in continuous professional development opportunities. Seminars, conferences, workshops, and training programs provide avenues for teachers and faculty members to enhance their knowledge of current chemistry practices and advancements.

Current Laboratory Experiments and Applications: Chemistry teachers and undergraduate programs should offer up-to-date laboratory experiments and applications. This allows students to apply the principles of chemistry in contemporary contexts and develop their laboratory skills. Employing current technological tools can further support these experiments.

2. Foreign Language Teaching

Foreign language teaching in chemistry teaching and chemistry undergraduate programs is a significant issue that needs attention. In today's scientific landscape, English has gained increasing importance as the accepted international language of communication. English serves not only as the language for publishing current scientific research and discoveries but also as a fundamental requirement for communicating and collaborating with international scientific communities. Proficiency in the English language provides numerous advantages for individuals studying in chemistry teaching and chemistry undergraduate programs. The problems identified related to foreign language teaching through the evaluation of workshop data, along with their respective impacts, are outlined below:

Difficulty in Accessing Scientific Literature: Most research and current scientific literature in chemistry are published in English. Individuals with insufficient foreign language skills may face difficulties in accessing such literature, thus being deprived of up-to-date information.

International Communication Barriers: Chemistry is an international field of science, and effective communication among scientists is vital. Since English is the international language of science, individuals with inadequate foreign language skills may encounter communication barriers when participating in international events, symposiums, projects, and competitions.

Limited Internship and Graduate School Opportunities: Students with inadequate foreign language skills may face disadvantages when applying for international internships or graduate programs. Many universities and organizations consider English language proficiency as a crucial criterion and evaluate applications accordingly.

Access to Resources and Materials: Faculty members, undergraduate, and graduate students with limited English proficiency may encounter difficulties in accessing resources and materials in English. Research articles, internet resources, and related literature used in their scientific studies may be incomprehensible or only partially understood due to insufficient language skills.

International Competitiveness: Participation in international projects and competitions requires competing at an international level. Individuals with inadequate English language skills may face disadvantages in this competitive environment and may struggle to effectively present their projects.

Based on the evaluation of all workshop findings, the following solution suggestions have been proposed:

English Language Education: Chemistry teaching and chemistry degree programs should place emphasis on English language training. Students can be offered additional English classes, language courses, or language support programs to enhance their language skills.

English Presentation and Writing Skills Training: Specialized training programs can be provided to students to enhance their English presentation and writing skills. Practical opportunities focusing on presentation techniques, report writing, and effective communication with judges or juries can be offered.

Project and Competition Preparation Groups: Communication groups can be established to assist students in preparing for projects and competitions. These groups can provide activities, study sessions, and mentoring to improve English language skills.

Access to English Resources: To facilitate students' access to English resources, dedicated sections containing materials in English can be created in libraries, university resources, or online platforms. These resources can support students' projects and facilitate access to up-to-date information.

By implementing these solution suggestions, it is possible to address the challenges associated with foreign language teaching in chemistry programs and enhance the language skills of students pursuing careers in this field.

3. Inadequacy of Internship Periods and School Experience Course Hours in Chemistry Teaching Programs

Inadequacy of internship periods and school experience course hours in chemistry teaching programs at faculties of education can pose challenges in the professional preparation of prospective teachers. Internships serve as a crucial phase where theoretical knowledge is translated into practical application, teaching skills are honed, and real classroom experiences are gained. However, in some instances, the duration of internships may fall short, resulting in deficiencies in teacher candidates' readiness for their teaching careers upon graduation. This can restrict their exposure to classroom settings and hinder their transition into the teaching role. The significant problems related to internship and school practice identified, along with their respective impacts as assessed from workshop data, are outlined below:

Insufficient Adaptation of Pre-service Teachers to the Teaching Role: Brief internship periods can impede pre-service teachers' full adaptation to the teaching role. Teaching encompasses more than merely conveying knowledge. It is crucial for pre-service teachers to acquire experience in classroom dynamics, student relationships, utilization of educational resources, and lesson planning. Insufficient internship durations may hinder this adaptation process.

Lack of Real Classroom Environment Experience: Short internship periods limit pre-service teachers' exposure to authentic classroom settings. They may lack opportunities to learn vital aspects such as classroom management, student interaction, lesson planning, and implementation through working with actual students. Consequently, pre-service teachers may face unpreparedness when confronted with challenges in the classroom after graduation.

Inadequate Development of Practical Skills: Insufficient internship periods restrict pre-service teachers' chances to practice and experience chemistry lessons. They may struggle to develop practical skills, including classroom management, experiment planning, and laboratory safety, to a satisfactory level. This can result in deficiencies and a lack of self-confidence in their preparation for the teaching profession.

Based on the evaluation of all workshop findings concerning these problems, the following solutions are suggested:

Extended Internship Duration: Faculties of education can lengthen the duration of internships in chemistry teaching programs. Extended periods allow pre-service teachers to gain more practical experience and enhance their skills. This enables them to work alongside students in authentic classroom settings, fostering better adaptation to the teaching role.

Diverse Internship Experiences: A variety of internship experiences can be offered during the internship period. Pre-service teachers can gain exposure to diverse classroom environments by interning at different school levels (elementary, middle, high school) and various types of schools (science high school, vocational high school, Anatolian high school). This provides them with the opportunity to work with different student groups and enhance their professional development. It is essential to ensure experiences across different grade levels during the internship.

Mentoring Programs: Pre-service teachers can benefit from mentoring programs where experienced teachers guide and support them throughout the internship process. This facilitates better teaching experiences for pre-service teachers and aids in their professional growth.

Increased Classroom Observation and Practice Opportunities: More opportunities for classroom observation and practice can be provided during the internship period. Pre-service teachers can actively participate in lessons delivered by experienced teachers, observe classroom interactions, and engage in practical exercises. This allows them to gain more hands-on experience and immerse themselves in the classroom environment.

4. Legal Barriers Against Payment of Internship Fees to Pre-service Teachers

Legal issues that prevent the payment of internship fees to pre-service teachers during their teaching internships can give rise to various challenges. Within this context, the problems identified through the evaluation of workshop data and their impacts are as follows:

Financial Hardships: Student teachers may encounter financial difficulties throughout their internships. The inability to cover expenses during the internship period can demotivate pre-service teachers and negatively impact their internship experiences.

Inequality: The absence of internship remuneration creates inequality between pre-service teachers and students interning in other fields. While students in other disciplines receive internship fees, providing them with better financial stability and improved working conditions, pre-service teachers who do not receive such compensation are put at a disadvantage.

Decreased Motivation and Ambition: Pre-service teachers who are not compensated for their internships may experience a decline in motivation and enthusiasm. The perception that their efforts and time are not financially valued may diminish their interest in the internship, hindering their ability to fully engage in the internship process.

Based on the evaluation of all workshop findings pertaining to these problems, the following solution suggestions have been proposed:

Revision of Regulations: A review of the relevant laws and the necessary adjustments should be made to allow for the payment of internship fees to prospective teachers. By considering internships as a valuable learning experience, it is essential to provide appropriate financial support to pre-service teachers.

Scholarship and Support Programs: Scholarship and support programs can be established to financially assist pre-service teachers during their internship period. These programs, funded by universities, educational institutions, or donations, can help alleviate the financial burdens faced by pre-service teachers.

Alternative Internship Models: Exploring alternative internship models can serve as an alternative to financial compensation. For instance, pre-service teachers can be provided with meals or transportation benefits, thereby reducing their financial burdens during the internship process.

5. Inadequate Coverage of Project-Based Learning, Aut-of-school Learning Environments, Current Instructional Technologies and STEM in Teacher Education Programs

The quality of teacher education programs holds significant importance in nurturing the professional skills of future teachers and enabling them to effectively educate their students. Given the rapidly evolving educational landscape, teacher education programs must adapt to current pedagogical approaches. Project-based learning, out-of-school learning environments, current instructional technologies, and STEM are crucial elements that facilitate the development of students' critical thinking, problem-solving, and collaboration skills. Therefore, it is essential to adequately integrate these approaches into teacher education programs. In light of this, the identified problems resulting from the evaluation of workshop data and their impacts are outlined below:

Limited Effective Learning Experiences: Approaches like project-based learning, out-of-school learning environments, current instructional technologies, and STEM foster active student engagement and promote meaningful learning. However, the scarcity of these contemporary teaching methods may deprive pre-service teachers of valuable learning experiences, constraining their learning environment and potentially impacting their future teaching competencies.

Insufficient Development of Technological and Applied Skills: Current instructional technologies empower teachers to plan and deliver lessons effectively. Project-based learning and STEM approaches enable students to cultivate practical skills and establish connections with real-world contexts. Inadequate exposure to these areas may hinder the development of pre-service teachers' technological and applied skills, limiting their ability to guide students proficiently in these domains.

Diminished Student Motivation: Approaches such as project-based learning, out-of-school learning environments, current instructional technologies, and

STEM enhance pre-service teachers' active participation and foster their interest in learning. However, the lack of emphasis on these approaches can lead to reduced student motivation and an uninspiring learning environment.

In light of the evaluation of workshop findings pertaining to these problems, the following solution suggestions have been proposed:

Curriculum Reorganization: Teacher education program curricula should allocate more space to incorporate project-based learning, out-of-school learning environments, current instructional technologies, and STEM. The curriculum should enable prospective teachers to acquire both theoretical knowledge and practical skills in these areas.

Embracing Contemporary Learning Approaches: Teacher education programs should prioritize training educators to effectively utilize approaches such as project-based learning, out-of-school learning environments, current instructional technologies, and STEM. Educators should specialize in these areas and instruct pre-service teachers on their effective implementation.

Collaboration and Partnerships: Collaboration and partnerships among educational institutions, civil society organizations, industry organizations, and universities need to be fostered. This will provide pre-service teachers with opportunities to gain exposure to out-of-school learning environments and industry settings. Additionally, access to up-to-date instructional technologies and STEM practices can be facilitated.

Continuous Professional Development: Teacher education programs should support the continuous professional development of pre-service teachers. This involves organizing training seminars, workshops, and activities focused on project-based learning, out-of-school learning environments, current instructional technologies, and STEM approaches.

6. Lack of Collaboration Between Faculties

Collaboration between faculties holds immense significance in the fields of education and research. By bringing together diverse disciplines to work towards shared objectives, innovative solutions can be generated, and social benefits can be enhanced. Particularly in the realm of education, collaboration among different faculties enables students and educators to have a more enriching learning experience. Inter-faculty collaboration is equally crucial in chemistry undergraduate programs, as chemistry is an interconnected discipline that requires various perspectives to address real-life problems. In this context, the problems identified and their effects, based on the evaluation of workshop data, are outlined below:

Limited Perspective: When different disciplines fail to collaborate, they may be confined to the knowledge and perspectives within their own fields. This limitation can hinder the development of innovative and holistic solutions, restricting students' exposure to a narrow perspective.

Lack of Application Opportunities: Without inter-faculty collaboration, students have limited chances to apply their knowledge to real-world problems. Collaborative work among different disciplines provides students with diverse application areas, enabling them to translate theoretical knowledge into practical applications.

Limited Areas of Application: Collaboration between faculties empowers educators and researchers to benefit from distinct perspectives. The absence of such collaborative opportunities may impede the emergence of novel ideas and joint projects, resulting in constrained academic growth.

As a result of evaluating all workshop findings regarding these problems, the following solutions have been proposed:

Interdisciplinary Programs and Courses: Establishing interdisciplinary programs and courses encourages collaboration among faculties. These initiatives provide students with the opportunity to work with teachers from different disciplines, facilitating knowledge and skill transfer across fields.

Joint Research Projects: Foster joint research projects involving faculties from different disciplines. These projects bring together faculty members and researchers from diverse backgrounds to pursue common objectives. Such endeavors enable the convergence of different perspectives, leading to more comprehensive solutions.

Cooperation and Coordination Centers: Set up cooperation and coordination centers within universities. These centers foster communication and collaboration among faculties. They can organize regular meetings, seminars, and events involving teacher education programs, chemistry degree programs, and other related disciplines.

Nurturing a Collaborative Culture: To promote inter-faculty collaboration, it is essential to cultivate a collaborative culture within universities. This culture encourages and supports collaboration among different faculties and faculty members. Units like teacher education programs and chemistry degree programs can organize events and facilitate collaboration to foster this culture.

7. Teaching of Pedagogical Courses such as Measurement and Evaluation, Material Design, Curriculum Development in Chemistry Teaching Undergraduate Programs by Faculty Other Than Chemistry Educators

This situation holds significant importance for the professional development of teacher candidates and their expertise in the field of chemistry teaching. These courses should be taught by chemistry educators for several reasons.

Lack of subject depth: While education experts generally specialize in the field of education, they may not possess the same level of in-depth knowledge about teaching chemistry. This may result in insufficiently comprehensive and qualified content for courses such as Measurement and Evaluation, Material Design, and Curriculum Development in chemistry teaching undergraduate programs.

Incompatibility with the Special Needs of Prospective Teachers: The needs of prospective teachers in chemistry teaching degree programmes can be better understood by those who specialise in chemistry teaching. Education specialists, although experts in general education issues, may not fully understand the specific needs and challenges related to chemistry teaching.

Lack of Application and Practical Experience: In chemistry teaching undergraduate programmes, courses such as Measurement and Evaluation, Material Design and Curriculum Development are taught by chemistry educators, which helps prospective teachers to develop practical skills and make real-world connections. Education specialists may not have enough experience and practice in this field, which may cause the practical skills of pre-service teachers to be insufficient.

As a result of evaluating all the workshop findings related to these problems, the following solution proposal has been reached:

Collaboration and partnership: Collaboration and partnership can be established between chemistry educators and education experts. This allows for the utilization of the areas of expertise from both groups, leading to a more comprehensive delivery of these courses.

8. Adequacy of Laboratory and Field Course Hours in Chemistry Teaching Undergraduate Programs

The inadequacy of laboratory and field course hours in chemistry teaching undergraduate programs, as well as the absence of dedicated physical chemistry, organic chemistry, and instrumental analysis laboratories in most universities pose a significant concern.

Insufficient development of applied skills: Laboratory and field courses provide students with the opportunity to apply chemistry principles in real-life settings. However, the limited hours allocated to these courses in the program may hinder the adequate development of students' applied skills. This restricts their chemistry experience and laboratory work.

Failure to learn current techniques and methods: Laboratory and field courses enable students to learn current laboratory techniques and analytical methods. Nevertheless, the insufficient hours allocated to these courses in the program may result in inadequate exposure to these techniques and methods, limiting students' awareness of current developments.

Inadequate professional preparation: Laboratory and field courses play a crucial role in preparing prospective teachers professionally. These courses allow teacher candidates to gain practical laboratory experience and develop the necessary skills for teaching chemistry. However, the limited hours in the program may leave teacher candidates lacking in terms of professional preparation, making it challenging for them to encounter real-world applications.

Based on the evaluation of workshop findings related to these problems, the following solution proposal has been reached:

Increasing the hours of laboratory and field courses: It is recommended to allocate more hours to laboratory and field courses in chemistry teaching undergraduate programs. This will provide students with the opportunity to enhance their hands-on skills and acquire a more comprehensive understanding of current techniques.

Diversifying laboratory and field courses: Programs should offer a variety of laboratory and field courses, including those focusing on different areas such as physical chemistry, organic chemistry, and instrumental analysis. This approach enables students to gain diverse experiences and learn various techniques.

Utilizing virtual laboratory applications: With the advancement of technology, virtual laboratory applications have been developed. Integrating these applications into the programs allows students to gain experience and improve their laboratory skills in a virtual setting.

9. *Classroom Teachers Without Sufficient Knowledge and Skills in Science Fields*

When examining the undergraduate programs for classroom teaching, it is evident that the content, number, and hours of theoretical, practical, and laboratory courses related to science fields have been reduced in the 2018 curriculum of many universities. Classroom teachers play a crucial role in properly conveying scientific knowledge to primary school students. Incorrect learning or modeling during primary education years can lead to the development of misconceptions that are difficult to rectify. Therefore, it is essential for classroom teachers to have a strong foundation in science. The problems identified from the workshop data evaluation and their effects are outlined below:

Insufficient knowledge and skills: Due to reduced teaching hours, classroom teachers may not have adequate opportunities to acquire fundamental knowledge and skills in science fields. This can compromise the quality of teaching and result in students receiving incomplete information.

Lack of motivation: Insufficient knowledge and skills in science can lead to a lack of motivation among classroom teachers during the teaching process. This can pose challenges in delivering lessons in an engaging and interesting manner to students.

Decline in student achievement: Classroom teachers with inadequate science knowledge may impact their students' performance in science subjects. They may struggle to provide sufficient support for students to address their weaknesses and make progress.

Based on the evaluation of the workshop findings concerning these problems, the following proposed solutions have been identified:

Increasing the time allocated to science courses: Instead of reducing the course hours in science fields, it is recommended to consider increasing the time dedicated to science courses. This would allow classroom teachers to cover science topics in greater depth and provide more opportunities for students to acquire essential scientific knowledge.

Professional development of teachers: Continuous professional development opportunities should be provided to classroom teachers to update their knowledge and skills in science. Seminars, workshops, training programs, and expert visits can help teachers stay updated and enhance their science-related competencies.

Cooperation and support: Collaboration and support mechanisms should be established between science teachers and classroom teachers. Science teachers can guide classroom teachers in science subjects, share resources, and collaborate to improve the quality of science lessons.

Utilizing expert resources: Classroom teachers should be encouraged to use expert resources to supplement their teaching of science subjects. Various resources, interactive materials, and instructional videos available on the Internet can assist classroom teachers in delivering science lessons more effectively.

Adopting a student-centered teaching approach: Classroom teachers can employ a student-centered teaching approach when teaching science subjects. This approach involves allowing students to engage in experiments, exploration, and questioning. It can foster students' interest in and understanding of science subjects.

5.2.2. Instructor (Lecturer/Teacher)

1. General and Academic Competencies of Lecturers

During the workshop, it was highlighted that the competencies of lecturers are negatively impacted by the lack of merit and periodic training. As a solution to these issues, it has been proposed to reintroduce the associate professor oral examination, create a competitive environment to enhance qualifications, and improve instructors' competencies through targeted in-service training programs.

2. Qualifications of Faculty Members for Training Pre-service Teachers

Chemistry teacher training programs in education faculties have a primary responsibility to develop pedagogical content knowledge (PCK) among chemistry teacher candidates (Van Driel, De Jong and Verloop, 2021). Naturally, instructors bear the greatest responsibility in this regard. The use of traditional teaching methods, deficiencies in laboratory skills, teaching with a confirmatory approach in a cookbook style, and inadequacies in technological pedagogical content knowledge (TPCK) are some of the problems that negatively impact the training of teacher candidates. Insufficient course hours have been identified as a significant factor contributing to these problems, limiting the ability to foster critical thinking, research skills, and 21st century competencies among candidates. Allocating adequate budget resources, increasing laboratory courses, and enhancing instructors' TPCK skills can effectively address these issues. Furthermore, the instructors' competence limited to their own fields hampers their ability to provide effective guidance to candidates. Overcoming this challenge can be achieved through instructors' engagement in interdisciplinary studies. Since graduates from science faculties outside of education faculties can also become teachers, the competency of faculty members in science faculties to train their students as teachers has been recognized as a problem. It has been suggested that gaining a pedagogical perspective could serve as a solution. To enhance instructors' qualifications in training teacher candidates, suggestions include their participation in workshops and in-service training programs, cooperation with the MoNE, and providing opportunities for them to teach in high schools.

3. Technology Use and Distance Education Competencies of Instructors

As previously mentioned in the section on high school teachers, it was revealed in the workshop that instructors working at universities also face challenges in utilizing technology and conducting distance education. To address these issues, it has been suggested to provide training in online chemistry teaching and measurement-evaluation methods and techniques. Additionally, increasing and activating units such as ÖGEM, which facilitate student and lecturer analysis at the university level, have been proposed as potential solutions.

5.2.3. Learning Environment/Teaching Materials

1. The State of Physical Conditions

Deficiencies in the infrastructure of university buildings (e.g., Cevher, 2015) can have a negative impact on students' learning experiences. For instance, old and neglected buildings may encounter various technical problems, such as power outages, water leaks, insufficient heating or cooling, and limited access to the internet. These issues can distract and hinder students during their lessons, consequently diminishing the quality of the learning process. Moreover, infrastructure deficiencies can impede the development of 21st century skills among students. In today's business and society, skills like communication, collaboration, critical thinking, and problem-solving are highly valued. However, many of these skills are honed through modern technologies and activities that require teamwork. Outdated and limited laboratory equipment can restrict students' opportunities to practice these skills. Insufficient computers, limited internet access, and outdated software can limit students' interaction with technology, hindering the development of their digital skills.

2. Inadequate Hours for Field Courses and Laboratory Work in Chemistry Teaching Programs

The inadequacy of course and laboratory hours in chemistry teaching programs is a significant problem that affects students' academic and practical experiences. Reducing the credits allocated to field courses in chemistry teaching undergraduate programs exacerbates the problem of inadequate time for course work and laboratory sessions. Chemistry is a discipline that places great importance on practical experience alongside theoretical knowledge (Zimmerman, Melle, Huwer, 2021). Reducing the credits for field courses can limit students' opportunities to acquire the necessary theoretical and practical knowledge, resulting in graduates with incomplete skills and knowledge for a successful career in chemistry. Lowering course credits also limits students' ability to engage in in-depth learning. Chemistry encompasses complex theoretical topics and laboratory experiments. With reduced course credits, there may be insufficient time to delve deeply into subjects, resulting in superficial coverage. This prevents students from fully understanding and comprehending the principles of chemistry. In-depth learning enables students to develop analytical thinking skills, conduct independent research, and keep up with new developments in the field. Therefore, reducing course credits may impede students' cognitive development and professional skills in chemistry.

3. Availability of Course Materials and Resources in Chemistry Education/ Undergraduate Programs

The re is a need for course materials and resources at both secondary and the undergraduate level. However, the requirements for course materials and resources are usually more basic in middle/high schools, where students are still learning fundamental concepts and may require fewer lab materials and devices. Basic chemicals and simple materials may suffice for basic laboratory experiments in chemistry classes. Conversely, at the university level, more complex experiments and advanced laboratory equipment are often necessary. In middle/high schools, the responsibility for meeting the need for course materials and resources typically lies with the teacher and the school. Schools should possess adequate textbooks, learning materials, and resources to fulfill curriculum requirements. In universities, students are expected to independently seek and acquire course materials and resources, benefiting from a broader network of resources and conducting their own research (Kirkwood and Price, 2005). Additionally, middle/high schools often face budget constraints, resulting in limited supplies, devices, and technological equipment for labs. Universities generally have larger budgets, allowing for more extensive laboratories and equipment and technology infrastructure. At both levels, it is crucial to meet the course material and resource needs of students to ensure a comprehensive education.

4. Teaching Methods and Techniques in Undergraduate Programs

Similar challenges arise in chemistry teaching/undergraduate programs regarding teaching methods and techniques as those experienced in middle/high schools. In chemistry teaching/ chemistry undergraduate programs, a more advanced and in-depth understanding of knowledge and skills is required. Furthermore, conducting laboratory experiments and research is essential for undergraduate students. The use of traditional experimental report formats may limit students' ability to develop research design and report writing skills. Modern teaching methods engage students actively, encouraging them to discover knowledge rather than passively receive it. Problem-based or context-based learning methods, particularly suited for teaching chemistry, enable students to analyze and solve real-life problems. These methods foster critical thinking, problem-solving, and communication skills. While traditional teaching methods focus solely on memorization, new methods promote understanding and application of information. Incorporating technology and digital tools is a vital aspect of contemporary teaching approaches. Interactive simulations, virtual experiments, and online resources offer students the opportunity to explore chemistry topics, making learning more engaging and interactive. These methods enable students to interact with visual and auditory elements, facilitating a more concrete understanding of abstract concepts.

5. Anxiety and Self-confidence Issues Among Teacher Candidates

Pre-service teachers' anxiety about potential harm from tools, devices, and chemicals in the laboratory significantly affects the design and effectiveness of the learning environment. This anxiety is often linked to safety concerns, as lab environments can pose hazards and risks that raise apprehensions among prospective teachers. Such concerns can lead to cautious and restrictive approaches in designing and implementing laboratory-based lessons. Similarly, a lack of self-confidence can impact pre-service teachers' ability to effectively use tools and devices, conduct experiments, and ensure student safety. Consequently, pre-service teachers may engage in laboratory experiments less frequently, resort to alternative methods, or avoid risky experiments altogether. Teachers play a vital role in setting an example and instilling confidence in their students within the laboratory environment. However, their own lack of self-assurance can hinder their ability to guide students effectively, compromising the potential of laboratory experiments to offer rich learning experiences. Therefore, it is crucial to develop pre-service teachers' skills in managing anxiety related to tools, devices, and chemicals in the laboratory. Providing training on safety precautions, procedures, and risk management can enhance their self-confidence. Mentoring and guidance from experienced teachers can also boost their confidence and help them manage laboratory-based learning environments more effectively.

5.2.4. Student

1. Low Interest in the Course and Low Motivation to Learn

One of the main problems affecting undergraduate students is their lack of interest and motivation in the course. This problem can be attributed to several factors, including teachers' failure to incorporate technology into their lessons, students' passive attitude, anxiety related to assignments, and the choice of an unsuitable profession. These issues have notable consequences, such as students becoming disconnected from science and experiencing a lack of meaningful learning due to their indifference. To address this problem, various approaches are recommended, including enriching the courses with diverse teaching methods, providing teachers with in-service training, implementing interactive lessons, and enhancing the value attributed to the profession. By adopting these measures, it is possible to encourage meaningful learning processes and strengthen students' interest and motivation in the course, thereby fostering their engagement in science.

2. Lack of Meaningful Learning Among Undergraduate Students

Undergraduate students often struggle to achieve meaningful learning due to factors such as their limited interest and motivation towards the chemistry course and laboratory activities, as well as their low proficiency levels. This problem may also arise from the prevalent use of teacher-centered teaching approaches in the classroom. To address this issue, it is suggested to create interactive learning environments that prioritize student-centered activities and laboratory practices, allowing for active participation of students. Additionally, students should be encouraged to actively engage in the learning process by leveraging technology and promoting social interaction. These measures aim to support meaningful learning processes, enhance students' attitudes towards laboratory work, and improve their proficiency levels.

The lack of meaningful learning among university students is a significant problem. It stems from various factors, including students' low interest and motivation in the chemistry course and laboratory activities, as well as their limited proficiency levels. The problem is further compounded by students' disinterest in classroom activities and their passive attitudes. Teacher-centered teaching approaches are frequently used, exacerbating the issue. To address this problem, it is crucial to allocate more time to activities that create interactive learning environments and promote active student participation. Additionally, motivating students through technology and social interaction should be prioritized. By supporting meaningful learning processes, it is possible to improve students' attitudes towards laboratory work and enhance their proficiency levels.

INNOVATIVE APPROACHES AND GOOD PRACTICES IN CHEMISTRY EDUCATION

6.1. Examples of Good Practices Presented at the Workshop

The workshop presentations showcased various innovative approaches and good practice examples implemented in chemistry education. The following briefly summarizes the innovative approaches and good practice examples associated with each of these presentations:

6.1.1. Curriculum Redesign and Reform Efforts (TUBITAK Science High School Skill-Based Chemistry Curriculum)

Given the rapid development of technology and ease of accessing to information, educational systems need to be updated and revised more frequently. In this era of knowledge production, disseminated, and organization, there is a shift in expectations for learner qualifications. Hence, the preparation of curricula that will serve to raise individuals with desired competencies has become increasingly important. Curricula should have a simple and comprehensible structure, accomidating individual differences and aiming to foster knowledge, skills, values and attitudes, rather than merely a structure that only conveys information. Moreover, curricula should be designed with the principle of progressive reinforcement of learning objectives across grade levels. Chemistry curricula, as the guiding framework for education, are periodically updated in both high school and undergraduate programs to reflect the changes and advancements in education systems. For instance, the "Skill-Based Chemistry Curriculum" was developed for TUBITAK Science High School students, and pilot implementation of this program began in the 2022/2023 academic year. The primary objective of this program is to raise individuals equipped with integrated knowledge and skills aligned with our values and competencies, adopting an educational approach that emphasizes meaningful and experiential learning.

6.1.2. Implementation Studies of Skill-Based Learning Program at TUBITAK Science High School

Many general skills such as accessing information, problem-solving, teamwork, technological proficiency, and understanding economic and social events have gained increased significance today. The skills-based curriculum, developed to address these needs, emphasized the teaching of learning and thinking skills, information and media literacy, and technology skills, and personal and social skills. It underscores the necessity of instilling these skills across all subjects, recognizing their importance for students' success in life.

The skill-based chemistry curriculum places scientific process skills at the core while aiming to cultivate a broader set of skills. Particularly in science high schools, which have a mission of nurturing scientists, providing skill-based education to students is of paramount importance. Skill-based education not only enhances students' acquisition of 21st century skills but also facilitates the development of their scientific process skills and abilities. This educational approach enables students to apply knowledge in practical contexts, moving beyond theoretical learning. Skills serve as the foundation for lifelong learning, benefiting students not only during their academic journey but also in their future professional and personal development. Teaching skills empower students to develop crucial abilities such as problem-solving, critical thinking, communication, collaboration, and leadership, which are essential for success in the workforce. Skill-based education also boosts students' self-confidence and engagement in the learning process, fostering their interest and active participation, ultimately leading to successful learning outcomes. Therefore, providing skill-based education to students in science high schools contributes to their academic and personal growth, equipping them with the necessary skills for a successful future.

6.1.3. Integration of Digital Technologies and Educational Resources in Chemistry Education

The utilization of digital technologies in chemistry education enhances students' comprehension of abstract and complex concepts. These technologies offer diverse learning experiences, including simulations, virtual laboratories, and multimedia materials, in addition to traditional laboratory work involving experimentation, observation, and data collection. Simulations enable students to visualize and understand chemical processes, helping them grasp the abstract concepts. Virtual laboratories allow students to plan experiments and make observations in a digital environment, ensuring safer and more accessible laboratory experiences. Multimedia materials, such as videos, animations, and interactive resources, enrich students' learning by providing engaging and effective ways to study chemistry topics. These materials cater to different learning styles and paces, making the learning process more tailored to individual needs. In conclusion, the integration of digital technologies and educational resources enhances students' learning experiences in chemistry education while enabling teachers to better track student progress. Simulations, virtual laboratories, and multimedia materials aid students in better understanding chemistry topics and make their learning experiences more enjoyable.

6.1.4. A New Instructional Approach in Chemistry Education: Systems Approach

Each discipline has its unique characteristics, epistemological and ontological aspects, practices, and modes of thinking. Understanding the nature of a discipline and its knowledge structure is crucial to identify and address misconceptions and learning difficulties effectively. When examining the literature on chemistry philosophy, chemistry education, and chemistry practices, it becomes apparent that chemistry is a systems science with an inherent aspect of systems thinking. Chemistry explores dynamic systems at the atomic, molecular, and molar levels, and systems thinking is a fundamental characteristic of chemistry, even though it may not be explicitly stated in curricula or classroom discussions. All chemical entities, starting from the simplest atoms, are complex-dynamic systems, and the experimental and theoretical applications of chemists, their way of thinking, and the nature of chemical knowledge are shaped by chemistry's inherent system science nature. From a systems thinking perspective, chemistry practices can be conceptualized as a three-stage dynamic systems thinking cycle: 1) Modeling systems, 2) Prediction, and 3) Retrospective evaluation (Looking back).

6.1.5. Utilization of Active Learning Strategies in Chemistry Education

Creating an active learning environment that promotes student engagement should be approached with a comprehensive understanding of the ecosystem. Unfortunately, active learning environments are relatively scarce at the undergraduate level, and even when they are implemented, it is challenging to witness active student participation. In an ideal active learning environment, students construct knowledge through model-based reasoning processes. However, studies indicate that students tend to prefer shortcut reasoning processes, resulting in lower cognitive load. The relationship between the learning environment and student participation depends on various variables, including the timing and layout of activities. Activities conducted during post-lesson discussions and practice sessions have shown to promote more knowledge application dynamics compared to activities conducted during the lesson itself. Moreover, active learning environments that encourage student collaboration yield higher student participation rates. The learning process is complex, with numerous factors influencing students' levels of learning. To create an effective learning environment, teachers must consider various factors, such as the communicative approach used in the classroom, cooperative learning environments, the cognitive level of activities, student success as a priority, timing of activities, and classroom layout. Additionally, the delivery of activities plays a significant role. Teachers should provide students with learning opportunities that actively engage them and involve them in the learning process. Diversifying activities and enabling students to utilize their diverse skills fosters creativity and critical thinking during the learning process. Ultimately, the learning process is multifaceted, with various factors influencing its outcomes. Therefore, teachers need to account for multiple factors to design and manage effective learning experiences, including the learning environment, student participation, cognitive levels of activities, activity delivery, timing, and classroom layout. By considering these factors, teachers can enrich students' learning experiences and create effective learning environments.

6.2. Analysis of the Effectiveness and Applicability of Innovative Approaches and Good Practices

The analysis of the effectiveness and applicability of innovative approaches and good practice examples reveals their potential to enhance the quality and relevance of chemistry education. However, the effectiveness of these approaches depends on various factors, such as school resources, availability and accessibility of technologies, support, and participation from stakeholders (teachers, students, school administration), and alignment with education policies and practices. It is important to recognize that the success of innovative approaches and good practices is also contingent upon curriculum requirements and the education system as a whole.

AN OVERVIEW OF CHALLENGES IN CHEMISTRY EDUCATION

Chemistry education in Türkiye plays a vital role in ensuring students' interest in fundamental sciences and engineering, and in preparing them for successful careers in these fields, similar to other science disciplines. However, the decline in the number of students opting for chemistry as a major or future career, observed in almost all countries, has become a growing concern for chemistry learning and related sectors. These identified challenges in chemistry education have significant effects on students, society, as well as science, technology, and industry. During the workshop, the following primary issues encountered in teaching chemistry were identified:

- Less and insufficient chemistry course hours compared to the chemistry curriculum,
- Inability of chemistry education programs to adequately meet the needs of the 21st century,
- Lack of student interest and motivation,
- Inadequacy of practical applications and learning outcomes in the chemistry curriculum,
- Failure to take into account student differences,
- Inadequate provision of chemistry education tailored to different school types and student needs,
- Shortage of qualified teachers and teaching resources,
- Insufficient teaching materials,
- Limited access to educational technologies and resources,
- Inadequate support for innovative and effective teaching practices,
- Lack of interdisciplinary communication and cooperation,
- Absence of communication and cooperation between different institutions,
- Insufficient chemistry curriculum literacy among teachers,
- Insufficient inclusion of contemporary teaching approaches and methods, such as project-based learning, out-of-school learning environments, up-to-date teaching technologies and STEM,

- Uniform adaptation of the same chemistry curriculum across all school types,
- Insufficient utilization of up-to-date teaching methods and techniques,
- Inadequate internship periods and teaching practice course hours in chemistry teaching programs within education faculties.

7.1. Analysis of Factors Causing Challenges in Chemistry Education

An analysis of factors contributing to the problems in chemistry education has revealed several key issues, including:

- Misalignment between education policies and practices,
- Lack of funding and resources for chemistry education,
- Inadequate teacher training and professional development opportunities,
- Deficiencies or failure to update the chemistry curriculum,
- Insufficient implementation of student-centered teaching approaches,
- Lack of proper laboratory facilities or equipment,
- Overemphasis on rote memorization in evaluation and examination systems,
- Insufficient student-teacher communication and interaction,
- Students' inability to recognize the importance and applications of chemistry in daily life.

7.2. Impact of Challenges on Students and Society

The challenges identified in chemistry education have significant implications for students and society. Lack of interest and motivation among students, an educational system primarily focused on exams, and a shortage of qualified teachers and teaching resources can lead to a decline in the overall quality of education, which can worsen the problems in chemistry education. This can have adverse effects on a country's economic growth and competitiveness. Without improvements and updates in chemistry curricula and teaching materials, students may be ill-prepared for the changing needs and demands of the modern world. Additionally, limited access to educational technologies and resources can deepen the digital divide and restrict opportunities for students from disadvantaged backgrounds.

7.3. Overview of Recommendations for Future Research and Actions in Chemistry Education

The workshop has generated several valuable recommendations for future research and action in the field of chemistry education. These include:

- Conducting research to assess the effectiveness and impact of innovative approaches and best practices in chemistry education,
- Increasing funds and resources to enhance chemistry education at all levels,
- Developing and implementing policies and guidelines that facilitate innovative and effective teaching practices in chemistry education,
- Prioritizing teacher training,
- Providing additional professional development and training opportunities for chemistry teachers,
- Promoting collaborations and partnerships among key stakeholders in chemistry education, such as industry, academia, government agencies, and non-governmental organisations.

7.4. Potential Benefits and Challenges of Implementing the Recommendations

Implementation of the recommendations can lead to a variety of benefits, such as enhancing the overall quality and relevance of chemistry education, fostering greater interest and motivation among students in chemistry and STEM fields, advancing professional development and job satisfaction of chemistry teachers, and strengthening collaboration and networking among stakeholders in the field. However, it is crucial to acknowledge that the implementation process of these recommendations may also encounter various challenges, such as resistance to change and innovation within the education system, lack of political will and support, and competing priorities and demands within the education system.

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APPENDICES

APPENDIX-1

Workshop Series on Fundamental Sciences Education -4

WORKSHOP ON CHALLENGES AND SOLUTIONS IN CHEMISTRY EDUCATION AT SECONDARY AND UNDERGRADUATE LEVELS IN TÜRKİYE

WORKSHOP PROGRAM

Ankara 2-3 March 2023

2 March 2023	
09.00-09.40	Registration
09.40-10:15	**Opening Speeches** Prof. Dr. M. Akif KİREÇCİ, President of ECOEI Prof. Dr. Yüksel ALTUN, Gazi University
10.15-10.35	**Skills in Chemistry Curriculum and Their Integration into the Teaching Process** Prof. Dr. Alipaşa AYAS, Bilkent University Mehmet BİLGİ (Teacher), Gebze TUBITAK Science High School
10.35-10.50	Opinions and Discussions
10.50-11.20	**Tea/Coffee Break**
11.20-11.40	**Challenges and Solutions in Chemistry Teaching from the Perspective of Chemistry Teachers: Edirne Example** Prof. Dr. Eylem BAYIR, Trakya University Fatma Emel IŞIK (Teacher), Şehit Nefize Çetin Özsoy Science and Art Center
11.40-11.55	Opinions and Discussions
11.55- 12.15	**Inadequacy of Chemistry Laboratory Practices and Limited Use of Particle Level Demonstrations (Animation and Simulation) in Classes** Assoc. Prof. Dr. Sevil AKAYGÜN, Boğaziçi University
12.15-12.30	Opinions and Discussions
12.30-13.30	**Lunch Break**
13.30-13.50	**The Nature of Chemistry and System Approach** Assoc. Prof. Dr. Halil TÜMAY, Gazi University
13.50-14.05	Opinions and Discussions

14.05-14.25	**Designing Chemistry Lessons with Teaching Methods and Techniques** Yasemin KESKİN ÇİNKAYA, Bahçeşehir Educational Institutions
14.25-14.40	Opinions and Discussions
14.40-15.10	**Tea/Coffee Break**
15.10-15.30	**Challenges Encountered by Chemistry Teachers in Project-Based Educational Institutions in Secondary Education and Solutions** Dr. Aysun İNAL (Teacher), MoNE General Directorate of Secondary Education
15.30-15.45	Opinions and Discussions
15.45-16.05	**Challenges and Solutions in Chemistry Education** Ali BUĞDAY (Teacher), Karatay TOKİ Anatolian High School
16.05-16.20	Opinions and Discussions

3 March 2023		
09.40-10.00	**An Examination of Challenges in Chemistry Education from the Perspective of Pedagogical Formation** Prof. Dr. Nilgün SEÇKEN, Hacettepe University	
10.30-10.15	Opinions and Discussions	
10.15-10.35	**Anatomy of Student Participation in Active Learning Environments in Undergraduate Chemistry Courses** Prof. Dr. Zübeyde Demet KIRBULUT GÜNEŞ, Gazi University	
10.35-10.50	Opinions and Discussions	
10.50-11.20	**Tea/Coffee Break**	
11.20-11.40	**Chemistry Education and the Challenges at High School/ Undergraduate Level: Challenges in Chemistry Teacher Training at Undergraduate Level** Prof. Dr. Sevgi AYDIN GÜNBATAR, Yüzüncü Yıl University	
11.40-11.55	Opinions and Discussions	
11.55-12.15	**Laboratory USe in Chemistry Education, Information Communication Technologies in Chemistry Teaching, Developing Higher Level Skills in Chemistry Education, Teacher Training Models** Prof. Dr. Faik KARATAŞ, Trabzon University Özge GÖKTÜRK (Teacher), Aydıncık Multi-Program Anatolian High School	
12.15-12.30	Opinions and Discussions	
12.30-13.30	**Lunch Break**	
13.30-14.30	**Parallel Session 1** Work Group on Challenges and Solutions in Secondary School Chemistry Teaching	**Parallel Session 2** Work Group on Challenges and Solutions in Undergraduate Chemistry/Chemistry Education
14.30-14.45	**Tea/Coffee Break**	

14.45-15.45	**Parallel Session 1 (continues)** Work Group on Challenges and Solutions in Secondary School Chemistry Teaching	**Parallel Session 2 (continues)** Work Group on Challenges and Solutions in Undergraduate Chemistry/Chemistry Education
15.45-16.00	**Tea/Coffee Break**	
16.00-16.30	**Challenges and Solutions in Secondary School Chemistry Teaching: Presentation and Discussions**	
16.30-17.00	**Challenges and Solutions in Undergraduate Chemistry/Chemistry Education: Presentation and Discussions**	
17.00-17.10	**Closing**	

APPENDIX-2

FORM 1 FOR AUDIENCE NOTES ON WORKSHOP PRESENTATIONS

Presentation Title	Challenges	Suggested Solutions
Skills in Chemistry Curriculum and Their Integration into the Teaching Process		
Challenges and Solutions in the Teaching of Chemistry from the Perspective of Chemistry Teachers: Edirne Example		
Inadequacy of Chemistry Laboratory Practices and Insufficient Use of In-Class Particle Level Demonstrations (Animation and Simulation) at High School Level		
The Nature of Chemistry and System Approach		
Designing Chemistry Lessons with Teaching Methods and Techniques		
Challenges Faced by Chemistry Teachers Working in Project Implementing Educational Institutions in Secondary Education		
Obstacles and Solutions in Chemistry Education		
Examination of Challenges in Chemistry Education from the Perspective of Pedagogical Formation		
Anatomy of Student Participation in Active Learning Environments in Undergraduate Chemistry Courses		
Chemistry Education and the Challenges at High School/Undergraduate Level: Challenges in Chemistry Teacher Teacher Training		
Laboratory in Chemistry Education, Information Communication Technologies in Chemistry Teaching, Developing Higher Level Skills in Chemistry Education, Teacher Training Models		

APPENDIX-3

FORM 2 FOR AUDIENCE NOTES ON CHALLENGES AND SOLUTIONS IN CHEMISTRY EDUCATION

Titles Related to the Challenges	Consequences of the Challenge	Sources of the Challenge	Suggested Solutions
Curriculum			
Textbook and other concrete course materials			
Teaching environment			
Teaching methods and techniques			
Connections of chemistry (other disciplines, daily life, society, environment, industry, etc.)			
Use of technology			
Laboratory and experiment			
Teacher/Faculty member competencies			
Student competencies (cognitive, affective, psychomotor)			
Student motivation and interest			
Extracurricular opportunities (projects, trips, etc.)			
Other			

APPENDIX-4

GOOGLE FORM FOR PARTICIPANT INVITATION

TEMEL BİLİMLER EĞİTİMİ ÇALIŞTAYLAR DİZİSİ

"ORTAOKUL, LİSE VE LİSANS DÜZEYİNDE KİMYA EĞİTİMİNDE SORUNLAR VE ÇÖZÜM ÖNERİLERİ ÇALIŞTAYI" Ankara Grand Mercure Otel, 2-3 MART 2023

Sayın Hocam,

"Kimya Eğitimi Çalıştay" 2-3 Mart 2023 tarihinde Ankara Grand Mercure Otel'de Türkiye, Azerbaycan, Kırgızistan, Tacikistan, İran, Pakistan ve Afganistan Eğitim Bakanları'nın oluşturduğu bir mütevelli heyeti tarafından yönetilen Ekonomik İşbirliği Teşkilatı Eğitim Enstitüsü (EİTEE) desteğiyle yapılacaktır.

EİTEE'nin programında yer alan faaliyetlerden biri olan temel bilimler (matematik, kimya, biyoloji ve fizik) eğitimi konusundaki çalıştaylar ile üye devletlerden araştırmacıları, eğitimcileri, yöneticileri ve öğrencileri bir araya getirmeyi planlamaktadır. Bu çalıştay dizisi, mühendislik, ekonomi ve tıp gibi çeşitli alanlarda eğitimin gelişimine olumlu katkı sağlamak üzere yeni nesillerin temel bilimler alanındaki eğitimine yardımcı olmak için alandaki sorunları, güçlü yönleri ve en iyi uygulamaları ele almayı amaçlamaktadır.

Bu kapsamda gerçekleştirilmesi planlanan çalıştay dizisinin ilk ikisi matematik eğitimi alanında düzenlenmiştir. "Ortaokul ve Liselerde Matematik Eğitimi" ile ilgili olan ilk çalıştay 24-25 Kasım 2022 tarihinde, "Lisans Düzeyinde Matematik Eğitimi" ile ilgili olan ikinci çalıştay ise 8-9 Aralık 2022 tarihinde Ankara Grand Mercure Otel'de gerçekleştirilmiştir. Bundan sonraki çalıştayların ise 23-24 Şubat 2023 tarihlerinde Biyoloji Eğitimi ve 2-3 Mart 2023 tarihlerinde Kimya Eğitimi alanında yapılması planlanmaktadır.

Çalıştayın teması Ortaokul, Lise ve Lisans Düzeyinde Kimya Eğitiminde Sorunlar ve Çözüm Önerileridir. Çalıştayın ilk günü Ortaokul ve Liselerde Kimya Eğitiminde Sorunlar ve Çözüm Önerileri" ikinci günü ise "Lisans Düzeyinde Kimya Eğitiminde Sorunlar ve Çözüm Önerileri" olarak planlanmaktadır. Çeşitli üniversitelerden ve eğitim kurumlarından davet edilen konuşmacılar öğrenci ve öğretmen niteliği, öğretim programı, öğrenme ortamı (sınıf, laboratuvar, teknoloji vb.), pedagojik formasyon programı, öğretim yöntem ve teknikleri, kimya biliminin doğası, sınav odaklı öğrenme, eğitim politikaları gibi ana konu başlıkları ile ilgili araştırmaları ve görüşlerini paylaşma ve diğer katılımcılarla tartışmalara katılma fırsatı bulacaktır.

Katılımcıların, çalıştay sırasında seçilen konulardaki tartışmalara sözlü olarak katkıda bulunmaları ve katılımcılardan oluşan bir araştırma ekibinin bu belirtilen görüşlerden de yola çıkarak bir çalıştay raporu hazırlaması beklenmektedir.

Çalıştayda sunulan çalışmaların ve yapılan tartışmaların bir çıktısı niteliğinde olan ve telif ücretinin de verileceği bir çalıştay raporu (ISBN numaralı) hem Türkçe hem de İngilizce olarak EİTEE tarafından hazırlanacaktır. Ayrıca söz konusu çalıştay raporunun ilgili birçok kurum ve kuruluşa EİTEE tarafından gönderilerek çalıştay çıktılarının yaygın etkisinin artırılması amaçlanmaktadır.

Çalıştay katılmanızdan ve katkılarınızdan onur duyacağız ve katılımınızın çalıştayımızın başarısına büyük katkı sağlayacağından eminiz. Ayrıca çalışmanıza katkıda bulunacağın düşündüğünüz bir kimya öğretmeni ile birlikte çalıştaya katılırsanız çok memnun oluruz. Lütfen katılma durumunuzu 05/02/2023 tarihine kadar bildiriniz.

Not: Katılımcıların konaklama ve seyahat masrafları EITEE tarafından karşılanacaktır. Herhangi bir sorunuz olursa lütfen bize bildirin. Sizi çalıştayda görmeyi dört gözle bekliyoruz.

DÜZENLEME KURULU

Prof. Dr. Yüksel ALTUN (Gazi Üniversitesi, Gazi Eğitim Fakültesi)
Doç. Dr. Ayşe YALÇIN ÇELİK (Gazi Üniversitesi, Gazi Eğitim Fakültesi)
Doç. Dr. Hakkı KADAYIFÇI (Gazi Üniversitesi, Gazi Eğitim Fakültesi)
Doç. Dr. Sevinç Nihal YEŞİLOĞLU (Gazi Üniversitesi, Gazi Eğitim Fakültesi)

E-posta*

Geçerli e-posta

Bu form e-posta topluyor. Ayarları değiştir

Adınız Soyadınız: *

Kısa yanıt metni

Çalıştaya katılacak mısınız?*

- ◯ Katılacağım
- ◯ Katılamayacağım

Katılacaksanız hangi günler katılacağınızı belirtiniz. *

- ◯ 2 Mart 2023- Ortaokul, Lise ve Lisans Düzeyinde Kimya Eğitiminde sorunlar ve Çözüm Önerileri
- ◯ 3 Mart 2023 Lisans Düzeyinde Kimya eğitiminde Sorunlar ve Çözüm Önerileri
- ◯ Her iki gün de katılmak istiyorum.

Çalıştayda ele almak istediğiniz konunun başlığını yazınız. *

Uzun yanıt metni

Çalıştaya birlikte katılmayı düşündüğünüz bir kimya öğretmeni var mı? *

- ◯ Evet
- ◯ Hayır

Çalıştaya birlikte katılmayı düşündüğünüz kimya öğretmeninin adı, soyadı ve e-posta adresini yazınız.

Kısa yanıt metni

APPENDIX-5

FOCUS GROUP MEMBERS

SECONDARY SCHOOL FOCUS GROUP

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Assoc. Prof. Dr. Sevil AKAYGÜN
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Assoc. Prof. Dr. Ümmüye Nur TÜZÜN
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Dr. Fatma Nur Akın
TUBITAK Directorate of Deneyap Technology Workshops and Science Center

Dr. Aysun İNAL
MoNE General Directorate of Secondary Education

Dr. Fatma Emel IŞIK
Edirne Şehit Nefize Çetin Özsoy Science and Art Center

Dr. Mehmet BİLGİ
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Prof. Dr. Faik Özgür KARATAŞ
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