Available online at ijci.wcci-international.org

International Journal of Curriculum and Instruction 17(3) (2025) 910–931

IJCI
International Journal of Curriculum and Instruction

Representation of Education 4.0 Competencies in Science Teaching: An Analysis of Türkiye's 2024 Curriculum

Haluk Yılmaz [a] *, Mehmet Tunçel [b]

[a] *Niğde Ömer Halisdemir University, Institute of Educational Sciences, 51240, Niğde, Türkiye*
[b] *Niğde Ömer Halisdemir University, Faculty of Education, 51240, Niğde, Türkiye*

Abstract

This study aims to examine the extent to which the learning outcomes in Türkiye's 2024 Science Curriculum are represented within the framework of Education 4.0, as defined by the World Economic Forum (WEF, 2020). The analysis focuses on four core content dimensions: Global Citizenship, Innovation and Creativity, Technology, and Interpersonal Skills. Employing a document analysis method, the study evaluates the learning outcomes both quantitatively and qualitatively. Findings reveal that only 55 out of 182 outcomes (30.2%) are directly related to Education 4.0 competencies. These outcomes are primarily concentrated around limited themes such as environmental awareness, design, and physical systems, while essential contemporary skills like digital literacy, interdisciplinary creativity, and interpersonal interaction are largely underrepresented. Moreover, the integration of Education 4.0 dimensions across grade levels is uneven, with some grades displaying minimal representation. The results offer significant insights into how Education 4.0 skills are incorporated into science education in Türkiye. They also provide valuable recommendations for developing countries seeking to modernize their science curricula in alignment with 21st-century skills. The findings are expected to inform curriculum developers, teacher educators, and policymakers working toward educational reform.

Keywords: Education 4.0; Science Education; Learning Outcomes; 2024 Curriculum; 21st Century Skills

1. Introduction

1.1. Introduce the problem

The rapid technological advancements and social transformations of today's world have profoundly reshaped expectations regarding the quality of education systems. According to the World Economic Forum's (WEF) 2023 report, mega-

* Haluk YILMAZ. ORCID ID.: https://orcid.org/0000-0002-3639-2371
E-mail address: yilmazhhaluk@gmail.com

trends such as increasing inequality, misinformation, climate change, and the dizzying pace of technological progress are also transforming the skills individuals will need throughout their lives. It is estimated, however, that less than half of children worldwide are acquiring the skills necessary to succeed in the future (WEF, 2023). This situation highlights the urgent need for education systems to abandon traditional knowledge-transfer approaches and prioritize the development of 21st-century skills.

Indeed, international organizations emphasize that developing competencies such as curiosity, imagination, adaptability, critical thinking, and collaboration through education is vital for preparing students for an uncertain future (OECD, 2018b; UNESCO, 2017). In the literature, the term "21st-century skills" refers to a broad set of competencies that are considered essential for individuals to succeed in modern economic and social life. These skills include critical thinking and problem-solving, creativity, communication, collaboration, leadership, digital literacy, and information access (UNESCO, 2022).

In response to the demands of the digital transformation era, the concept of "Education 4.0" emerged as a framework aiming to integrate these 21st-century skills into education systems. It envisions redesigning learning processes through advanced technologies such as artificial intelligence, automation, and robotics (UNESCO-UNEVOC, 2022). In this context, the World Economic Forum's 2020 "Schools of the Future" report identifies eight key transformation areas related to the content and experience of future education (WEF, 2020).

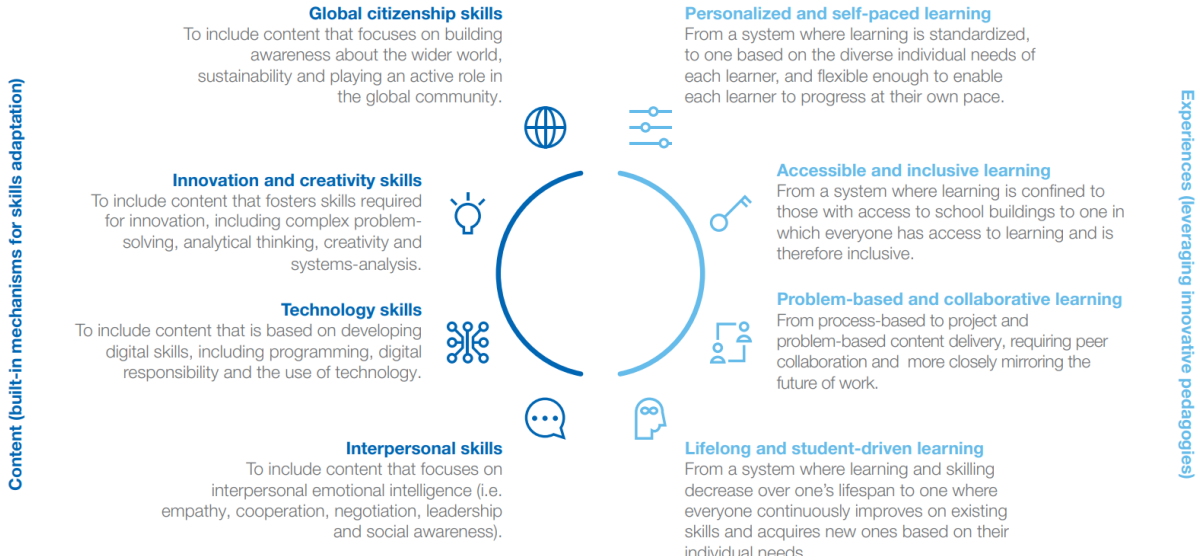

Figure 1. Global Transformation Areas for Education 4.0. From "Schools of the Future: Defining New Models of Education for the Fourth Industrial Revolution" (World Economic Forum, 2020).

As illustrated in Figure 1, four of these areas are related to learning content: (1) global citizenship skills, (2) innovation and creativity skills, (3) digital technology skills, and (4) interpersonal social skills. The other four areas, which focus on learning experiences, include personalized learning, inclusivity and accessibility, lifelong learning, and the promotion of project- and problem-based collaborative learning environments (WEF, 2020).

In Türkiye, as in many other countries, curricula are being updated in parallel with global trends to equip students with 21st-century competencies. High-quality science education plays a critical role in raising individuals who can meet the expectations of the information age, and Türkiye has been making efforts to improve the effectiveness of science instruction (Aydoğdu & Kesercioğlu, 2005). Accordingly, the Science Curriculum has undergone major reforms in 2005, 2013, and 2018, with a vision to cultivate scientifically literate individuals (Turkish Ministry of National Education [MoNE], 2018). These revisions aimed to develop students' higher-order thinking skills such as scientific problem-solving, critical thinking, and creative reasoning (Balbağ et al., 2016).

In 2024, the Ministry of National Education introduced a revised Science Curriculum under the "Century of Türkiye Maarif Model." The new program adopts a holistic, student-centered approach that aims to foster individuals who possess the skills required by the age, continue learning throughout their lives, effectively use higher-order thinking and scientific process skills, uphold ethical and national values, and exhibit entrepreneurial qualities (MoNE, 2024). Moreover, the program promotes the use of out-of-school learning environments (e.g., science centers, museums) and encourages process-based, skill-oriented assessment approaches to support students' holistic development (MoNE, 2024). Within this scope, it becomes essential to examine how well the updated learning outcomes in the science curriculum align with the content dimensions envisioned by Education 4.0.

This study aims to reveal that alignment by analyzing the learning outcomes in Türkiye's 2024 Science Curriculum based on the four core content dimensions of Education 4.0.

1.2. Global Transformation and the Vision of Education 4.0

In the era of the Fourth Industrial Revolution—characterized by digital technologies, artificial intelligence, and data-driven innovations—education systems are increasingly recognized as requiring a fundamental transformation. Leading international organizations emphasize the need to redesign current models of education to adapt to the uncertainty and rapid changes of the 21st century. According to UNESCO's Futures of Education report (2021b), socio-ecological and technological trends are placing unprecedented pressures on

educational systems. However, the report also stresses that education holds the potential to construct a more just and sustainable future. It calls for a renewed "social contract" grounded in human rights, social justice, human dignity, and cultural diversity, and emphasizes the need to strengthen global solidarity in education. Similarly, the OECD's Education 2030 project (2018b) urges countries to adapt their systems to equip students with a broad set of 21st-century competencies, encompassing knowledge, skills, attitudes, and values necessary for future success.

This transformation vision is conceptualized by the World Economic Forum (WEF) under the term "Education 4.0." According to WEF (2023), Education 4.0 is a learner-centered approach that focuses on the broad skill sets needed for success in future economies, while leveraging technological and pedagogical innovations. Fisk (2017) defines Education 4.0 as a new educational paradigm that prepares individuals for the future from an early age by utilizing the opportunities offered by technology, embracing lifelong learning, and adapting to the demands of the Fourth Industrial Revolution. The WEF's Schools of the Future report (2020) outlines eight key features of high-quality learning experiences, aiming to equip students not only with academic knowledge but also with critical thinking, creativity, communication, collaboration, adaptability, entrepreneurship, and a sense of responsibility. Furthermore, the WEF's Catalyzing Education 4.0 report (2022) highlights the urgency of transformation in education, emphasizing that empowering learners with skill-oriented, technology-enabled, and innovative pedagogies has become a global imperative for success in the Fourth Industrial Revolution era. In line with this vision, the role of teachers must also evolve—from being the "sage on the stage" to the "guide on the side"—to promote higher-order thinking skills (e.g., analysis, synthesis, problem-solving) and creativity, and to facilitate active, responsible learning.

1.3. Science Curriculum in Türkiye and 21st Century Skills

Türkiye's education policies have aligned with global trends by emphasizing the integration of 21st-century skills into curricula. As early as 2011, the MoNE published the "21st Century Student Profile" report, categorizing essential competencies into four main areas:

Ways of Thinking – creativity, innovative and critical thinking, problem-solving, decision-making, metacognition;

Ways of Working – communication, effective use of native language, basic foreign language proficiency, and teamwork;

Tools for Working – information literacy and ICT literacy;

World Citizenship – awareness of local/global citizenship, life and career skills, cultural awareness, and personal-social responsibility (MoNE, 2011).

This profile envisions students as collaborative, communicative, responsible, critically thinking individuals who effectively use technology.

This vision was particularly reflected in the 2018 revision of the Science Curriculum. Studies by Kalemkuş (2021) and Demir and Çetin (2023) show that the 2018 curriculum is linked to 21st-century skills. Both studies emphasized communication as the most prominent skill in the curriculum. While critical thinking, problem-solving, and information literacy were also significantly represented, skills such as creative thinking, entrepreneurship, and self-management were less emphasized. Demir and Çetin (2023) noted the absence of media literacy, and Kalemkuş (2021) highlighted the limited presence of ICT literacy. Both scholars emphasized the need for a more balanced distribution of skills in curriculum development.

In a comparative study, Bilir (2025) examined the 2018 and 2024 Science Curricula in terms of learning outcomes and competencies. It was reported that the 2024 program reduced the number of learning outcomes, reorganized some units, and restructured the student profile to encompass a broader developmental spectrum. Another study that explored teachers' perspectives on the 2024 curriculum found that teachers appreciated the inclusion of scientific culture and values, and viewed the simplification of content and reduced number of outcomes as improvements that enhance the program's implementability (Ak & Köse, 2024).

These studies suggest that Turkish science curricula are undergoing a transformation aligned with global educational policies to incorporate 21st-century skills. The 2018 revision aimed to integrate such competencies into instruction, but reviews indicated that certain skills were underrepresented and that a more balanced distribution was needed. The 2024 update appears to address these shortcomings by simplifying learning outcomes and expanding the student profile. This reform process presents significant opportunities for integrating Education 4.0 competencies more comprehensively into the education system.

In the context of Education 4.0 and 21st-century skills, the literature shows that science education is undergoing a rapid transformation both globally and in Türkiye. International policy documents call for a global rethinking of education systems to foster resilient and adaptable individuals who can navigate an uncertain future. Organizations such as UNESCO, OECD, and WEF emphasize a shift from knowledge transmission toward the development of broad competencies and provide roadmaps for governments. This highlights the need for further improvements in embedding 21st-century skills into education.

Meanwhile, studies on the classroom implementation of Education 4.0 tools and methods indicate that technology-supported, innovative learning environments positively impact student achievement and skill development (Başgül & Coştu, 2024). These findings form the basis of the present study. By exploring the relationship between science education and 21st-century skills through policy documents and academic research, this study aims to assess the alignment of Türkiye's science curriculum with the goals of Education 4.0. The presented literature provides the conceptual framework and knowledge base necessary for this evaluation. Consequently, the analyses and discussions within the study will be grounded in up-to-date literature in both global and national contexts.

In response to global educational trends and the growing demand for 21st-century skills, the Ministry of National Education in Türkiye introduced a revised Science Curriculum in 2024. This updated curriculum aims to better integrate contemporary competencies and align with international benchmarks such as Education 4.0.

1.4. Aim and Research Question

The primary aim of this study is to examine the extent to which the learning outcomes in Türkiye's 2024 Science Curriculum align with the four core content dimensions of Education 4.0, as defined by the World Economic Forum (WEF, 2020): (1) Global Citizenship, (2) Innovation and Creativity, (3) Technology, and (4) Interpersonal Skills.

Accordingly, the central research question guiding this study is as follows:

To what extent do the learning outcomes in the Science Curriculum overlap with the four core content dimensions of Education 4.0?

In addition to addressing this main question, the study also aims to evaluate each content dimension individually to provide a more detailed analysis of the curriculum's alignment with Education 4.0.

2. Method

2.1. Research Design

This study employed document analysis, a qualitative research method that involves the systematic examination, interpretation, and content-based evaluation of written materials (Bowen, 2009). The primary objective was to determine the extent to which the learning outcomes in Türkiye's 2024 Science Curriculum align with the four core skill dimensions defined by the Education 4.0 framework. The main data source was the official Science Curriculum document

published by the Ministry of National Education (MoNE, 2024**)** and made publicly available online.

2.2. Data Source

The dataset consisted of all learning outcomes included in the 2024 Science Curriculum for grades 3 through 8. Each learning outcome was treated as a unit of analysis, and its original textual structure was preserved. These outcomes were examined in terms of their alignment with the four Education 4.0 content dimensions and were coded accordingly.

2.3. Coding and Data Analysis

The analysis was grounded in the Education 4.0 transformation framework proposed by the World Economic Forum (WEF, 2020). Coding was carried out based on the following four content dimensions:

Global Citizenship Skills: Content related to environmental sustainability, climate change, social awareness, energy efficiency, and recycling.

Innovation and Creativity Skills: Content promoting model creation, original design, problem-solving, critical thinking, and idea generation.

Technology Skills: Topics involving electrical circuits, energy transformation, simple machines, space technologies, and experimental technological literacy.

Interpersonal Skills: Content referring to empathy, cooperation, communication, social cohesion, and socio-emotional learning.

These four dimensions were not only used as a conceptual framework but also served as analytical categories in classifying learning outcomes. Each outcome was assigned to the most appropriate category based on key concepts and intended objectives. Contextual interpretation was employed when necessary.

In addition to thematic coding, the study also examined the distribution of learning outcomes across grade levels. This supplementary analysis provided numerical insights into how Education 4.0 skills are represented at each grade, contributing to an evaluation of the structural coherence of the curriculum.

2.4. Reliability

To ensure the reliability of the coding process, two independent researchers coded all learning outcomes separately. Inter-coder agreement was calculated using the formula proposed by Miles and Huberman (1994):

Reliability = Agreement / (Agreement + Disagreement)

The resulting agreement rate exceeded 85%, indicating high consistency. Discrepancies were resolved through discussion until consensus was reached.

2.5. Limitations

This study is limited to the explicit learning outcomes stated in the 2024 Science Curriculum. Teacher guides, instructional methods, or classroom implementation examples were excluded. Furthermore, indirectly acquired skills that may emerge during instruction were not considered. Therefore, all interpretations were based solely on the textual content of the learning outcomes.

3. Results

In this section, the learning outcomes in the 2024 Science Curriculum were analyzed according to the four core content dimensions of Education 4.0: Global Citizenship Skills, Innovation and Creativity Skills, Technology Skills, and Interpersonal Skills. In addition, the distribution of the outcomes across different grade levels was also examined. Figure 2 presents the overall distribution of learning outcomes related to these four skill dimensions.

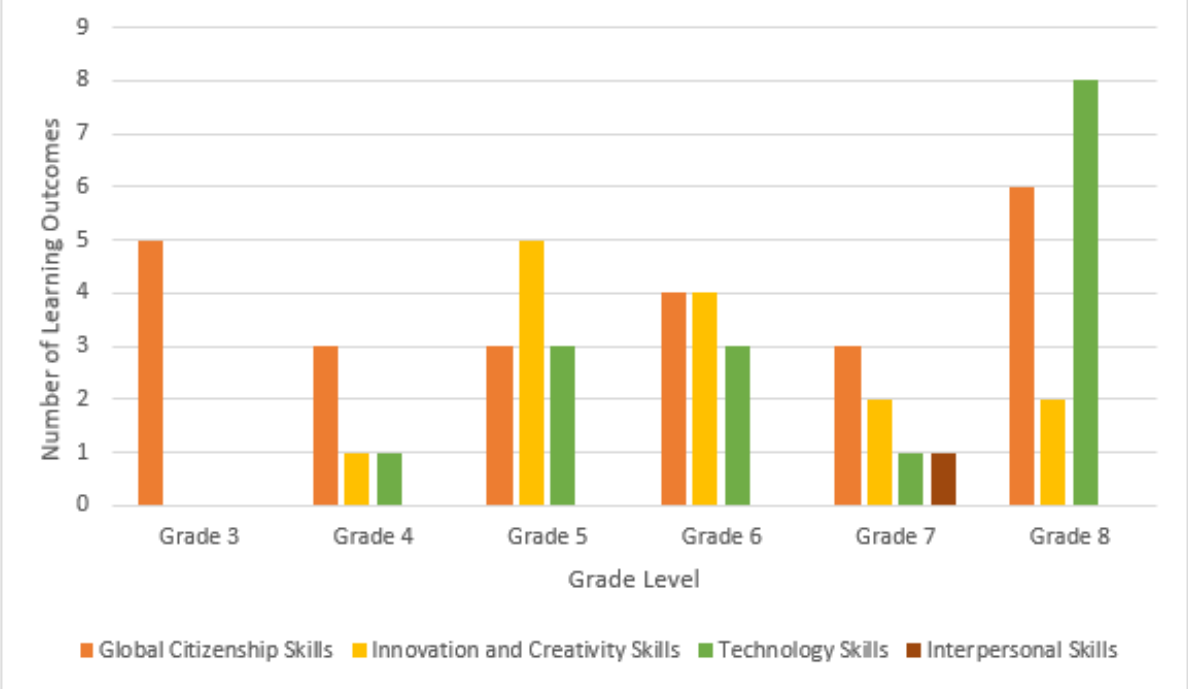

Figure 2. Distribution of Education 4.0-Aligned Learning Outcomes by Grade Level in the 2024 Science Curriculum

3.1. Findings Related to Global Citizenship Skills

The analysis revealed that a total of 24 learning outcomes across Grades 3 to 8 align with the global citizenship skills dimension. These outcomes are shaped around key themes such as environmental awareness, energy efficiency, sustainability, recycling, pollution, and biodiversity. Notably, the 3rd and 8th grades include the highest concentration of such outcomes.

Grade 3: Learning outcomes focus on everyday life contexts, such as waste separation, electricity conservation, and the protection of living habitats.

Grade 8: The curriculum addresses global climate change, the environmental impacts of energy plants, and conscious energy consumption.

Grade 5: Outcomes emphasize recycling, waste management, and the efficient use of natural resources.

These learning outcomes frequently include high-level cognitive skills, such as scientific inquiry, critical thinking, and problem-solving. Action-oriented verbs like analyze, discuss, and propose solutions reflect the Education 4.0 emphasis on fostering student sensitivity to societal issues and promoting active citizenship.

Example learning outcomes:

"Make evidence-based predictions about energy-saving practices." (Grade 3)

"Draw scientific conclusions about the importance of recycling for resource efficiency." (Grade 5)

"Discuss the causes and potential consequences of global climate change." (Grade 8).

3.2. Findings Related to Innovation and Creativity Skills

The analysis identified 14 learning outcomes in the 2024 Science Curriculum that directly align with the Innovation and Creativity dimension of Education 4.0. These outcomes predominantly include action-oriented expressions such as constructing models, designing, and generating original solutions. In terms of grade-level distribution, outcomes focused on this skill set are particularly concentrated in Grades 5 and 6.

At these grade levels, students are encouraged to develop creative and tangible products around themes such as:

Simple tools (e.g., dynamometers),

Environmentally sensitive models (e.g., thermal insulation),

Practical everyday solutions (e.g., simple machine design).

Additionally, several outcomes aim to foster students' ability to generate original interpretations of observed phenomena and to create conceptual representations through model design.

Example learning outcomes:

"Construct a model demonstrating thermal insulation." (Grade 5)

"Create a scientific model representing the solar system." (Grade 6)

3.3. Findings Related to Technology Skills

The analysis revealed that 16 learning outcomes in the 2024 Science Curriculum are directly aligned with the Technology dimension of Education 4.0. These outcomes aim to engage students in conducting experiments, making systematic observations, and conceptually classifying technological systems in topics such as electric circuits, energy transformations, simple machines, and space technologies.

Although learning outcomes related to this skill appear most frequently in Grade 8, they are also notably present in Grades 5 and 6 compared to other levels.

Through these outcomes, students are expected to:

Grasp fundamental physical systems such as electric current, circuit components, and light bulb brightness,

Identify and classify energy transformations,

Compare the advantages and disadvantages of various types of power plants,

Develop technological solutions to everyday problems.

Action verbs such as formulating hypotheses, conducting experiments, and reasoning inductively indicate that these outcomes are closely integrated with scientific process skills.

Example learning outcomes:

"Formulate a hypothesis regarding the variables affecting the brightness of a bulb in an electric circuit." (Grade 5)

"Make scientific inferences about the effects of an adjustable resistor on bulb brightness." (Grade 6)

"Use inductive reasoning to explain the relationship between the voltage across and the current through a circuit element." (Grade 8)

3.4. Findings Related to Interpersonal Skills

The analysis revealed that the 2024 Science Curriculum includes only one learning outcome that explicitly refers to interpersonal skills. This outcome,

found in Grade 7, emphasizes social responsibility through the statement:

"Discuss the importance of blood donation in terms of social solidarity."

No other outcomes in the remaining grade levels were found to directly target interpersonal competencies such as empathy, collaboration, effective communication, or teamwork. This finding indicates that the interpersonal skills dimension is minimally represented in the curriculum.

3.5. Distribution of Education 4.0 Learning Outcomes by Grade Level

An analysis of the 182 learning outcomes in the 2024 Science Curriculum revealed that 55 outcomes are directly aligned with the four core content dimensions of Education 4.0: Global Citizenship, Innovation and Creativity, Technology, and Interpersonal Skills. This corresponds to approximately 30.2% of all curriculum outcomes.

Table 1. Distribution of Learning Outcomes Related to Education 4.0 by Grade Level

Grade	Total Learning Outcomes	E4.0-Related Outcomes	Percentage (%)
3	20	5	25.0
4	19	5	26.3
5	28	11	39.3
6	32	11	34.4
7	40	7	17.5
8	43	16	37.2
Total	182	55	30.2

This distribution indicates that while Education 4.0-related learning outcomes are spread across all grade levels, they are not evenly distributed. Notably, the upper grade levels emphasize these skills more heavily, while Grade 7 demonstrates the lowest representation of Education 4.0 content dimensions.

The data also show that in Grade 3, the only learning outcomes aligned with Education 4.0 fall under the Global Citizenship dimension. No outcomes at this level are linked to the other three dimensions. In contrast, from Grade 4 onward, all dimensions except Interpersonal Skills are represented by at least one learning outcome at each grade level.

Furthermore, when the 55 identified outcomes are categorized by Education 4.0 content dimensions, the representation is as follows:

24 related to Global Citizenship,

16 related to Technology,

14 related to Innovation and Creativity,

1 related to Interpersonal Skills.

These findings provide both quantitative and qualitative insight into the extent to which Education 4.0 competencies are integrated within the curriculum. Potential reasons and implications for this distribution will be discussed in detail in the next section.

4. Discussion

4.1. Global Citizenship Skills

The findings of this study revealed that a total of 24 learning outcomes in the 2024 Science Curriculum could be associated with global citizenship. These outcomes are primarily shaped around themes such as environmental awareness, energy efficiency, sustainability, recycling, pollution, and biodiversity. Specifically, these themes appear in outcomes related to electricity conservation and the protection of living habitats in Grade 3, efficient resource use and recycling in Grade 5, and climate change and the environmental impact of power plants in Grade 8. The use of higher-order cognitive verbs such as "predict," "draw scientific conclusions," and "generate solutions" indicates that these outcomes aim not only to convey knowledge but also to promote active citizenship by fostering problem-solving skills, global responsibility, and social awareness.

However, most of these outcomes are environmentally focused, and the concept of global citizenship seems to be narrowly framed around ecological awareness. As noted by Oğuz Haçat and Tekkol (2017), Turkish science curricula often address citizenship themes through environmental issues, while socio-cultural dimensions—such as global cooperation, respect for cultural diversity, human rights, and global inequalities—are largely neglected. Although the concept of "global citizenship" is included for the first time among the program's objectives (MoNE, 2024), it is predominantly represented in an indirect manner (e.g., "conscious use of natural resources"), with no explicit reference to deeper concepts like climate justice, environmental equity, or ecological footprint.

International comparisons highlight both the strengths and the development areas of Türkiye's curriculum in this domain. For example, Finland's science curriculum addresses not only environmental but also cultural awareness and global responsibility through an interdisciplinary approach. In the national core curriculum, the theme of "participation and global responsibility" is defined as a key competence area across all subjects (Finnish National Board of Education,

2016). Students are encouraged to evaluate scientific issues such as climate change and biodiversity in both scientific and societal contexts.

Similarly, Estonia emphasizes environmental themes in global citizenship education while incorporating human rights and intercultural communication to some extent. Estonia is regarded as one of the leading European countries in this area and promotes global citizenship competencies systematically throughout formal education (SOLIDAR Foundation, 2020).

Singapore, on the other hand, primarily delivers global citizenship education through programs outside the science curriculum, but within a well-structured institutional framework. Under the 21st-century competencies model, "Civic, Global, and Intercultural Literacy" is defined as a distinct category, aiming to cultivate students as active members of the global community. Notably, Singapore ranked first in the 2018 PISA Global Competence assessment, highlighting the effectiveness of this approach (OECD, 2018a).

In recent years, South Korea has also begun to systematically integrate global awareness and citizenship themes into its curriculum. Citizenship competence is listed among the core skills in the 2015 revised curriculum, with growing emphasis in science classes on sustainable development, science-technology-society relationships, and ethical discussions. Additionally, Korea actively participates in UNESCO-led Global Citizenship Education (GCED) initiatives (UNESCO, 2021a).

Compared to these countries, Türkiye's new science curriculum supports environmental global awareness but does not yet systematically address broader concepts such as sustainable development and planetary citizenship.

In conclusion, the 2024 Science Curriculum in Türkiye marks a significant step forward in fostering global citizenship competencies by promoting sensitivity to global issues through themes such as environmental awareness, energy conservation, and recycling. However, while these outcomes support basic ecological literacy, more comprehensive and systematic integration of concepts such as the Sustainable Development Goals (SDGs), intercultural engagement, global ethical challenges, and humanity's shared scientific heritage is needed. Structuring science education not only on knowledge but also on values from a global citizenship perspective would align more closely with the vision of Education 4.0 (WEF, 2020).

4.2. Innovation and Creativity Skills

The findings of this study indicate that a total of 14 learning outcomes in the 2024 Science Curriculum align with the "Innovation and Creativity" dimension of Education 4.0. The use of action-based expressions such as "creating models,"

"designing," and "producing original solutions" in these outcomes demonstrates the curriculum's aim to foster students' creative thinking and productivity skills. Particularly in Grades 5 and 6, students are expected to develop tangible products around themes such as simple tools (e.g., dynamometers), environmentally friendly systems (e.g., thermal insulation), and practical solutions for daily life (e.g., simple machine design). Outcomes such as "being able to construct a model demonstrating thermal insulation" and "being able to construct a scientific model of the solar system" assign students the responsibility not only of recalling knowledge but also of making observations and producing original representations.

However, the emphasis on creativity in the curriculum remains somewhat limited. National content analyses show that while the curriculum values experiential and context-based learning, the number of outcomes that explicitly highlight "creativity" is relatively low. Although teachers note that interdisciplinary themes and process-oriented activities support creative thinking, aspects such as project development, entrepreneurship, and digital creativity are insufficiently represented in the curriculum. In their evaluation within a STEM context, Elmas and Gül (2020) argue that the science program emphasizes only the "design" phase of the engineering design process, thereby constraining the broader creative process. As noted in user comments, the curriculum lacks clear and up-to-date learning outcomes related to contemporary creative approaches such as coding, gamification, augmented reality, and interdisciplinary production. In this respect, the curriculum supports basic creative thinking but falls short of realizing the digitized and multidimensional creativity vision required by Education 4.0.

In an international context, Türkiye's new science curriculum places stronger emphasis on innovation and creativity than its predecessors (MoNE, 2024). Encouraging interdisciplinary approaches, adding "innovative thinking" to the list of science education skills, and offering teachers greater flexibility in activity planning are regarded as positive developments. Nevertheless, implementation challenges—such as overcrowded classrooms, exam pressure, and the need for pedagogical transformation—may hinder the full realization of this potential.

Comparative examples from other countries reveal promising models. Finland stands out with its systematic structure that fosters students' curiosity and original thinking through "phenomenon-based learning" (Finnish National Board of Education, 2016). Project tasks, interdisciplinary research, and laboratory activities in science courses not only convey knowledge but also teach problem-solving. Singapore promotes students' original idea generation through inquiry-based learning, research projects, and scientific investigations in science classes. Its top ranking in the 2022 PISA Creative Thinking assessment indicates the effectiveness of this approach (OECD, 2024). Estonia draws attention with

creative initiatives such as informatics-science collaborative robotics projects and the "Young Entrepreneurs" program (SOLIDAR Foundation, 2020), while South Korea supports design-based thinking, maker education, and project-based learning through initiatives like the "Creative Schools Initiative" implemented over the past decade (UNESCO, 2022).

Compared to these countries, Türkiye's curriculum includes structural components that support innovation and creativity, but the instructional ecosystem has not yet fully evolved to develop these competencies in a multidimensional manner. Developing explicit learning outcomes in areas such as digital creativity, entrepreneurship, and interdisciplinary productivity will be an important step toward achieving a contemporary vision of creativity in line with Education 4.0..

4.3. Technology Skills

According to the findings of this study, a total of 16 learning outcomes in the 2024 Science Curriculum are directly related to the "Technology" dimension of Education 4.0. These outcomes revolve around topics such as electric circuits, energy transformations, simple machines, and space technologies. They aim to develop students' conceptual understanding of technological systems, support systematic observation and experimentation, and enhance the use of scientific process skills. These learning outcomes are especially concentrated in Grade 8, with noticeable representation also in Grades 5 and 6.

Through these outcomes, students are expected to grasp fundamental physical systems such as electric current, circuit components, and bulb brightness; classify energy transformations; compare the advantages and disadvantages of different types of power plants; and develop technological solutions to everyday life problems. Action verbs such as "formulating hypotheses," "conducting experiments," and "reasoning inductively" demonstrate that these outcomes are integrated with scientific thinking and problem-solving skills.

However, the analysis shows that most of these outcomes are based on traditional physical systems and do not explicitly include contemporary digital competencies such as digital literacy, algorithmic thinking, artificial intelligence, augmented reality, or coding. This highlights the need for updates to the curriculum in terms of digital technology integration. National studies acknowledge some steps toward digital transformation in the curriculum—such as the inclusion of QR codes, digital data collection, and graphing—but emphasize that digital competencies have not yet been formulated as clear learning outcomes (Demir & Çetin, 2023).

International comparisons suggest that countries like Finland, Estonia, Singapore, and South Korea deliver technology skills in an integrated manner

within science education. In Finland, coding has become a compulsory subject from the early grades, while Estonia promotes algorithmic thinking through early education initiatives such as the ProgeTiiger program. Singapore offers STEM education enriched with virtual laboratories and artificial intelligence applications; South Korea defines compulsory outcomes in areas such as coding, data analysis, and digital ethics (Finnish National Board of Education, 2016; OECD, 2021; SOLIDAR Foundation, 2020; UNESCO, 2021a; WEF, 2020).

In conclusion, while the 2024 curriculum reflects a certain level of awareness regarding digital technology, it lacks the structural integration required to systematically cultivate the competencies demanded by the contemporary digital age. The program largely centers on traditional physical systems, sidelining the dimension of digitalization. Therefore, technology skills need to be revised in alignment with current digital competencies. The experiences of countries like Finland and Estonia could serve as valuable references in this process.

4.4. Interpersonal Skills

The analysis conducted in this study revealed that the 2024 Science Curriculum includes only a single learning outcome that directly references interpersonal skills. This outcome appears at the 7th-grade level with the statement: "Discuss the importance of blood donation in terms of social solidarity," reflecting a theme of social responsibility. No other outcomes at different grade levels explicitly target interpersonal competencies such as empathy, collaboration, communication, or teamwork. Thus, the program appears to offer only limited representation of this skill dimension (MoNE, 2024).

The national literature emphasizes the need to highlight interpersonal communication and collaboration skills more prominently in curricula. For example, Asıl and Asıl (2024) underline that the new education paradigm requires both teachers and students to become cooperative individuals with global awareness. Demir and Çetin (2023) point out that while the 2018 curriculum provided minimal space for communication and social skills at the seventh-grade level, the 2024 curriculum introduced more interdisciplinary approaches. However, they argue that the new curriculum still lacks concrete references to interpersonal interaction within learning outcomes. Teacher opinions suggest that group work could enhance classroom interaction, yet challenges such as overcrowded classrooms make such practices difficult to implement. In this regard, the development of interpersonal skills seems to largely depend on teachers' individual initiatives (MoNE, 2024).

Internationally, countries such as Finland, Singapore, Estonia, and South Korea have adopted systematic policies to integrate these skills into the science education process. Finland's curriculum centers cultural and interactional

competencies, embedding social skills such as empathy, respect, and teamwork into everyday educational practice through small-group activities (Finnish National Board of Education, 2016; OECD, 2021). In Singapore, science lessons are conducted through pair or group work, and communication and collaboration are supported both through in-class activities and extracurricular programs (WEF, 2020). Estonia aims to develop students' interpersonal competencies both in and beyond the classroom through a democratic school culture and a focus on communication skills (SOLIDAR Foundation, 2020). South Korea, on the other hand, has implemented significant reforms with character education and the Free Semester program, enabling students to experience different roles within project-based group work (UNESCO, 2021a).

Although the vision of the 2024 curriculum includes raising individuals capable of collaboration in scientific processes, this objective is not sufficiently reflected in the actual learning outcomes. Instead, the development of interpersonal skills is implicitly targeted through suggested instructional methods (MoNE, 2024). Therefore, classroom strategies that enhance active student participation, supported by teacher guidance and flexible learning environments, are seen as crucial.

In conclusion, the 2024 Science Curriculum presents a structure in which interpersonal skills are not clearly formulated as learning outcomes. The experiences of countries like Finland—renowned for their long-term pedagogical culture—and reform-driven models like South Korea's could offer valuable guidance for Türkiye. To effectively develop students' social competencies in line with the needs of the modern era, it is recommended that these skills be made more explicitly visible in future curriculum revisions.

4.5. Discussion of the Grade-Level Distribution of Education 4.0 Learning Outcomes

The data obtained from this study indicate that approximately 30% of the learning outcomes in the 2024 Science Curriculum can be directly associated with the four core content dimensions of Education 4.0. While this ratio reflects an effort to address the knowledge, skills, and values required in the 21st century, it also suggests that such coverage is not realized in an equal or balanced manner across all grade levels.

Learning outcomes related to Education 4.0 are more frequently observed in the 5th, 6th, and 8th grades, implying that students in higher grades are exposed to 21st-century competencies in a more comprehensive way. However, the rate drops significantly to 17.5% in the 7th grade—a period in which students are cognitively and socially more capable of engaging with complex problems. This discrepancy suggests an underutilization of the potential for integrated skill development at

this critical stage. Indeed, the literature emphasizes that the development of abstract thinking in upper grades enables more holistic integration of competencies (OECD, 2021).

In contrast, only global citizenship-related outcomes are found at the 3rd-grade level, with no outcomes associated with technology, innovation and creativity, or interpersonal skills. This finding points to the lack of a systematic approach for cultivating competencies such as technological literacy or creative thinking at early ages. Yet, research underlines that early interaction with technology and the acquisition of communication and collaboration skills provide a foundation for more advanced competencies in later stages (Voogt & Roblin, 2012; Trilling & Fadel, 2009).

Moreover, the fact that interpersonal skills are represented by only one learning outcome across the entire curriculum suggests a lack of emphasis on social-emotional learning, which is one of the foundational pillars of Education 4.0. In contrast, countries like Finland, Estonia, and South Korea embed communication, empathy, and collaboration explicitly into their science curricula, integrating these skills into students' daily learning experiences (Finnish National Board of Education, 2016; OECD, 2021). In Türkiye, however, such competencies are often left to be developed through instructional strategies rather than clearly articulated learning outcomes.

In conclusion, the grade-level distribution of Education 4.0 learning outcomes in the 2024 Science Curriculum reveals notable imbalances. This suggests that the curriculum does not fully reflect a coherent Education 4.0 vision aligned with national education policies. Developing a more balanced structure that systematically addresses contemporary educational needs is crucial for guiding teachers and ensuring equitable learning opportunities for all students.

5. Conclusions

This study examined the extent to which the learning outcomes in the 2024 Science Curriculum reflect the key content dimensions of Education 4.0—namely, Global Citizenship, Innovation and Creativity, Technology, and Interpersonal Skills—as defined by the World Economic Forum (WEF, 2020). Findings from the document analysis indicate that while the curriculum includes a limited number of learning outcomes directly aligned with these dimensions, the examples identified are conceptually meaningful and illustrative.

Among a total of 182 learning outcomes, only 55 (30.2%) were found to be aligned with the Education 4.0 framework. These outcomes were predominantly concentrated in grades 5, 6, and 8, whereas grades 3 and 7 featured significantly fewer learning outcomes associated with Education 4.0 competencies. In terms of

content areas, Global Citizenship was the most represented domain (n=24), while Interpersonal Skills were addressed by only a single outcome.

Qualitative analysis revealed that the Global Citizenship dimension was largely confined to environmental themes, with limited emphasis on social and cultural dimensions. Learning outcomes related to innovation and creativity primarily focused on modeling and basic design tasks, without adequately incorporating digital or interdisciplinary creativity. The Technology dimension emphasized traditional physical systems, whereas modern digital competencies—such as coding and algorithmic thinking—were not explicitly included in the curriculum. The extreme scarcity of learning outcomes related to interpersonal skills suggests that this area is not systematically integrated into the program. This limitation may be due to the curriculum's stronger emphasis on cognitive and disciplinary content rather than socio-emotional development, which remains implicitly addressed.

In this context, the 2024 curriculum demonstrates partial alignment with the core objectives of Education 4.0. However, it lacks a comprehensive, balanced, and forward-looking structure at the level of learning outcomes. In particular, there is a pressing need to strengthen learning outcomes related to interpersonal competencies, digital creativity, and global ethics.

This study provides important insights into how Education 4.0 is reflected in Türkiye's national curriculum and offers a guiding framework for revising science education programs in developing countries toward contemporary competencies. The findings contribute valuable evidence for reforms in curriculum design, policy-making, and teacher training, emphasizing the need for the systematic integration of interdisciplinary and skills-based learning.

In light of these findings, the following recommendations are presented:

1. Strengthen the alignment of learning outcomes with Education 4.0 dimensions. In particular, learning outcomes related to interpersonal skills and digital creativity should be increased to promote a more balanced and holistic curriculum.
2. Expand the scope of global citizenship beyond environmental issues. Social components such as human rights, cultural pluralism, peace education, and global ethics should be systematically addressed through learning outcomes.
3. Enrich innovation and creativity skills through interdisciplinary and digital contexts. Learning outcomes should include areas such as coding, maker activities, design thinking, and digital productivity.
4. Update technology skills to reflect the demands of the digital age. Topics such as digital literacy, algorithmic thinking, artificial intelligence

awareness, and cybersecurity should be explicitly integrated into the curriculum.

5. Ensure explicit representation of interpersonal skills. Social-emotional competencies such as communication, collaboration, empathy, and leadership should be supported not only through instructional strategies but also through well-defined learning outcomes.
6. Address the imbalance across grade levels. Grade levels with limited representation—such as the 7th grade—should be revised to incorporate more Education 4.0-related learning outcomes.
7. Incorporate international best practices into curriculum development. Skill-based and interdisciplinary curricular approaches from countries like Finland, Singapore, Estonia, and South Korea should serve as models for similar reforms in Türkiye.

These recommendations are not only relevant for curriculum development but also provide practical guidance for teacher education, instructional implementation, and policy-making processes.

Acknowledgements

This article is based on a paper presented at the XII. International Symposium on Turkish World Studies, held in Niğde, Türkiye, on May 21–23, 2025. The full-text version of the original paper is scheduled to appear in the symposium proceedings. The manuscript has been substantially revised and extended for journal publication.

References

Ak, B. S. ve Köse, M. (2024). 2024 Fen bilimleri dersi öğretim programı hakkında öğretmen görüşlerinin incelenmesi. *Akademik Platform Eğitim ve Değişim Dergisi, 7*(2), 132-169. https://doi.org/10.55150/apjec.1582677

Asıl, M. ve Asıl, E. (2024). Eğitim 4.0 perspektifinde öğretmen becerilerinin incelenmesi. *Recep Tayyip Erdoğan Üniversitesi Eğitim Fakültesi Dergisi (REFAD), 4*(1), 21-39.

Aydoğdu, M. ve Kesercioğlu, T., (2005). *İlköğretimde fen ve teknoloji öğretimi*. Ankara: Anı.

Başgül, M., & Coştu, B. (2024). Eğitim 4.0 araçlarının fen öğretiminde kullanımı: Bir eylem araştırması. *International Journal of Social Science Research, 12*(3), 108–147.

Bilir, U. (2025). Türkiye'de 2018 ve 2024 Yılları Fen Bilimleri Dersi Öğretim Programlarının Temel Ögeler Açısından Karşılaştırılması. *Milli Eğitim Dergisi*, 54(246), 793-836. https://doi.org/10.37669/milliegitim.1532604

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal, 9*(2), 27–40.

Demir, K., & Çetin, P. (2023). 2018 Fen Bilimleri Dersi Öğretim Programının 21. yüzyıl becerileri açısından incelenmesi. *Anadolu Öğretmen Dergisi, 7*(1), 25–43. https://doi.org/10.35346/aod.1279320

Elmas, R., & Gül, M. (2020). STEM eğitim yaklaşımının 2018 fen bilimleri öğretim programı kapsamında uygulanabilirliğinin incelenmesi. *Turkiye Kimya Dernegi Dergisi Kısım C: Kimya Egitimi, 5*(2), 223-246. https://doi.org/10.37995/jotcsc.794547

Finnish National Board of Education. (2016). *National core curriculum for basic education 2014*. Helsinki: Finnish National Agency for Education. Retrieved from https://www.oph.fi/sites/default/files/documents/new-national-core-curriculum-for-basic-education.pdf

Fisk, P. (2017, January). The future of education: How young and old, and everyone in between, will be taught together. *Peter Fisk*. https://www.peterfisk.com/2017/01/future-education-young-everyone-taught-together/

Kalemkuş, J. (2021). Fen bilimleri dersi öğretim programı kazanımlarının 21. yüzyıl becerileri açısından incelenmesi. *Anadolu Journal of Educational Sciences International, 11*(1), 63–87. https://doi.org/10.18039/ajesi.800552

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). Thousand Oaks, CA: SAGE Publications.

OECD. (2018a). *Preparing our youth for an inclusive and sustainable world: The OECD PISA global competence framework*. OECD Publishing. https://www.oecd.org/content/dam/oecd/en/topics/policy-sub-issues/global-competence/Handbook-PISA-2018-Global-Competence.pdf

OECD. (2018b). *The future of education and skills: Education 2030—The OECD learning compass 2030*. OECD Publishing. https://www.oecd.org/content/dam/oecd/en/publications/reports/2018/06/the-future-of-education-and-skills_5424dd26/54ac7020-en.pdf

OECD. (2021). *21st-century readers: Developing literacy skills in a digital world*. OECD Publishing. https://www.oecd.org/content/dam/oecd/en/publications/reports/2021/05/21st-century-readers_26f2b462/a83d84cb-en.pdf

OECD. (2024). *PISA 2022 results (Volume III): Creative Minds, Creative Schools*. OECD Publishing. https://www.oecd.org/content/dam/oecd/en/publications/reports/2024/06/pisa-2022-results-volume-iii_1933a4a1/765ee8c2-en.pdf

Oğuz Haçat, S., & Aşkın Tekkol, İ. (2017). İlkokul ve Orta Okul Fen Bilimleri Dersi Öğretim Programında Yer Alan Vatandaşlık Konularının İncelenmesi. *Online Science Education Journal, 2*(1), 45-54.

SOLIDAR Foundation. (2020). *Estonia – National report: Citizenship and lifelong learning monitor 2020.* Retrieved from https://www.solidar.org/wp-content/uploads/2024/02/clll_monitor2020_national_report_estonia.pdf

Trilling, B., & Fadel, C. (2009*). 21st century skills: Learning for life in our times*. Jossey-Bass.

Turkish Ministry of National Education (MoNE). (2011). *MEB 21st century student profile*. https://yahyacavusgorengortaokulu.meb.k12.tr/meb_iys_dosyalar/17/09/746912/dosyalar/2020_12/04180457_21._yy_og_pro.pdf

Turkish Ministry of National Education (MoNE). (2018). *Science course curriculum (grades 3–8).* https://mufredat.meb.gov.tr/Dosyalar/201812312311937-FEN%20B%C4%B0L%C4%B0MLER%C4%B0%20%C3%96%C4%9ERET%C4%B0M%20PROGRAMI2018.pdf

Turkish Ministry of National Education (MoNE). (2024). *Science course curriculum (grades 3–8).* https://mufredat.meb.gov.tr

UNESCO. (2017). *Education for sustainable development goals: Learning objectives*. Paris: UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000247444

UNESCO. (2021a). *Global citizenship education: Progress and challenges*. Paris: UNESCO.

UNESCO. (2021b). *Reimagining our futures together: A new social contract for education*. Paris: UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000379707

UNESCO. (2022). *Progress on education for sustainable development and global citizenship education: Findings of the 7th consultation (2017–2020).* Paris: UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000381362

UNESCO-UNEVOC. (2022). *Education 4.0: The future of learning and skills development.* In TVETipedia Glossary. Retrieved June 17, 2025, from https://unevoc.unesco.org/home/tvetipedia+glossary/show=term/term=Education+4.0

Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. *Journal of Curriculum Studies*, 44(3), 299–321. https://doi.org/10.1080/00220272.2012.668938

WEF. (2020). *Schools of the future: Defining new models of education for the Fourth Industrial Revolution.* World Economic Forum. https://www3.weforum.org/docs/WEF_Schools_of_the_Future_Report_2019.pdf

WEF. (2022). *Catalysing Education 4.0: Investing in the future of learning for a human-centric recovery*. World Economic Forum. https://www3.weforum.org/docs/WEF_Catalysing_Education_4.0_2022.pdf

WEF. (2023). *Future of jobs report 2023.* World Economic Forum. https://www3.weforum.org/docs/WEF_Future_of_Jobs_2023.pdf