

Chemistry Teacher Training Programs in the Context of Sustainable Development Goals: A Comparative Analysis of Türkiye and the Netherlands

Rukiye Turan Bal¹, Ayhan Yilmaz^{2*}

¹Graduate Student, Faculty of Education (2023–2025), Hacettepe University, Chemistry Teacher, Ministry of National Education, Ankara, Turkey,

²Department of Mathematics and Science Education, Division of Chemistry Education, Faculty of Education, Hacettepe University, Ankara, Turkey

*Corresponding Author: ayhankorhanfikri@gmail.com

ABSTRACT

This study aims to conduct a comparative analysis of chemistry teacher training programs in Türkiye and the Netherlands from the perspective of the United Nations 2030 Sustainable Development Goals (SDGs) within the scope of integrating global sustainability principles into education systems. The curricula of the bachelor's degree programs in chemistry education at Hacettepe University in Türkiye and Hogeschool Utrecht in the Netherlands are examined in this study based on the social, environmental, and economic dimensions of the SDGs. The findings of the analysis reveal that both higher education institutions have included sustainability goals in their education programs, but the priorities emphasized differ according to institutional and regional dynamics. While the “Quality Education” goal (SDG 4) is a dominant element in the Turkish program, the Dutch program allocates much more space to the themes of “Industry, Innovation and Infrastructure” (SDG 9) and environmental sustainability in addition to SDG 4. It is concluded that while the programs in both countries primarily focus on the social dimension of sustainability, a more balanced and holistic approach is needed to integrate the environmental and economic dimensions into the curriculum for the training of future chemistry teachers. Thus, this study serves as an important indicator of the process of modernizing teacher training curricula in line with the SDGs.

KEY WORDS: Chemistry education, comparative education, education for sustainable development, pre-service chemistry teacher education, science curriculum analysis, sustainable development goals

INTRODUCTION

Since the industrial revolution, the uncontrolled consumption of natural resources and environmental degradation have been leading to increases in environmental, economic, and social crises at the global level. Problems such as global warming, drought, and natural disasters make sustainable development models an inevitable necessity. The concept of sustainable development was first formulated in the 1987 Brundtland Report as the meeting of the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). This definition reflects a holistic perspective that emphasizes the need to address environmental sustainability, economic growth, and social justice in a balanced manner as three complementary pillars. In line with this conceptual framework, the 2030 Agenda for Sustainable Development, announced by the United Nations in 2015, set out a strategic action plan consisting of 17 main goals and 169 sub-goals to produce comprehensive solutions to global problems (SBB, 2019; UNDP, 2015). The agenda emphasizes that technological solutions alone are not sufficient to achieve sustainable development goals (SDG); fundamental changes in individuals' attitudes and behaviors are also necessary.

In this context, education for sustainable development (ESD) stands out as the most critical tool for imparting the knowledge and values that will bring about social transformation. Teacher training programs, in particular, play a key role in raising awareness in society and passing it on to new generations (UNESCO, 2022).

In the development of education programs, the comparative education approach is a strategic tool that allows for the in-depth analysis of pedagogical practices in different countries and the integration of global best practices into local curricula. In this context, examining teacher training processes from the perspective of ESD and using a comparative methodology is of strategic importance in terms of improving program quality and comparing education policies with universal standards.

Purpose and Importance of the Study

The primary objective of this study is to compare chemistry teacher training undergraduate programs in Türkiye and the Netherlands from the perspective of the United Nations 2030 SDGs and to determine the extent to which current curriculum outcomes align with sustainability principles. This research is of great importance in filling the existing gap in the literature at the intersection of chemistry education and sustainability and in providing concrete outputs for implementation. Comparing two

countries with different educational structures, such as Türkiye and the Netherlands, allows for the identification of good practice examples on an international scale and facilitates the more balanced integration of the SDGs into education systems. Considering the direct impact of chemistry on industry, the environment, and the economy, analyzing teacher training processes within the SDG framework serves as a critical guide for both the modernization of education policies and the intergenerational transfer of sustainability awareness. In this respect, the present study provides strategic data for both the academic literature on a theoretical level and for curriculum developers and policymakers on a practical level.

LITERATURE REVIEW

The theoretical framework of this study is structured by the integrated relationship existing among the concepts of sustainable development, ESD, the UN SDGs, and comparative education.

The sustainable development paradigm is a comprehensive model, the foundations of which were laid by the World Commission on Environment and Development (1987), aiming to meet today's needs while preserving the potential of future generations. The UN 2030 Agenda for Sustainable Development, which embodies this vision, provides a broad global roadmap covering everything from poverty to climate action through 17 core goals known as the SDGs. The key to the social transformation necessary to achieve these goals is the ESD approach. As defined by UNESCO (2012, 2022), this approach envisions individuals growing up as sensitive citizens who can analyze ecological, social, and economic issues from an interdisciplinary perspective. In this context, teacher training programs focused on natural sciences, such as chemistry, play key roles in integrating sustainability awareness into education systems and redesigning curricula in line with this global vision.

A review of the literature reveals that there is an extensive body of work on chemistry education based on comparative analyses of teacher training systems and curricula. However, studies addressing the convergence of these topics with ESD and the SDGs are quite limited.

In recent years, the sustainability paradigm has grown markedly more common in chemistry education. Doğan (2022) stated that themes such as green chemistry and environmental awareness have increased in chemistry education studies and that social SDG components, such as equal opportunity, have also been included in the process. However, curriculum-focused studies reveal that this quantitative increase does not always translate into in-depth content. For example, Andersen (2017) in Luxembourg and Pettig and Kuckuck (2021) in Germany found that sustainability and energy topics were treated superficially in science and geography textbooks and those experiential learning approaches were lacking.

Studies on the structural analysis of education programs clearly reveal differences in approaches between countries. Erdoğan (2019) noted that Türkiye's science programs are more

theoretical and detailed compared to Japan's, whereas Japan places greater emphasis on practical application. Similarly, Ataş (2022), comparing Taiwanese and Turkish mathematics programs, drew attention to the impact of the timing of the presentation of learning outcomes on international success. In the field of social sciences, Yerbolat (2022) emphasized that although the history teacher education programs of Türkiye and Mongolia have similar content, they diverge in their institutional implementation processes.

In comparisons between Türkiye and the Netherlands, which constitute the focus of the present study, application-based differences come to the fore. Avcı (2010), in a study examining science teacher training programs, determined that in the Netherlands, application courses are spread throughout the program, while in Türkiye, such processes are more limited. Supporting this finding, Turan Bal et al. (2024) revealed that chemistry teacher training programs in Türkiye are theory-heavy, while those in the Netherlands are student-centered and practice-oriented. Alkan (2012), in an evaluation of EU countries, argued that the weight of interviews and school-based experiences should be increased in the selection of teacher candidates in Türkiye.

The imbalance among the dimensions of sustainable development is a common finding in the literature. Tatlıoğlu (2019) found that SDGs in science programs are predominantly focused on the environmental dimension and remain only at the knowledge level. This is a global trend, as seen in the study by Barak and Avcı (2022) comparing the curricula of Türkiye and Germany, where the economic dimension of the SDGs was found to be weak in both countries. In contrast, Valli (2021) stated that the social dimension has gained importance with the inclusion of values such as peace education in curricula. Simó (2014), who studied the impact of different pedagogical approaches, noted that ESD showed significant differences in Germany, Romania, and Mexico, depending on the educational traditions of each country.

Finally, stability and quality of implementation in teacher training processes will be decisive factors in achieving the SDGs. Aghayeva (2022), in analysis specific to Türkiye and Azerbaijan, argued that the instability created by frequent system changes and the inadequacy of implementation courses negatively affect the quality of education, pointing out that sustainability goals can only be achieved with a solid and stable implementation structure.

In conclusion, the literature demonstrates that ESD has not yet been addressed with a holistic approach in chemistry education and teacher training programs, with the focus to date being largely limited to the environmental dimension. Considering the UNESCO (2012) vision of "education that encompasses all goals," the present study aims to fill a critical gap in the literature by concretizing the differences in practice between Türkiye and the Netherlands and analyzing the three dimensions of the SDGs (i.e., social, environmental, and economic) in a balanced manner.

RESEARCH METHODS

Study Design

This research was undertaken as a quantitative, descriptive document review study conducted within the framework of a comparative educational approach. Within the scope of the research, chemistry teacher training undergraduate programs in Türkiye and the Netherlands were examined within the context of the 2030 SDGs.

Data Collection

Hacettepe University was chosen as the example for Türkiye due to the institution's long-standing history in teacher education in Türkiye, its academic expertise in chemistry education, and the fact that it has the first chemistry teacher education program in Türkiye to be accredited by the Association for Evaluation and Accreditation of Teacher Education Programs (Turkish acronym: EPDAD). Hogeschool Utrecht in the Netherlands was chosen for the study due to its comprehensive and practice-based teacher training models, diverse international programs, and robust internship opportunities, which enable it to equip prospective teachers with both theoretical and practical competencies in a holistic manner.

The dataset for the study consisted of official curriculum documents from the chemistry teacher training programs of Hacettepe University in Türkiye and Hogeschool Utrecht in the Netherlands. The relevant data were accessed through the official websites of the universities and national education authorities (<https://www.hu.nl>; <http://www.hacettepe.edu.tr>; Council of Higher Education [Turkish acronym: YÖK], 2018). Documents related to the Dutch program were translated faithfully into Turkish by a researcher of Turkish origin who is a Dutch citizen and was educated there to prevent any loss of meaning.

Data Analysis

In analyzing the data, a content analysis method was adopted, allowing for systematic coding and categorization. The analysis process consisted of the following stages:

1. Creation of the analysis matrix: A comprehensive analysis matrix based on the ESD framework was prepared
2. Coding and linking: Each achievement in the programs was coded by matching it with one of the 169 sub-goals defined by the UN
3. Classification and thematization: The coded sub-goals were grouped under the 17 main SDGs, and then those goals were thematically classified in line with the three pillars of sustainability: the environmental, social, and economic dimensions (Turan Bal et al., 2024).

The data obtained were tabulated by calculating frequency (f) and percentage (%) values based on the main objectives, sub-objectives, and thematic dimensions of the study. To maintain the scientific quality of the analysis results and the validity of the classifications, the opinions of field experts were sought and data were only accepted after obtaining expert confirmation. Using this method, the distribution rates and differences in

SDG-focused gains in the programs of both countries were evaluated from a statistical and descriptive perspective.

RESULTS

In examining the teacher training processes of the two countries, significant differences were identified, ranging from candidate acceptance to post-graduation appointment mechanisms, as detailed in the following subsections.

Program Admission and Education Process

Türkiye: Candidates are admitted to the program based on their scores on a national university entrance examination known as the Higher Education Institutions Examination (Turkish acronym: YKS), and they receive a 4-year undergraduate education. The education process includes field education, professional knowledge, and general culture courses. With the establishment of the National Education Academy in 2025, an additional 14-month preparation and internship period after graduation was incorporated into the system.

Netherlands: Applicants may be admitted without an entrance exam if they hold certain types of high school diplomas. Those who complete the 1st year of study continue their education by obtaining a 1st-year qualifying (propedeutic) certificate. Pedagogical training and school practices are carried out simultaneously throughout the education period.

Employment and Career Levels

Türkiye: Appointments to public schools are made based on the results of centralized examinations, namely the teaching field knowledge test (Turkish acronym: ÖABT), and interviews. The title of “teacher” is understood as conferring a general status.

Netherlands: Appointments are made through school-based applications and employment contracts rather than a centralized system. In addition, teaching authority is divided into two levels according to the level of education provided: “first degree” (upper secondary education) and “second degree” (lower secondary education).

Academic Standards and European Credit Transfer and Accumulation System (ECTS)

Although 240 ECTS credits are required for graduation in the teaching programs of both countries, the assessment systems differ. A passing grade of 5.5 out of 10 in the Netherlands corresponds to a general grade-point average of 2.00 out of 4 in Türkiye (Hogeschool Utrecht, 2024a; Hogeschool Utrecht, 2024b; Student Selection and Placement Center [Turkish acronym: ÖSYM], 2024a, 2024b; Rijksoverheid [Dutch Government], 2024; Teachers' Professional Quality Foundation [Dutch acronym: SBL], 2024; Council of Higher Education [Turkish acronym: YÖK], 2018, 2021, 2023).

Analysis of Curriculum Outcomes within the SDG Framework

For the curriculum analyses forming the basis of this research, 50 compulsory courses from Hacettepe University and 25 compulsory courses from Hogeschool Utrecht were examined

using content analysis methods. The key trends observed in this analysis were as follows:

- Course distribution and intensity: The program in Türkiye has more courses and is more theory-focused, while the Dutch program has fewer courses but is modular and application-focused (Turan Bal et al., 2024)
- SDG integration: In both programs, the level of alignment of the learning outcomes with the three core dimensions of the SDGs (environmental, social, and economic) differs. The Turkish program has a much higher frequency of focus on “Quality Education” (SDG 4), while the Dutch program has a more pronounced focus on economic and technical dimensions such as “Industry, Innovation and Infrastructure” (SDG 9).

Analysis of the Turkish Curriculum and Sustainable Development

According to the results of this study, there is a striking difference in focus between the learning objectives in the Turkish curriculum and the SDGs. The data in Table 1 clearly show that the curriculum’s center of gravity is quality education (SDG 4). The emphasis on quality education, which is 72.32% in the 1st year of the program, reaches a very high rate of 86.54% in the 4th year. This shows that the Turkish education system attaches much more strategic importance to issues of equality of opportunity and quality in education as the years progress. An examination of the general structure of the curriculum reveals that the social dimension (social development and education) is prioritized over the environmental and economic aspects of sustainability. Critical goals such as health (SDG 3), responsible consumption and production (SDG 12), and innovation (SDG 9) are only addressed at certain times and to a limited extent in the Turkish program.

Examining the data in Table 2, it is clear that the curriculum of Türkiye addresses the SDG sub-goals in a hierarchical manner. The thematic distribution by year of enrollment is as follows:

- 1st and 2nd years: At these levels, the program focuses on students gaining practical skills (Sub-goal 4.4) and instilling awareness of sustainability (Sub-goal 4.7).
- 3rd year: At the 3rd-year level, the element of access to quality education (Sub-goal 4.3) becomes dominant at a

striking rate of 62.71%. This indicates that the program considers participation in education a fundamental priority at this stage.

- 4th year: By the final year, the goals show a more balanced distribution. At this stage, topics that strengthen the institutional quality and social justice dimension of education, such as equality in education (Sub-goal 4.5) and increasing the supply of qualified teachers (Sub-goal 4.c), come to the fore.

The analysis results reveal that the program has charted a course focused on “human and social development,” but some critical areas remain limited. Goals in the areas of health (SDG 3), innovation (SDG 9), responsible consumption (SDG 12), and strong institutions (SDG 16) remain secondary priorities throughout the curriculum.

Analysis of the Dutch Curriculum and Sustainable Development

The data in Table 3 strikingly illustrate how the relationship between the Dutch curriculum and the SDGs evolves across years of enrollment. The findings show that the broad perspective initially offered by the program gives way entirely to a focus on quality education (SDG 4) as students progress to the later years of program enrollment.

- 1st year: At the start of the program, the emphasis on quality education is limited to 39.18%, while environmental and economic dimensions such as industry and innovation (SDG 9), clean energy (SDG 7), and climate action (SDG 13) carry significant weight. At this stage, a more holistic vision of sustainability is presented.
- 2nd and 3rd years: The proportion of emphasis on SDG 4 rises to 70.43% in the 2nd year, and in the 3rd year it dominates the curriculum at 90.11%. This sharp increase is a sign that pedagogical competencies have become the main focus of the program.
- 4th year: Nearly all 4th-year learning objectives (96.55%) are shaped within the scope of quality education. This indicates that in the final stage of the program, the focus is entirely on the teaching profession and the quality of education. Unlike other goals, the goal of peace, justice, and strong institutions (SDG 16) remains low

Table 1: Relationship between learning outcomes and main SDG goals by year in the Turkish curriculum

Main SDG goals	1 st year, f (%)	2 nd year, f (%)	3 rd year, f (%)	4 th year, f (%)
SDG 4: Quality education	81 (72.32)	59 (80.82)	49 (80.33)	45 (86.54)
SDG 3: Good health and well-being	7 (6.25)	–	4 (6.56)	2 (3.85)
SDG 12: Responsible consumption and production	9 (8.04)	5 (6.85)	3 (4.92)	1 (1.92)
SDG 9: Industry, innovation, and infrastructure	6 (5.36)	8 (10.96)	2 (3.28)	1 (1.92)
SDG 16: Peace, justice, and strong institutions	3 (2.68)	–	3 (4.92)	1 (1.92)
SDG 10: Reduced inequalities	2 (1.79)	–	–	–
SDG 7: Affordable and clean energy	2 (1.79)	–	–	–
SDG 8: Decent work and economic growth	1 (0.89)	–	–	–
SDG 6: Clean water and sanitation	–	1 (1.37)	–	–
SDG 11: Sustainable cities and communities	–	–	–	1 (1.92)
SDG 17: Partnerships for the goals	–	–	–	1 (1.92)
SDG: Sustainable development goals				

Table 2: Relationship between learning outcomes and SDG sub-goals by year in the Turkish curriculum

SDG sub-goals	1 st year, f (%)	2 nd year, f (%)	3 rd year, f (%)	4 th year, f (%)
SDG 4.3: Equal access to affordable and quality education	17 (13.93)	23 (28.05)	37 (62.71)	19 (36.54)
SDG 4.4: Skills for employment, decent jobs and entrepreneurship	38 (31.15)	24 (29.27)	8 (13.56)	6 (11.54)
SDG 4.7: Education for sustainable development and global citizenship	21 (17.21)	16 (19.51)	3 (5.08)	4 (7.69)
SDG 4.c: Increase the supply of qualified teachers	6 (4.92)	4 (4.88)	1 (1.69)	8 (15.38)
SDG 4.5: Eliminate gender disparities in education and ensure equal access	1 (0.82)	–	–	8 (15.38)
SDG 12.4: Environmentally sound management of chemicals and waste	7 (5.74)	5 (6.10)	–	1 (1.92)
SDG 12.8: Information and awareness for sustainable development	–	–	3 (5.08)	–
SDG 9.5: Enhance scientific research and innovation capacity	5 (4.10)	8 (9.76)	2 (3.39)	–
SDG 9.4: Sustainable infrastructure and clean technologies	1 (0.82)	–	–	1 (1.92)
SDG 3.9: Reduce deaths and illnesses from environmental pollution	4 (3.28)	–	2 (3.39)	2 (3.85)
SDG 3.4: Promote mental health and well-being	2 (1.64)	–	1 (1.69)	–
SDG 3.7: Universal access to sexual and reproductive health services	–	–	1 (1.69)	–
SDG 6.3: Improve water quality and wastewater treatment	–	1 (1.22)	–	–
SDG 7.3: Improve energy efficiency	2 (1.64)	–	–	–
SDG 16.7: Inclusive and participatory decision-making	2 (1.64)	–	2 (3.39)	1 (1.92)
SDG 16.6: Effective, accountable and transparent institutions	–	–	1 (1.69)	–
SDG 16.10: Ensure public access to information and fundamental freedoms	3 (2.46)	–	–	–
SDG 10.2: Promote social, economic, and political inclusion	2 (1.64)	–	–	–
SDG 11.3: Inclusive and sustainable urbanization	–	–	–	1 (1.92)
SDG 17.17: Partnerships for sustainable development	–	–	–	1 (1.92)
SDG 8.2: Promote productive economic activities	1 (0.82)	–	–	–

SDG: Sustainable development goals

Table 3: Relationship between learning outcomes and main SDG goals by year in the Dutch curriculum

Main SDG goals	1 st year, f (%)	2 nd year, f (%)	3 rd year, f (%)	4 th year, f (%)
SDG 4: Quality education	38 (39.18)	81 (70.43)	82 (90.11)	28 (96.55)
SDG 9: Industry, innovation and infrastructure	22 (22.68)	17 (14.78)	2 (2.20)	–
SDG 7: Affordable and clean energy	11 (11.34)	–	–	–
SDG 13: Climate action	8 (8.25)	2 (1.74)	–	–
SDG 12: Responsible consumption and production	5 (5.15)	1 (0.87)	1 (1.10)	–
SDG 8: Decent work and economic growth	3 (3.09)	–	–	–
SDG 10: Reduced inequalities	3 (3.09)	5 (4.35)	1 (1.10)	–
SDG 16: Peace, justice and strong institutions	3 (3.09)	5 (4.35)	5 (5.49)	1 (3.45)
SDG 3: Good health and well-being	3 (3.09)	3 (2.61)	–	–
SDG 11: Sustainable cities and communities	1 (1.03)	1 (0.87)	–	–

SDG: Sustainable development goals

but consistent in its emphasis across all grade levels. The weight of social goals such as reduced inequalities (SDG 10) and good health and well-being (SDG 3) in the overall curriculum remains quite low.

The data in Table 4 detail how the Dutch curriculum builds its learning objectives around specific SDG sub-goals. The analysis results demonstrate that the multidimensional vision offered by the program in the early years of enrollment is replaced by a specific pedagogical specialization in subsequent years.

- 1st year: At the start of the program, in addition to quality education, Scientific Research and Innovation (Sub-goal 9.5) is strongly represented at a rate of 22.68%. Furthermore, environmental themes such as climate change awareness (Sub-goal 13.3) and clean energy (Sub-goal 7.b) demonstrate that a holistic understanding

of sustainability prevails in the initial phase of the curriculum.

- 2nd and 3rd years: The program's focus is on Developing Professional Skills (Sub-goal 4.4) in the second and 3rd years. This emphasis, which reaches 50.55% in the 3rd year in particular, reflects the strategic importance given to preparing students for the world of work and technical competence. During the same period, the topics of ESD (Sub-goal 4.7) and Qualified Teacher Training (Sub-goal 4.c) also gained momentum.
- 4th year: The focus has shifted significantly by the 4th year. At this stage, Safe and Inclusive Learning Environments (Sub-goal 4.a) takes the lead at 34.48%, followed by education for human rights and peace (Sub-goal 4.7; 27.59%) and equal opportunities in education (Sub-goal 4.1; 24.14%). This shift demonstrates that the program's

Table 4: Relationship between learning outcomes and SDG sub-goals by year in the Dutch curriculum

SDG sub-goals	1 st year, f (%)	2 nd year, f (%)	3 rd year, f (%)	4 th year, f (%)
SDG 4.4: Skills for employment, decent jobs and entrepreneurship	27 (27.84)	47 (40.52)	46 (50.55)	–
SDG 9.5: Enhance scientific research and innovation capacity	22 (22.68)	16 (13.79)	2 (2.20)	–
SDG 13.3: Climate change education and awareness	7 (7.22)	2 (1.72)	–	–
SDG 7.b: Knowledge on clean energy technologies	5 (5.15)	–	–	–
SDG 4.c: Increase the supply of qualified teachers	5 (5.15)	10 (8.62)	18 (19.78)	–
SDG 7.3: Improve energy efficiency	4 (4.12)	–	–	–
SDG 12.2: Sustainable management and efficient use of natural resources	4 (4.12)	–	–	–
SDG 10.2: Promote social, economic, and political inclusion	3 (3.09)	5 (4.31)	1 (1.10)	–
SDG 16.7: Inclusive and participatory decision-making	3 (3.09)	1 (0.86)	–	–
SDG 3.4: Promote mental health and well-being	3 (3.09)	1 (0.86)	–	–
SDG 7.a: Renewable energy research and technology development	2 (2.06)	–	–	–
SDG 4.5: Eliminate gender disparities in education	2 (2.06)	1 (0.86)	1 (1.10)	–
SDG 4.7: Education for sustainable development, human rights and peace	2 (2.06)	21 (18.10)	7 (7.69)	8 (27.59)
SDG 4.a: Safe, inclusive and effective learning environments	2 (2.06)	3 (2.59)	10 (10.99)	10 (34.48)
SDG 8.3: Promote productive employment and decent work	1 (1.03)	–	–	–
SDG 8.5: Full and productive employment and decent work for all	1 (1.03)	–	–	–
SDG 8.8: Protect labour rights and safe working environments	1 (1.03)	–	–	–
SDG 11.6: Reduce the environmental impact of cities (air pollution)	1 (1.03)	1 (0.86)	–	–
SDG 12.5: Waste reduction, recycling, and reuse	1 (1.03)	1 (0.86)	1 (1.10)	–
SDG 13.1: Climate resilience and disaster risk reduction	1 (1.03)	–	–	–
SDG 16.10: Access to information and fundamental freedoms	–	2 (1.72)	3 (3.30)	1 (3.45)
SDG 16.3: Promote the rule of law and ensure equal access to justice	–	1 (0.86)	1 (1.10)	–
SDG 16.1: Reduce violence and related deaths	–	1 (0.86)	1 (1.10)	–
SDG 3.9: Reduce deaths and illnesses from environmental pollution	–	1 (0.86)	–	–
SDG 3.7: Universal access to sexual and reproductive health services	–	1 (0.86)	–	–
SDG 4.1: Quality education and equal learning opportunities	–	–	–	7 (24.14)
SDG 4.6: Literacy and numeracy skills	–	–	–	3 (10.34)
SDG 9.4: Sustainable infrastructure and clean technologies	–	1 (0.86)	–	–
SDG: Sustainable development goals				

closing phase is entirely focused on the quality of the educational ecosystem. Numerous other goals in areas such as health (SDG 3), energy (SDG 7), economic growth (SDG 8), and sustainable cities (SDG 11) have very limited representation across all years. These themes remain supporting elements throughout the curriculum.

The data presented in Table 5 reveal how the learning objectives of the Turkish and Dutch curricula are distributed across the social, economic, and environmental dimensions of the SDGs. The curriculum structures of both countries place the social dimension at the center of the sustainability approach. This trend is reflected by very high representation rates of 85.91% in the Turkish curriculum and 75.37% in the Dutch curriculum. These findings confirm that both education systems primarily focus on social development, educational quality, and human values, thus demonstrating that both countries have internalized sustainable development primarily through quality education (SDG 4) and pedagogical competencies. When examined in terms of the environmental and economic dimensions, the topics of environment and economy, which are the other two fundamental pillars of sustainability, remain in the background in both programs compared to the social dimension. The environmental dimension, which addresses the

Table 5: Distribution of the SDGs in Turkish and Dutch teacher education programs by social, economic, and environmental dimensions

Dimension	Türkiye, f (%)	Netherlands, f (%)
Social	256 (85.91)	254 (75.37)
Environmental	23 (7.72)	31 (9.20)
Economic	19 (6.38)	52 (15.43)

protection of natural resources and ecological balance, remains a secondary priority in the overall curriculum of both countries, accounting for a limited percentage of 7.72% in Türkiye and 9.20% in the Netherlands.

When the programs are evaluated from an environmental perspective, it is observed that although the field of chemistry is at the heart of solutions to global crises such as green energy and carbon management, teacher training programs have not yet been able to translate that potential into pedagogical action. The fact that prospective chemistry teachers graduate without internalizing the environmental management of chemicals in laboratory settings (SDG 12.4) or the potential of innovative and clean technologies in industry (SDG 9.4) poses a serious risk to the quality of future education.

There is a striking difference between the two countries in terms of the representation of the economic dimension (Netherlands: 15.43%; Türkiye: 6.38%). This difference may be understood as an indication of the strong link between industry and innovation (SDG 9) in the teacher training model of the Netherlands.

DISCUSSION AND CONCLUSION

The comparison of chemistry teacher training programs in Türkiye and the Netherlands in the context of the UN SDGs has revealed the priorities and sustainability visions of both countries' education policies with concrete data. The analyses show that both curricula have internalized the SDGs, but the distribution and depth of these goals differ according to the national context. The research findings have demonstrated that SDG 4 (quality education) is the absolute focus in the Turkish program, while in the Netherlands, SDG 4 is represented in a more balanced manner alongside SDG 9 (industry, innovation, and infrastructure) and SDG 7 (affordable and clean energy). This finding parallels the conclusions of Barak and Avcı (2022) regarding the curricula of Türkiye and Germany; in both studies, the focus was found to be on education quality, while economic gains were less prominent. In the case of the Netherlands, the fact that SDG 9 (industry, innovation, and infrastructure) and SDG 7 (clean energy) carry significantly more weight compared to Türkiye stems from the Netherlands' education philosophy with a focus on vocational professionalization. This broad spectrum aligns with Simó's (2014) argument that contemporary pedagogical approaches must address sustainability in a multidimensional manner. The limited representation of environmental goals in Türkiye supports Doğan's (2022) bibliometric analysis of the relationship between equal opportunity in education and environmental awareness. Evaluating the programs in terms of the social, environmental, and economic dimensions of the SDGs, the social dimension was found to be represented at a rate of 85.91% in Türkiye and 75.37% in the Netherlands. These high rates show that both countries place values such as social equality, inclusiveness, and human rights at the center of chemistry education. In contrast, the environmental and economic dimensions together constitute only a small part (approximately 14%) of the curriculum in Türkiye, while in the Netherlands, this rate is higher and shows a more balanced distribution. As Pettig and Kuckuck (2021) emphasized, the risk of superficial treatment of energy and sustainability issues confirms the need to strengthen the environmental dimension, particularly in Türkiye. The fact that the environmental dimension remains underdeveloped in both countries suggests that this shortcoming stems not only from a lack of knowledge but also from the failure to adapt curricula to transformations such as economic shifts or green chemistry. In light of these findings, the following steps should be taken to make chemistry teacher training programs more inclusive of visions of sustainability:

- SDGs should be addressed not only in specific sections of the curriculum but as a core theme throughout all years

of education. Topics such as sustainable material use, waste management, clean energy technologies, and the circular economy should be systematically integrated into chemistry courses.

In chemistry education, sustainable development content should be made compulsory rather than optional. It should be integrated into all topics, from atomic theory to organic chemistry and across subtopics such as waste management and clean energy technologies. Prospective teachers' laboratory activities should be organized in accordance with the criteria of zero waste and energy efficiency (SDGs 7 and 12).

- Project-based learning approaches that enhance prospective teachers' perceptions of their self-efficacy regarding SDGs should be incorporated into the curriculum.
- Partnerships should be supported to incorporate the connection between industry and innovation (SDG 9), as seen in the example of the Netherlands, into the Turkish curriculum as a "best practice."

In conclusion, these differences between Türkiye and the Netherlands are not shortcomings but rather a reflection of national policies and cultural contexts. However, the future transformative role of chemistry teachers will only be possible with more balanced curricula that incorporate all dimensions of sustainable development.

DECLARATIONS

This submission has not been previously published, nor is it before another journal for consideration.

FUNDING

No funds, grants, or other support was received.

CONFLICT OF INTEREST DISCLOSURE

The authors report that there are no conflicts of interest to declare.

ETHICAL APPROVAL

In this study, data were collected from the official website of Hogeschool Utrecht's Dutch chemistry teacher training program (<https://www.hu.nl>). The chemistry teacher education bachelor's degree program implemented at Hacettepe University in Türkiye was accessed from Hacettepe University's official website and the Council of Higher Education (Turkish acronym: YÖK) Chemistry Teacher Education Bachelor's Degree Program (<http://www.hacettepe.edu.tr>; YÖK, 2018). These web addresses are publicly available sources. In addition, on August 09, 2024, the Research Ethics Committee of the Hacettepe University Rectorate Education Sciences Institute examined the project and granted ethical approval (E-51944218-050-00003715021).

The data for this study were collected for the master's thesis conducted by the first author under the supervision of the second author.

REFERENCES

- Aghayeva, M. (2022). *A Comparison of Azerbaijani and Turkish Legal Regulations Regarding Teacher Training and Appointment, and Recommendations for AZERBAIJAN* [Master's Thesis]. Hacettepe University.
- Alkan, S. (2012). *A Comparison of Teacher Training Programs in EU Countries and Turkey, and a Proposed Model for Türkiye* [Master's Thesis]. Mustafa Kemal University.
- Andersen, K. (2017). Evaluation of school tasks in the light of sustainability education: Textbook research in science education in Luxembourg primary schools. *Environmental Education Research*, 24(9), 1301-1319.
- Ataş, B.D. (2022). *Comparative Analysis of Taiwan-Türkiye 5th-8th Grade Mathematics Curricula* [Master's Thesis]. Gaziantep University.
- Avcı, S. (2010). *A Comparison of Science Teacher Training Programs in the Netherlands and Turkey, and Prospective Teachers' Opinions about these Programs* [Doctoral Dissertation]. Ondokuz Mayıs University.
- Barak, B., & Avci, G. (2022). Comparative analysis of Turkey and Germany (Bavaria) secondary education curricula in terms of education for sustainable development. *Discourse and Communication for Sustainable Education*, 13(2), 108-132.
- Doğan, M. (2022). *Bibliometric Analysis of Studies on Sustainable Development and Green Chemistry in Chemistry Education* [Master's Thesis]. Atatürk University.
- Erdogan, Y. (2019). *Comparison of the Science Curriculum of Türkiye (2018) and Japan (2008)* [Master's Thesis]. Sakarya University.
- Hogeschool Utrecht. (2024a). *The Propedeutic Phase: More Than Just the First Year*. Available from: <https://www.hu.nl/onderzoek/publicaties/depropedeuse-meer-dan-een-eerste-jaar> [Last accessed on 2026 Feb 26].
- Hogeschool Utrecht. (2024b). *Second-Degree Chemistry Teacher*. Available from: <https://www.hu.nl/voltijd-opleidingen/leeraar-scheikunde-tweede-graads> [Last accessed on 2026 Jan 12].
- Ölçme, Seçme ve Yerleştirme Merkezi (Measurement, Selection and Placement Center). (2024b). *2024-KPSS Lisans Alan/ÖABT Kılavuz ve Başvuru Bilgileri*. [Undergraduate Field/Teaching Field Knowledge Test (ÖABT) Guide and Application Information]. Available from: <https://www.osym.gov.tr/TR,29351/2024-kpss-lisansalanoabt-kilavuz-ve-basvuru-bilgileri.html> [Last accessed on 2026 Mar 12].
- Ölçme, Seçme ve Yerleştirme Merkezi. (2025). *Kamu Personel Seçme Sınavı KPSS-2024/3 Tercih Kılavuzu*. Available from: https://dokuman.osym.gov.tr/pdfdokuman/2025/KPSS/TERCIH2/tercih2_kilavuz_18122025.pdf [Last accessed on 2026 Mar 15].
- Pettig, F., & Kuckuck, M. (2021). Narratives of sustainability on energy-related topics: Empirical findings from German geography textbooks for secondary schools. *Review of International Geographical Education*, 11(2), 605-628.
- Rijksoverheid (Dutch Government). (2024). *How do I Become a Teacher in Secondary Education?* Available from: <https://www.rijksoverheid.nl/onderwerpen/werken-in-het-onderwijs/vraag-en-antwoord/leeraar-voortgezet-onderwijs> [Last accessed on 2026 Feb 21].
- Simó, P. (2014). Tracing sustainability: Education for sustainable development in the lower secondary geography curricula of Germany, Romania, and Mexico. *International Research in Geographical and Environmental Education*, 23(2), 126-141.
- Stichting Beroepskwaliteit Leraren (SBL) (Teachers' Professional Quality Foundation). (2024). *We Learn*. Available from: <https://wij-leren.nl/sbl-competenties.php> [Last accessed on 2026 Mar 16].
- Strateji ve Bütçe Başkanlığı (Presidency of Strategy and Budget). (2019). *Sustainable Development Goals Evaluation Report*. Available from: https://www.sbb.gov.tr/wp-content/uploads/2020/03/surdurulebilir-kalkinma-amaclari-degerlendirme-raporu_13_12_2019-web.pdf [Last accessed on 2026 Jan 10].
- Tatlıoğlu, E. (2019). *Analysis of Science Curriculum and Textbooks in Terms of Sustainable Development Goals: A Case Study* [Master's Thesis]. Orta Doğu Teknik University.
- Turan Bal, R., Yılmaz, A., & Dinçol Özgür, S. (2024). Comparison of chemistry teacher training programs: The case of Türkiye and the Netherlands. *Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 19(2), 264-297.
- UNDP. (2015). *Human Development Report 2015*. Available from: <https://files.acquia.undp.org/public/migration/tr/HDR2013-Report-EN.pdf> [Last accessed on 2026 Jan 09].
- UNESCO. (2012). *Education for Sustainable Development: Sourcebook*. Available from: unesdoc.unesco.org/in/rest/annotationSVC/DownloadWatermarkedAttachment/attach_import_1692bfcd-9844-448c-8c8b-53a1decc5b56?_220416eng.pdf&to=124&from=1 [Last accessed on 2026 May 24].
- UNESCO. (2022). *What you Need to Know about Education for Sustainable Development*. Available from: <https://www.unesco.org/en/sustainable-development/education/need-know> [Last accessed on 2026 Jan 08].
- Valli, B. (2021). *An Analytical Study of the Curriculum of Upper Primary Education in Gujarat: Peace Education Perspective* [Doctoral Dissertation]. The M.S. University of Baroda.
- World Commission on Environment and Development. (1987). *Report of the World Commission on Environment and Development: Our Common Future*. United Nations.
- Yerbolat, A. (2022). *A Comparative Study of History Teacher Training Programs in Türkiye and Mongolia* [Master's Thesis]. Erciyes University.
- Yükseköğretim Kurulu (Council of Higher Education). (2018). *Undergraduate Program in Chemistry Teacher Education*. Available from: https://www.yok.gov.tr/documents/kurumsal/egitim_ogretim_dairesi/yeni-ogretmen-yetistirme-lisans-programlari/kimya_ogretmenligi_lisans_programi.pdf [Last accessed on 2026 Jan 09].
- Yükseköğretim Kurulu (Council of Higher Education). (2021). *New Undergraduate Teacher Education Programs*. Available from: <https://www.yok.gov.tr/documents/documents/68f1dc912d8a0.pdf> [Last accessed on 2026 Jan 09].
- Yükseköğretim Kurulu (Council of Higher Education). (2023). *Information on Pedagogical Formation*. Available from: <https://egitim.yok.gov.tr/tr/page/496> [Last accessed on 2026 Feb 16].