Does Science Education Contribute to Citizenship Education in Turkey?

Zafer Kuş[a]
Hilal Mert
Ahi Evran University

Abstract: *This research aims to explore the connections between science and citizenship education and how science education contributes to citizenship education in Turkey. To achieve these goals, we focused on two research questions: First, what does the science curriculum in Turkey encompass concerning citizenship education? Second, how do science educators perceive their role in contributing to citizenship education, and how do they foster students' citizenship skills? Multiple data sources were employed to provide comprehensive answers to these research questions. In this context, the science curriculum in Turkey was analyzed, and interviews were conducted with science educators using a semi-structured interview protocol. The data were processed using the Maxqda Qualitative Data Analysis Program and subjected to content analysis. The research findings underscore that there is a relationship between science education and citizenship education. Science courses have the potential to cultivate citizenship competencies. However, science educators feel that science education is falling short of meeting its citizenship objectives due to various challenges they encounter. It is essential to train and support teachers to seamlessly integrate citizenship skills into science education.*

Keywords: *Citizenship Education, Curriculum, Science Education, Science Teachers*

Introduction

Since the French Revolution, many nation-states have focused on constructing national identity through citizenship education (Carretero, Haste & Bermudez, 2016). However, the concept of citizenship and citizenship education has evolved beyond merely building a national identity. Citizenship education transcends being just a subject in the national curriculum. It is an educational process designed to equip students with the knowledge, skills, and understanding they need to actively and responsibly participate in a democratic society. Democratic citizenship education emphasizes the importance of producing informed, active, and responsible individuals, not just within their own countries, but on a global level as well. The perception of citizenship education varies by country. Often, subjects like religious education, geography, history, social studies, and other social sciences are associated with it (Mckenzie, 2000; Kuş, 2020). In today's world, pressing issues such as climate change, pandemics, mass migrations, and wars affect not just individual countries or regions, but the entire globe. Amid these events, liberties are curtailed and human rights are gravely compromised. These circumstances underscore the increasing role of science in our daily lives and the ever-growing importance of citizenship skills in addressing societal challenges. If we genuinely value citizenship education, it must go beyond merely being a course title. We must recognize that global citizens require the knowledge, attitudes, skills, and values emphasized by various scientific disciplines.

a Correspondence can be directed to: zaferkus@gmail.com

Science and Citizenship Education

Undoubtedly, there are interconnections between citizenship education for fostering responsible citizenry and scientific literacy, as highlighted in science education (Bayram-Jacobs, Wieske & Henze, 2019). Today, the goal of science education is to cultivate scientifically literate and responsible citizens across the entire student population, not solely future scientists and engineers. This implies that students are equipped to grasp the concepts, principles, and processes of science (Bayram-Jacobs, Wieske & Henze, 2019).

When examining the concepts emphasized in science education in recent years—such as ethics, morals, values, skills, socio-scientific issues, technology, society and environment, critical thinking, culture, law, politics, GMO crops, vaccinations, and climate change—it's evident that these concepts are directly relevant to citizens and, by extension, citizenship education. To equip young individuals for life beyond school, recent educational reports from various parts of the world have advocated for a science education that prioritizes scientific literacy, relates science to everyday experiences, and underscores the social dimensions of science (European Commission, 2015; Evagorou & Dillon, 2020). In its report titled Science *Education for Responsible Citizenship*, the European Commission (2015) articulates the following:

> We need science to inform policy, objectively. We need science to inform citizens and politicians in a trustworthy and accessible way. We need to make decisions together rather than from polarised positions and to take responsibility for those decisions, based on sound scientific evidence (p. 5).

The emphasis on the significance of science education for citizens is not a recent development. Over a century ago, Dewey (1910) argued that the school curriculum should encompass the social and moral aspects of science. He believed that science education was insufficient, offering only "ready-made material" and failing to acknowledge science as a metacognitive process. Notably, scientific research focusing on "science for citizenship" saw an uptick in the 1990s and early 2000s (Reiss, 1993; Solomon, 1994; Bingle & Gaskell, 1994; Kolstø, 2000; Kolstø, 2001).

The literature advocates for the integration of citizenship education into science courses via Science, Technology, Society, and Environment (STSE) topics (Davies & Thorpe, 2003; Mansour, 2009; Osborne, 2000; Sadler, 2004). Such integration encourages students to delve into the interplay between science and society, fostering a more comprehensive grasp of their roles as informed and accountable citizens. By confronting real-world challenges and instilling critical thinking and decision-making abilities, students enhance their scientific literacy and become actively involved in democratic deliberations. Numerous works highlight the pivotal role of science in citizenship education across various domains. Foremost among these is the "scientific literacy" skill that every conscientious citizen should possess (Vesterinen, Tolppanen & Aksela, 2016; Wellington, 2002; DeHart Hurd, 1998; Laugksch, 2000). The practical application of science informs life competencies and undertakings, necessitating the inculcation of citizenship values in students (Kolstø, 2008). Notably, socio-scientific subjects serve as vital instruments for cultivating citizenship abilities (Sadler, 2004; Solomon, 1994). Chen and Cowie (2013, p. 2) pinpoint three primary rationales for emphasizing science within the context of citizenship: First, citizens require scientific knowledge to comprehend socio-scientific matters. Second, an absence of scientific expertise can lead to marginalization and exclusion. Third, authentic and sustainable scientific inquiries are more attainable when approached from a citizenship perspective. Given these factors, it's imperative for science courses to underscore the tenets of "scientific literacy", the essence of scientific knowledge, and the decision-making framework pertinent to scientific concerns (Barbosa, 2004).

"Science education for citizenship" is defined as the approach to science education that aims to equip students for active, informed, critical, and responsible involvement in situations where an understanding of various scientific aspects can enhance the quality of their participation (Kolstø, 2001). Westheimer and Kahne (2004) delve into the intrinsic connection between science education

and citizenship. They pinpoint three primary traits students should embody to be considered citizens: personal responsibility, participation, and justice. Science education plays a pivotal role in moulding critical, globally-conscious citizens. Furthermore, citizenship education offers avenues for hands-on experiences, discernible social and environmental impacts, and empowers individual and communal voices (Sperling, 2009).

Environmental topics addressed in science education represent another crucial domain concerning citizenship. Including any environmental concept or process in science, textbooks can greatly enrich the citizenship values that shape students' environmental awareness (Siatras & Koumaras, 2013). In September 2015, the UN endorsed the Sustainable Development Goals for 2030 (SDG-2030) to tackle an array of global challenges. The goals strive to eliminate poverty, foster social and economic development, combat climate change, and ensure equal opportunities and access to quality education in line with the post-2015 education and development agenda (UN, 2015). A robust connection exists between the objectives of education for democratic and global citizenship and the Sustainable Development Goals. Citizenship education equips citizens with an understanding of the significance of the Sustainable Development Goals by addressing worldwide challenges. National and international collaboration is pivotal in attaining these goals. Through citizenship education, individuals are motivated to raise awareness, assume responsibility, and collaborate, all of which contribute to a sustainable global future. Furthermore, it is acknowledged that many sustainable development challenges, such as droughts, climate change, energy transitions, biodiversity depletion, economic growth, technological advancements, employment, and industrialization, are intertwined with scientific concepts that science education addresses. To realize these objectives, it is vital for citizens to maintain environmental sustainability and scientific literacy. Given the multitude of societal and global challenges, science education is poised to make significant contributions to citizenship education.

Citizenship Education and Science Education in Turkey

In Turkey, from the establishment of the Republic (1923) until the 2000s, the foundation of citizenship education policy revolved around the duty-driven formation of national identity. In this regard, particularly social science courses such as history, geography, and social studies, which contributed to the formation of national identity, were viewed as citizenship courses. However, Since the 2000s, in alignment with the harmonization process with the European Union, there have been significant shifts in the citizenship education policy in Turkey. Within this framework, numerous modifications have been introduced to citizenship courses. In 2005, a curriculum grounded in constructivist education was developed, wherein citizenship education was envisioned as a multidisciplinary approach, with contributions expected from all subjects (MoNE, 2005). The primary objective of citizenship education is to nurture democratic individuals who respect human rights, are environmentally conscious, and value diverse cultures. However, this interdisciplinary approach was short-lived. Starting in the academic year 2010-2011, "citizenship" began to be offered as a standalone course, but only for the 4th grade. At the secondary level, the responsibility for citizenship education was solely entrusted to the social studies course (Kuş, 2014; Kuş, 2020). This approach has severed the link between science education and citizenship education. The foundation of contemporary citizenship education in Turkey centres on democratic citizenship, which upholds national values, thinks globally and is environmentally conscious.

Shifts in science education in Turkey began in the 1990s with the "Science-Technology-Society" concept, mirroring global trends. In 2005, science education underwent a transformation influenced by educational reform, with its content thoroughly revised based on the Science-Technology-Society and Environment (STSE) approach. While the science curriculum was framed around STSE, direct links were not established between the curriculum topics and this framework. As a result, the manner in which to integrate subjects with daily life and citizenship competencies remained ambiguous. Consequently, the primary objective of the science curriculum, last updated in 2018, was articulated

as to heighten the individual's awareness of the interplay between the individual, environment, and society; and to foster an understanding of sustainable development concerning society, economy, and natural resources (MoNE, 2018). This curriculum accentuates the notions of scientific literacy, technological literacy, and environmental literacy, which are essential for contemporary citizens, in addition to numerous values and skills integral to citizenship education. Additionally, the European Qualifications Framework, which encompasses qualifications in science and technology that bolster students' lifelong learning, is integrated. In this vein, the science curriculum's contribution to the objectives of citizenship education is paramount. However, in Turkey, the relationship between science education and citizenship education remains tenuous, and research in this domain is sparse (Özden, 2011).

Turkey is dedicated to exerting efforts at both the national and international levels to realize the SDG 2030 objectives and to undertake the requisite steps for sustainable development. In the Sustainable Development Goals Assessment Report compiled by the Turkish government, it is underscored that Turkey has advanced in many of the goals but still necessitates enhancements across various tiers, spanning policy, strategy, and execution (SDGAR, 2019). The shared tenets of citizenship education and science education (like sustainability, environment, socio-scientific issues, scientific literacy, and society) appear pivotal in achieving the Sustainable Development Goals. Yet, despite their significance, the connection between science education and citizenship education has not been distinctly defined. This frailty in the relationship between science education and citizenship education is not just a national issue for Turkey; it is a challenge recognized on a global scale. Davies (2004) states that although there is literature showing the relationship between science education and citizenship education, there is currently a weak relationship between science education and citizenship tools. Davies (2004) also states that science and citizenship (as well as science education and citizenship education) are closely intertwined. During the current nascent stage of citizenship education, there is a pressing need to delve deeper into how this collaboration can materialize.

This research seeks to examine the links between science and citizenship education in Turkey. To achieve these objectives, we centred on two primary research questions. Firstly, what aspects of citizenship education are encompassed in the Turkish science curriculum? Secondly, how do science educators perceive their role in contributing to citizenship education, and how do they foster students' citizenship skills? To address these questions, this article relies on interviews with eight science educators and contextualizes these interview insights by analyzing the science curricula in Turkey.

Method

Research Design

In this study, a qualitative research design was employed. Qualitative research is an inquisitive and interpretative method that seeks to understand the essence of a problem in its natural setting (Guba & Lincoln, 1994; Klenke, 2016). Such research strives for a profound understanding of the event or phenomenon under analysis (Morgan, 1996). Therefore, qualitative researchers typically collect data from various sources, such as interviews, observations, and documents, rather than relying on a single data source (Creswell, 2013). This study delves into the relationship and contribution of science education to citizenship education in Turkey. To this end, the perspectives and experiences of science educators regarding the science-citizenship relationship were explored, and this phenomenon was contextualized within the science curriculum.

To achieve this, the science curriculum was first reviewed. Subsequently, to address the research question, interviews with science educators were meticulously analyzed.

Data Collection

In this study, multiple types of data (documents and interviews) were utilized to provide clear answers to the research questions. Yin (2014) suggests that using more than one data source helps encompass a broader spectrum of perspectives, behaviours, and attitudes, thereby enhancing reliability. In this regard, the science curriculum, which serves as the foundational guide for science educators and outlines the core content of the subjects to be taught, was examined. In Turkey's secondary schools, science educators teach science for 4 hours a week in grades 5 through 8. Curricula are made available on the official website of the Ministry of National Education (http://mufredat.meb.gov.tr/). In the second phase, interviews were conducted with science educators, who are responsible for implementing the curriculum, using a "Semi-Structured Interview Protocol". The interview questions were formulated based on the themes highlighted in the curriculum after analyzing the science curriculum (see Appendix A). The interview protocol was initially pilot-tested with a science teacher. During this pilot test, questions that the teacher found challenging to comprehend were clarified and made more understandable, and additional sub-questions were incorporated. Once the form was finalized, interviews were conducted with 8 teachers. In qualitative research, the study group comprises individuals familiar with the research topic and capable of articulating their experiences. For this study, criterion sampling, a type of purposeful sampling method, was utilized to select the group. Face-to-face interviews were conducted with eight science teachers. All interviews were carried out in the teachers' native language (Turkish) and were video-recorded. The interviews with the teachers typically lasted between 27 and 35 minutes. Throughout the interviews, the researcher was careful not to impose their assumptions or biases.

Table 1. Demographic Information of the Teachers Interviewed

Participant	Subject Taught	Gender	Years of Teaching	Education Level
ST1	Science	Male	20	Bachelors
ST2	Science	Male	7	Bachelors
ST3	Science	Male	13	Masters
ST4	Science	Male	26	Bachelors
ST5	Science	Female	19	Bachelors
ST6	Science	Female	15	Masters
ST7	Science	Female	27	Bachelors
ST8	Science	Female	17	Masters

As indicated in Table 1, the study sample comprised 8 science teachers. Of these, 4 were male and 4 were female. The teachers' years of experience ranged from 7 to 27 years.

Data Analysis

The data collected from the science curricula and science educators via a semi-structured interview protocol were subjected to thematic analysis. Thematic analysis is a method employed to delve deeper into the content of texts, identify patterns (themes) within the data, and subsequently analyze and report on these findings (Braun & Clarke, 2006). In terms of the analytical procedure, the research data were organized according to the six-stage thematic analysis outlined by Braun and Clarke (2006). These stages include (1) familiarization, (2) generating codes, (3) searching for themes, (4) reviewing codes, (5) defining themes, and (6) producing the report.

Curriculum Analysis

Thematic analysis began with the examination of the science curriculum. The curriculum's introductory section encompasses the objectives of science teaching, as well as associated values and skills. This is followed by units, topics, and outcomes for each grade level. The researchers meticulously read the science curriculum multiple times. Through these repeated readings and during the coding process, it was observed that the codings predominantly pertained to the "*science, technology, society, and environment*" approach, which underpins the science curriculum. Since citizenship education in Turkey is not delivered through an interdisciplinary approach but rather as an independent course, there is no explicit link to citizenship education within the science curriculum. Nonetheless, given that the concepts of "*science, technology, society, and environment*" relate to citizenship education, these notions were designated by the researchers as the framework for thematic analysis. In the pursuit of identifying themes, the *"values and skills"* segment in the science curriculum was also pinpointed as a distinct theme due to its relevance to citizenship education. During the coding phase, emphasis was placed on the relation of each statement in the science curriculum to citizenship education and the concepts that citizens require in a democratic society (see Appendix B). The Maxqda software was employed for qualitative data analysis. To enhance the internal validity of the data procured, direct quotes from the curriculum were incorporated into the findings section. Citations from the science curriculum are abbreviated as 'SC', followed by the respective page number.

Teacher Interview Analysis

Following the analysis of the science curriculum, teacher interviews were examined in the subsequent phase. This is because teachers are the executors of the curriculum and are responsible for linking it to citizenship education. Therefore, their perspectives on the themes derived from the curriculum are crucial. In this phase, all teacher interviews were initially transcribed and uploaded to the Maxqda software as Word files. The interviews were meticulously coded based on the themes that emerged from the science curriculum analysis (i.e., scientific literacy, technology, society, environment, values, and skills). Beyond these themes, a new theme titled "*problems*" surfaced, highlighting challenges in achieving the citizenship objectives of science teaching, as expressed by the teachers during the interviews. Subsequently, all codes were revisited, and the data were categorized under seven pertinent themes (Table 2). In this study, all thematic analyses were driven by the data. To bolster the internal validity of the data, direct quotations from the gathered data are presented in the findings. In these quotations, teacher names were omitted, and instead, abbreviations were used. For example, (ST-1/M) denotes the first male science teacher, while (ST-2/F) signifies the second female science teacher.

Table 2. Main Themes Emerging from the Data Analysis

Data Source	**Themes**						
	t-1	***t-2***	***t-3***	***t-4***	***t-5***	***t-6***	***t-7***
Science Curriculum	*scientific literacy*	*technology*	*society*	*environment*	*values*	*skill*	
Teacher Interview							problems

Findings

Science/Scientific Literacy

Scientific knowledge from various fields, essential for scientific literacy, is frequently incorporated into the science curriculum. This knowledge is categorized under four main subject areas: "*Earth and Universe," "Living Things and Life," "Physical Events," and "Matter and Nature*." For instance, the initial unit on "*Earth and the Universe*" covers objectives related to the Earth, sun, moon, stars, and planets across all grade levels. The "*Living Things and Life*" section provides scientific details about human anatomy, animals, plants, DNA, and cells. Within the realm of scientific literacy, there is a pronounced focus on scientific process skills in the curriculum's objectives. These skills are highlighted with phrases such as adopting a scientific research approach, emphasizing safety in scientific studies, making observations, measuring, classifying, recording data, understanding the evolution of scientific knowledge, and embracing scientific and ethical principles. Furthermore, the curriculum frequently underscores that "scientific knowledge is not fixed and can evolve and advance."

> In the process of discovering nature and understanding the relationship between human and environment, adopting scientific process skills and scientific research approach and producing solutions to the problems encountered in these areas (MoNE 2018, p. 9).

In this study, science teachers strongly highlighted the significance *of scientific knowledge,* viewing it as directly linked to citizenship education. They regarded being *scientifically literate* as an essential attribute for modern citizens. Within this theme, initial discussions centred on the elaboration of scientific concepts. Teachers conveyed that through science classes, students grasp concepts vital for daily life. Lacking knowledge of these concepts would hinder their understanding of many phenomena. Possessing this foundational knowledge allows them to achieve scientific literacy, evolving into scientifically informed citizens. Underlining the importance of scientific literacy, teachers broadly noted that the primary goal of science classes is to cultivate scientifically literate citizens. Such literacy empowers students with problem-solving skills relevant to everyday life, comprehension of their biological development, and abilities like research, inquiry, and critical thinking. Addressing the tie between scientific literacy and citizenship education, ST-2/M remarked:

> *In our laboratory lessons, we typically conduct experiments following the steps of the scientific method. If students can apply these steps in their daily lives, they can address numerous problems* (ST-2/M).

Conversely, some teachers drew a link between scientific literacy and active citizenship, asserting that individuals lacking scientific literacy cannot be active citizens. Additionally, a few teachers mentioned that scientifically literate individuals can make significant contributions to the country and societal harmony.

> *One of the most important characteristics of an active citizen is the ability to inquire. In science lessons, we teach students to question all events that occur in nature. In this way, students gain the ability to question, which is the most basic characteristic of an active citizen* (ST-5/F).

Technology

In the curriculum, there are specific sections emphasizing technology. The technology category is addressed in the context of space exploration, human necessities, our country's scientific research and technological advancements, certain devices, and engineering.

In order to increase our country's capacity for scientific research and technological development, socio-economic development and competitiveness, it is important that students experience the applications of science and engineering (MoNE 2018, .p.10).

The teachers interviewed did not draw a strong connection between technology and citizenship. Opinions on this theme were quite limited, with a few comments primarily centred on space technologies and understanding technological devices. One science teacher remarked on the subject:

> *Technology is everywhere today. There is science in all the technological tools we use in our homes, schools and daily lives. For example, the use of electric vehicles is rapidly spreading. We make them the subject of our lessons. Science teaching contributes to understanding the technological structure of these tools* (ST-1/M).

Society

The science curriculum reveals that certain topics are linked with society. For instance, in the objectives section, there is an emphasis on students taking responsibility for everyday problems, showing interest in events around them, and enhancing their reasoning skills through socio-scientific subjects. Discussions of certain topics highlight non-governmental organizations. For example, the Red Crescent, a blood donation organization, is highlighted when discussing the topic of "blood", while the Green Crescent is underscored in the context of combatting alcohol and smoking. Additionally, there are notes on the significance of organ donation for social solidarity, the importance of first aid, the dangers of unsupervised drug use, and the economic impact of illegal electricity consumption. The curriculum suggests that these topics are primarily addressed in the context of civic responsibilities.

> To take responsibility for daily life problems and to use science knowledge, scientific process skills and other life skills to solve these problems (MoNE 2018, p.9).

In the study, science teachers directly associated science with society (everyday life) and linked it to citizenship within the context of science and society. Teachers noted that while the topics covered in science courses might appear abstract, they are elements students encounter frequently in daily life. Science teachers highlighted that the course delves into all living entities, such as humans, animals, and plants, and that the knowledge acquired about these organisms can be beneficial for students in their day-to-day lives. Every science educator pointed out that through the science course, students first become acquainted with themselves and their bodies, gaining insight into biological changes. A significant connection was drawn between science education and health, emphasizing that the course educates students about healthy eating, sleep habits, detrimental behaviours, and first aid.

> *Through science teaching, the individual discovers himself/herself and learns the biological structure of the body. He learns things that can harm his health. In this respect, it makes an important contribution to public health. They also learn first aid. This is also a kind of citizenship responsibility* (ST-7/F).

Another domain bridging daily life and science pertains to hazards and safety. Several science educators mentioned that through this course, students acquire knowledge about potentially dangerous daily situations, such as electricity, poisoning, and the mixing of harmful chemicals (like acids and bases), thereby helping prevent certain hazards. Furthermore, teachers highlighted the direct influence of scientific advancements on societal life, noting that scientific research propels society forward and significantly contributes to civilization. In this regard, a tight-knit connection was established between science, society, and citizenship.

> *Children are interested in science through science teaching. They become aware of scientific developments. In the future, they may become scientists themselves and make an important contribution to their country and to the whole of humanity* (ST-3/M).

Science educators mentioned that they introduce socio-scientific issues in the classroom, emphasizing that these topics have a direct connection to citizenship. The socio-scientific topics most frequently discussed by teachers include global warming, climate change, various environmental issues, the COVID-19 pandemic, GMOs, organ donation, genetics, child labor, and human rights.

> *Many events in society have scientific causes and effects. The best example is Covid-19, climate change and other environmental issues. All of these come up in science lessons...* (ST-1/M).

Environment

The content related to environmental issues is prominently featured in the science curriculum, directly linking it to citizenship education. In the "*general objectives of the science course*" section, which appears at the beginning of the science curriculum, numerous objectives related to the environment are listed. For instance, specific objectives of the science curriculum contain the following statement, "to make the individual realize the mutual interaction between the individual, environment, and society; to develop an awareness of sustainable development regarding society, economy and natural resources" (MoNE 2018, p. 9). The curriculum contains numerous references to environmental topics, including environmental problems, recycling, natural disasters, climate and climate change, natural environments, biodiversity, renewable energy, and nature conservation. Specific environmental problems addressed include noise and light pollution, space pollution, household solid and liquid waste, and acid rain. The curriculum also discusses the adverse effects of environmental pollution on human health and suggests solutions to these environmental challenges. The causes, potential consequences, and preventive measures related to global climate change are detailed. Additionally, topics such as recycling, reuse, and the economic benefits of recycling facilities are covered. The curriculum also emphasizes aspects directly related to citizenship education, such as environmental protection, the conscientious use of resources, and conservation.

> Students consider how environmental problems may affect the future of the world (MoNE 2018, p. 53).

> Makes inferences about environmental problems that may arise in the future as a result of human activity (MoNE 2018, p.29).

In the study, science educators frequently highlighted environmental topics as being directly related to citizenship education. Teachers drew a clear connection between effective citizenship and various environmental concerns, including environmental problems, protection, recognition, awareness, and sustainable development. They asserted that science education helps students recognize and comprehend their environment, fostering increased sensitivity and consciousness towards environmental matters. Educators pointed out that through science teaching, students gain a deeper understanding of environmental issues like global warming, climate change, greenhouse gases, industrialization, erosion, and various forms of pollution. This understanding enables them to brainstorm solutions to these challenges. The strong link between science, the environment, and active citizenship was a recurring theme. Science educators stressed that an active citizen should be an advocate for environmental protection. Through science education, students cultivate habits such as environmental conservation, appreciation for nature, thriftiness, and maintaining cleanliness. Additionally, some educators mentioned that their courses familiarize students with international environmental treaties and highlight nations that significantly contribute to global pollution.

> *The most fundamental impact and contribution of science education to citizenship is on environmental issues. Science education aims to develop environmentally responsible individuals. It develops knowledge, skills and values related to the environment. In particular, they can understand the causes of what happens in nature. One of the most fundamental aims of citizenship education is to develop environmentally aware individuals* (ST-5/F).

> *In a democratic society, citizens show interest in the environment. Nowadays, climates are changing, different natural disasters occur in different parts of the world. Science teaching can contribute to individuals becoming active citizens in all these issues* (ST-2/M).

Values and Skills

Science educators highlighted that values including scientific integrity, respect-love, compassion, patriotism, and responsibility are crucial in science teaching. They emphasized that science education fosters love and respect for all living beings in students. Through collaborative projects, students cultivate values of responsibility and compassion, becoming more conscious of their environmental responsibilities. Additionally, some teachers mentioned that students' scientific endeavors can significantly benefit their country. By learning about notable Turkish scientists, students also nurture a sense of patriotism.

> *When it comes to patriotism, we think more about military service, but we do not think about that, we think more about inventions. Contributing to the defence of the country through scientific development is the greatest contribution to the country* (ST-8/F).

The teachers interviewed emphasized that science education cultivates numerous skills essential for citizens. They highlighted that modern citizens should possess critical thinking, inquiry, scientific literacy, and problem-solving skills and that science education significantly contributes to honing these abilities. Notably, they pointed out that addressing socio-scientific issues in science lessons aids in the development of these vital skills. Teachers also mentioned that through experiments, students enhance their observational skills, enabling them to better perceive natural phenomena around them. For instance, teachers underscored that after conducting experiments, students create tables and graphs, interpret the results, discuss the significance of using evidence, and refine their expertise in using technological equipment in the laboratory.

> *There are many socioscientific issues in science teaching. When we address these issues, students' communication, questioning and observation skills improve. They learn to listen and understand each other* (ST-7/F).

Problems

In the study, while science educators acknowledged a theoretical connection between science and citizenship, they contended that in practice, science education often falls short of its goals due to various challenges. Initially, the predominant concerns were related to infrastructural deficiencies and the issues stemming from an education system heavily reliant on standardized testing.

Challenges tied to the physical environment encompass overcrowded classrooms (with 35-40 students), the absence or inadequacy of laboratories and their equipment, a lack of sufficient instructional materials, and the unavailability of appropriate activities. Moreover, all educators expressed that the test-focused nature of the education system impeded the full realization of science education's potential. They noted that classrooms tend to prioritize solving test questions over engaging in scientific activities and discussions. The educators also pointed out the external pressures they face from parents and administrators due to exams. They emphasized that this exam-

centric approach acts as a significant barrier for science education to effectively promote citizenship education, leading students to prioritize test performance over real-life applicability.

Some educators highlighted issues stemming from the curriculum, students, and parents. They mentioned the inadequacy of the curriculum content, students' lack of readiness, and challenges in collaborating with parents. One educator also brought up the unique challenges posed by having refugee students in the classroom.

> *As I have said before, science is life itself. But because our education system is exam-oriented, we are moving away from the main purpose of science education. As a result, we are also moving away from citizenship education. We are educating students who can only solve test questions, but cannot solve problems in everyday life* (ST-4/M).

> *There are refugee students in the classes, we have difficulties communicating with these students. Since they do not understand me, they are busy with different things, they do not listen to the lesson and the atmosphere of the class can be spoilt*(ST-2/M).

Results and Discussion

In this study, which examined the relationship between science education and citizenship education in Turkey, the following conclusions were drawn: both the science curriculum and the perspectives of science educators conceptualized the connection between science and citizenship in terms of the environment, society, and scientific literacy. While the curriculum contains explicit objectives related to scientific literacy, educators underscored the importance of being scientifically literate as an essential attribute for contemporary citizens. Teachers conveyed that citizens equipped with scientific literacy develop crucial skills such as problem-solving, research, inquiry, and critical thinking. Furthermore, they posited that citizens lacking this literacy are unlikely to be active participants in their communities. The notion of integrating citizenship education within science is frequently framed and advocated for through the lens of scientific literacy, as supported by various studies (DeHart Hurd, 1998; Jack et al., 2017; Kerr, 1996; Oberhauser & Prysby, 2008; Laugksch, 2000; Wellington, 2002).

The theme most frequently highlighted in both the science curriculum and teachers' perspectives, in the context of science citizenship, was the "environment". Given the escalating global concerns about environmental issues, particularly climate change, environmental content has been incorporated into the science curricula of many countries. Notably, the science curriculum in Turkey, updated in 2018, encompasses an extensive array of environment-related topics. Science educators primarily drew a direct correlation between active citizenship and environmental challenges as well as environmental conservation. In the literature connecting science and citizenship, the environment has long been a focal concept, especially within the realm of socio-scientific subjects (Zeidler & Keefer, 2003; Sadler, Klosterman, & Topcu, 2011; Siatras & Koumaras, 2013; Sperling & Bencz, 2015).

Another domain where the connection between citizenship and science was explored was "society". The curriculum established the link between science and society through socio-scientific topics. Conversely, science teachers related science education to aspects we encounter in daily life, such as living organisms, the environment, safety, and health. The association between science education and everyday life predominantly revolves around scientific literacy and socio-scientific issues. The primary rationale for incorporating the concept of "society" into science education in many countries recently, conceptualized as the nexus of science, technology, society, and the environment is to anchor science education in daily experiences and underscore citizenship-related objectives (Davies, 2004; Sadler, Barab & Scott, 2007; Wellington, 2003). Xiao (2020) noted that one of the primary goals of school science is to equip students for their daily lives, leading to a heightened emphasis on nurturing citizens with robust literacy and a sense of duty. Prominent among the goals of school science are notions pertaining to democracy, participation, the environment, sustainability, social justice, and global citizenship. Consequently, recent educational reports globally

accentuate the significance of science education in fostering scientifically literate students (European Commission, 2015).

Socio-scientific issues are explicitly and directly incorporated into the science curricula in Turkey. In this study, teachers indicated that they introduced socio-scientific topics related to the environment, health, and human rights to their classrooms and endeavored to foster a discussion-rich environment. It is posited that employing socio-scientific issues not only aids students' scientific literacy or cognitive development but also bolsters their social and emotional growth (Topcu, 2010; Topcu, Sadler, & Yilmaz-Tuzun, 2010). As these subjects have societal implications, they encourage individuals to be sensitive and responsible towards social concerns. Socio-scientific issues can be categorized under one of three main areas: citizenship, scientific literacy, or sustainable development (Ratcliffe & Grace, 2003). In essence, a significant objective of science teaching is character development, which encompasses moral decision-making and the advancement of democratic citizenship (Driver et al., 2000; Sadler & Zeidler 2005).

Science educators have underscored the connection between science lessons and values including scientificity, respect-love, benevolence, patriotism, and responsibility. The values highlighted most frequently were scientificity, responsibility related to environmental concerns, and patriotism in the context of serving society. The skill most often linked with citizenship was "observation," which was associated with experiments and environmental occurrences. Other skills stressed by the teachers included questioning, interpreting tables and graphs, problem-solving, and critical thinking. In recent times, science education in many countries has not only centred on imparting knowledge but also on fostering skills like problem-solving, critical thinking, information literacy, and media literacy that students require in their daily lives (Joris et al., 2022; Jiménez-Aleixandre & Puig, 2012; Puig et al., 2019).

One of the most notable findings of this research is the perspective of science educators who feel that, while there is a close theoretical relationship between science and citizenship, science education often falls short in achieving its citizenship-related goals in practice. The literature has long suggested that science education holds significant potential to foster responsible and active citizenship (Lester, Ma, Lee, & Lambert, 2006; Levinson, 2010; Mansour, 2009; Ratcliffe & Grace, 2003; Reiss, 1993; Vesterinen et al., 2016). Yet, despite this strong theoretical linkage, various studies indicate fundamental challenges in realizing citizenship objectives within science education (Mansour, 2009; Pike, 2007).

Conclusion and Implications

In a democratic society, the primary goal of citizenship education is to nurture citizens who possess ethical values, can think critically, understand the causes and effects of scientific and technological developments, and participate democratically. The findings of this research underscore the connection between science education and citizenship education in Turkey. They also highlight the potential of science classes to bolster citizenship competencies, encompassing knowledge, skills, attitudes, and values. Education policymakers ought to explicitly accentuate the significance of citizenship skills in the science curriculum. Science classes should be structured to cultivate citizenship skills, including scientific literacy, critical thinking, problem-solving, inquiry, debate, and democratic participation. The integration of socio-scientific topics and environmental education in the curriculum should be promoted. Additionally, teachers need training and support to seamlessly incorporate citizenship skills into their science lessons.

Considering the global objectives of the SDG 2030, there is a pressing need to bolster a citizenship-oriented approach in science education worldwide. Science education should underscore the significance of environmental protection and sustainability to students, and active participation in scientific endeavors should be promoted through hands-on experiences. Moreover, educational policies should be formulated with a solution-oriented approach to address societal challenges. In

alignment with the Sustainable Development Goals, it is crucial to nurture citizens capable of offering scientific solutions to environmental, social, and economic issues.

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Appendix A : Semi-Structured Interview Protocol

1. Which subjects do you teach in science education?
   a. Do you include socio-scientific topics in your lessons? Why?
   b. What are the methods you use when teaching the subjects?

2. What is the main purpose of science teaching?
   a. Which of these aims do you prioritise and why?

3. Is there a relationship between science teaching and citizenship?
   a. How do you interconnect science, technology, society and environment with citizenship education?

4. Do you include socio-scientific topics in your lessons? Why?

5. How can science teaching contribute to citizenship competences?

6. Which skills do you focus on in science education teaching process?
   a. How do you develop students' skills?

7. Is there anything else you would like to add?

Appendix B - Generated Themes (Science Course Curriculum, 2018)

THE SPECIFIC OBJECTIVES OF THE SCIENCE CURRICULUM

The main objectives of the Science Curriculum, which aims to raise all individuals as science literate, are as follows:	**Themes**
1. To provide basic knowledge about astronomy, biology, physics, chemistry, earth and environmental sciences and science and engineering applications,	scientific literacy
2. In the process of exploring nature and understanding the relationship between human and environment, to adopt scientific process skills and scientific research approach and to produce solutions to the problems encountered in these areas	environment scientific literacy
3. To make students realise the mutual interaction between the individual, environment and society; to develop awareness of sustainable development of society, economy and natural resources,	environment
4. To take responsibility for daily life problems and to use science knowledge, scientific process skills and other life skills to solve these problems,	society scientific literacy
5. To develop career awareness and entrepreneurial skills related to science,	
6. To help to understand how scientific knowledge is created by scientists, the processes through which this knowledge is created and how it is used in new research,	scientific literacy
7. To arouse interest and curiosity in the events occurring in nature and society, to develop attitudes.,	environment society
8. To create awareness of safe working by realizing the importance of safety in scientific studies,	scientific literacy
9. To develop reasoning ability, scientific thinking habits and decision-making skills using socioscientific issues,	scientific literacy
10. To ensure the adoption of universal moral values, national and cultural values and scientific ethical principles	values

SPECIFIC SKILLS IN THE CURRICULUM	**Themes**
a. Scientific Process Skills	scientific literacy
b. Life Skills *Analytical thinking *Creative thinking *Entrepreneurship *Communication *Collaboration *Decision making	skills
c. Engineering and Design Skills *Innovative thinking	skills

VALUES IN THE CURRICULUM	**Themes**
The "root values" in the curricula are: justice, friendship, honesty, self-control, patience, respect, love, responsibility, patriotism and benevolence. These values will come to life in the learning-teaching process by being handled both on their own, together with the sub-values they are related to, and together with other root values	values

Appendix B- Generated Themes (Science Course Curriculum, 2018)

5TH GRADE SCIENCE CURRICULUM

Unıt: Sun, Earth and Moon / Earth and Universe	**Themes**
In this unit, it is aimed for students to recognise and comprehend the basic structure, shape, size and features of the Sun and the Moon; to comprehend the rotational motion of the Sun; to comprehend the rotational and wandering motions of the Moon; to explain that the phases of the Moon occur depending on the motion relationship between the Earth and the Moon; to comprehend the movements of the Sun, the Earth and the Moon relative to each other; to gain knowledge and skills about the destructive natural events seen on Earth.	*scientific literacy* *environment*
1. Structure and Properties of the Sun Recommended Duration: 6 lesson hours Subject / Concepts: Structure and rotational motion of the Sun 1.1. students explain the properties of the Sun. a. The geometrical shape of the Sun is explained. . b. It is explained that the Sun consists of layers like the Earth. c. The rotational motion of the Sun is explained. 1.2. students prepare a model to compare the size of the Sun with the size of the Earth.	*scientific literacy*
2. Structure and Properties of the Moon Recommended Duration: 4 lesson hours. Subject / Concepts: Structure of the Moon 2.1. The functions of the Moon are explained. a. The size of the Moon is mentioned. b. The geometrical shape of the Moon is mentioned. c. Information is given about the surface structure of the Moon. ç. The atmosphere of the Moon is mentioned 2.2. Students discuss their ideas that living organisms can live on the Moon.	*scientific literacy*
Unit: Human and Environment / Organisms and Life	**Themes**
In this unit, it is aimed that students will be able to question the causes and consequences of environmental problems, biodiversity, endangered and endangered species and what needs to be done to protect these species, sensitivity to environmental problems caused by human activities and gain knowledge and skills to solve these problems.	*environment*
1. Biodiversity Recommended Duration: 6 lesson hours Subject / Concepts: Biodiversity, natural life, endangered species, habitat, ecosystem 1.1. Inquires the importance of biodiversity for natural life. Gives examples of plants and animals that are extinct or in danger of extinction in our country and in the world. 1.2. Discusses the factors threatening biodiversity based on research data	*environment*
2. Human and Environment Relationship Recommended Duration: 10 lesson hours Subject / Concepts: Environmental pollution, environmental protection and beautification, human-environment interaction (human impact on the environment), local and global environmental problems	*environment*
2.1. Expresses the importance of the interaction between human and environment. The negative effects of environmental pollution on people's health are mentioned. 2.2. Offers suggestions for the solution of an environmental problem in his/her neighborhood or in our country. 2.3. Makes inferences about environmental problems that may occur in the future as a result of human activities.	*environment*