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Alignment of the science curriculum with 21st-century educational goals: Teachers' evaluations

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ABSTRACT

This study evaluates the alignment of the science curriculum in Turkey with 21st-century educational goals based on teachers' perspectives. Conducted using a qualitative case study method, structured interviews were held with 20 science teachers from various regions, and the data were analysed using descriptive and content analysis techniques. Findings indicate that the curriculum's dense learning objectives result in time constraints, while the lack of concrete materials and technological infrastructure adversely impacts learning processes. Additionally, limitations were identified in fostering critical thinking, problem-solving, and hands-on learning skills. Teachers emphasized the need for a simplified curriculum, more opportunities for practical learning, integration of digital tools, and professional development programs for teachers. In conclusion, making the curriculum more flexible, technology-driven, and tailored to individual needs is critical to equipping students with 21st-century skills.

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Introduction

Society is undergoing rapid changes driven by advancements in science and technology. Educational programs, designed to foster individuals' development in the desired direction, are continuously updated in line with these changes. These updated programs aim to cultivate individuals who are equipped with the skills needed for the 21st century (Güllü & Akçay, 2022). The 21st century marks an era characterized by fast-paced technological progress and unrestricted access to vast amounts of information. As a result, individuals are expected to acquire essential competencies such as critical thinking, problem-solving, creativity, and teamwork (Trilling & Fadel, 2009). Education systems must be reshaped with curricula and practices that support individuals in acquiring these skills (Rotherham & Willingham, 2010). In this context, science education, in particular, plays a critical role in fostering scientific thinking and lifelong learning skills (Bybee, 2010). These competencies align with 21st-century skills, aiming to equip students to meet the demands of the modern era. However, various challenges have been observed in the implementation of the current curriculum (Keçeci & Kavukçu, 2023; MEB, 2023). Notably, differences in teachers' awareness of 21st-century skills and the insufficient integration of these skills into classroom practices have been identified (Çiftçi et al., 2023; Kalemkuş, 2021).

It is essential to evaluate education policies accordingly and develop new strategies. For example, studies focusing on Turkey's education policies in the context of 21st-century skills point to infrastructure and implementation gaps in achieving these skills (Hamarat, 2019). Key proposed solutions include integrating technological tools into education, effectively using digital content, and enhancing teachers' professional development (MEB, 2023; Yüksel et al., 2024).

This study aims to evaluate the potential of the science curriculum to instill 21st-century skills and offer solutions to the identified challenges. Based on teachers' perspectives and existing literature, the study discusses the strengths and weaknesses of science education and provides recommendations for curriculum improvement. In this context, the study is expected to contribute to enhancing education policies. In line with the study's objective, the following questions are addressed:

1. What are the perceptions of the applicability of the current learning outcomes in the 21st-century science curriculum, the benefits they provide to students, their impact on the teaching process, and the recommendations that can be made?
2. What solutions can be proposed to overcome the challenges encountered in implementing the learning outcomes of the science curriculum?
3. What recommendations can be made to address the deficiencies that need to be overcome in order to enhance the effects of materials used in science teaching??
4. What steps should be taken to resolve the fundamental issues encountered in the education system and the science curriculum?

Conceptual framework

Updates to the science curriculum and its alignment with 21st-century skills is one of the primary goals of modern education systems (MEB, 2023; OECD, 2020). In this context, it should be emphasized that fundamental changes in education and evolving teaching approaches enable students to develop scientific process skills, as well as acquire skills such as critical thinking, creative problem-solving, and the effective use of digital technologies. Education curricula must be continuously updated and restructured to meet the demands of the era. These updates highlight the need to direct students not only towards theoretical knowledge but also towards practical applications and skill-oriented learning (Yüksel et al., 2024). At this point, the integration of the STEM (Science, Technology, Engineering, Mathematics) approach and digital technologies aims to make the learning process more interactive and efficient (Bybee, 2010; Çiftçi et al., 2021; Twin Science, 2024a). However, it has become an important research topic how effectively the current science curricula achieve these goals and where there are deficiencies. Specifically, digital infrastructure shortcomings, limited use of technology, and the restricted integration of STEM practices pose barriers to fully realizing the curriculum's potential (Çiftçi et al., 2021; Kalemkuş, 2021). Before moving on to the subdimensions, it is crucial to understand how this general framework sets a direction in terms of modernizing the science curriculum, imparting 21st-century skills, and digitalization in education, and what steps need to be taken.

In this context, it is clear that the curriculum should be continuously reviewed and updated. However, in order to make these processes more effective, teachers need to be more aware of 21st-century skills, and the integration of digital tools into educational processes should be increased.

21st-century skills and education

21st-century skills include critical thinking, creative problem-solving, information literacy, and the use of digital technology (OECD, 2020). Studies conducted in Turkey indicate that the SC offers potential for fostering these skills but also highlight significant shortcomings in its implementation (Kalemkuş, 2021). Particularly, limited achievements related to information and communication technology skills reveal that the curriculum does not fully align with contemporary needs (MEB, 2023; Yüksel et al., 2024).

STEM approach in science education

STEM education promotes analytical thinking and innovative problem-solving skills through an interdisciplinary approach (Bakar, 2023; Bybee, 2010). The science curriculum integrates this approach with hands-on activities and problem-based learning methods. However, the integration of STEM practices into science lessons in Turkey remains limited (Çiftçi et al., 2021; Metin et al., 2021). Enhancing STEM-oriented achievements within the curriculum could facilitate students' acquisition of 21st-century skills.

Technology and digitalization

The effective use of technological tools in education plays a vital role in achieving the objectives of the science curriculum. Digital learning materials contribute to concretizing abstract concepts and enriching the learning process (Yüksel et al., 2024). However, the lack of technological infrastructure and limited use of digital tools hinder the full realization of this potential (Twin Science, 2024a).

Curriculum updates and future perspectives

To adapt to a changing world, education systems require regular curriculum updates. Recent curriculum changes in Turkey aim to prioritize applied learning and critical thinking skills (Kalemkuş, 2021; Yüksel et al., 2024). Future updates to the science curriculum should be supported by interdisciplinary approaches and digital learning materials (Bakar, 2023; Kalemkuş, 2021).

Ultimately, aligning the science curriculum with 21st-century educational goals is crucial for preparing education systems for the future. In this context, regular curriculum updates, increasing teachers' awareness of these skills, and integrating digital technologies into educational processes emerge as fundamental components for achieving set objectives (Kalemkuş, 2021; MEB, 2023; Yüksel et al., 2024).

Incorporating the STEM approach and interdisciplinary learning models into science education can strengthen students' analytical thinking and problem-solving abilities (Bybee, 2010). Additionally, improving technological infrastructure and addressing material deficiencies will enhance learning processes and increase the quality of education (OECD, 2020; Twin Science, 2024b). In this regard, future studies and measures will enable more effective and comprehensive implementation of the science curriculum.

Method

Research design

This study aimed to explore the perspectives of science teachers working during the 2024–2025 academic year on whether the science curriculum aligns with the educational goals of the 21st century. A case study, one of the qualitative research approaches, was employed to collect and analyze these perspectives. Case studies allow for an in-depth examination of a phenomenon and provide a contextual understanding within its environment. Yin (2018) highlights the critical role of this method in comprehending complex social phenomena, enabling researchers to evaluate phenomena from a broad perspective. Additionally, case studies involve the detailed investigation of interconnected systems, social groups, or events (Büyüköztürk et al., 2020). Yıldırım and Şimşek (2021) further emphasize the suitability of this method for analyzing the detailed experiences of a specific group or individual, particularly in disciplines like educational sciences.

This study adopted a holistic single-case design, focusing on a single unit of analysis to gain in-depth insights within the context of the research topic. This approach facilitates the examination of unique, atypical, or context-specific cases (Yeşilbaş Özenç, 2023). The selection of this design aligns with the study's objective of investigating science teachers' perspectives on the curriculum across Turkey.

Study group

The population of this study consists of science teachers across Turkey, with the sample comprising 20 science teachers working in the provinces of Trabzon, Gümüşhane, Ankara, Erzurum, Konya, Antalya, and Muğla. Maximum variation sampling was employed to ensure participation from teachers with diverse experiences and perspectives, enriching the data (Yıldırım & Şimşek, 2018).

Participants were selected from different geographical regions, representing a variety of educational backgrounds. While some participants held bachelor's degrees, others had completed master's degrees. This diversity allowed for a comprehensive evaluation of how the applicability of the curriculum and the challenges encountered varied based on teachers' educational levels. Individual interviews were conducted with each participant using a structured set of four questions. This approach provided an opportunity for in-depth analysis of teachers' views on curriculum implementation, challenges in teaching processes, material usage, and issues within the education system.

Table 1. Distribution of teachers based on demographic information

Demographic Questions		n	%
Gender	Female	7	35
	Male	13	65
Yaş	Under 30 years	2	10
	31-36 years	4	20
	37-42 years	3	15
	43-48 years	5	25
	49 years and above	6	30
Seniority	Under 9 years	3	15
	10-19 years	5	25
	20-29 years	8	40
	30-39 years	4	20
Educational Level	Bachelor's degree	13	65
	Master's degree	7	35
Total		20	100

Table 1 demonstrates that the majority of the participating science teachers were male (65%), aged 43 years and above (55%), had 20 or more years of experience (60%), and held a bachelor's degree (65%). The sample includes fewer younger and less experienced teachers (15%), forming a predominantly experienced and middle-aged to senior group. This distribution provides a suitable basis for assessing the influence of experience and academic background on the study.

Data collection tools

The study utilized interviews, one of the most frequently used qualitative data collection tools. Interviews are a robust qualitative method that enables the exploration of participants' perspectives, values, and perceptions (Yıldırım & Şimşek, 2008). Data were gathered through face-to-face interviews with the participating science teachers. A structured interview form was used, ensuring a standardized process for reliable and comparable results (Patton, 2002). This method facilitated the systematic analysis of responses to pre-determined questions.

The structured interview form consists of four questions designed to explore science teachers' perspectives on the adequacy of the science curriculum, challenges in the teaching process, material usage, and overall perceptions of the education system. The form was reviewed by a panel of five experts, including an assessment and evaluation specialist, a science teacher, and three academicians, and was finalized after incorporating necessary revisions. Initially prepared with ten questions, the form was condensed to four after seeking expert opinions. An average of 20 minutes was allocated for answering the questions. The questions included in the interview form are listed below:

1. What are your views on the applicability of the current learning outcomes in the 21st-century science curriculum and their benefits for students? How do these outcomes affect the teaching process, and what recommendations can you provide in this regard?
2. What challenges do you encounter in implementing the learning outcomes of the science curriculum during the teaching process? What solutions or recommendations can you propose to overcome these challenges?
3. What are your thoughts on the effects of materials used in teaching science and the current material shortages? What recommendations can you make to address these deficiencies?
4. What are the main issues you encounter in the education system and curriculum? What steps do you think should be taken to address these issues?

Data analysis

The audio recordings from structured interviews with teachers were analyzed using content analysis, a widely used qualitative data analysis method. During the content analysis, both qualitative and quantitative content analyses were conducted together. In qualitative content analysis, categories are created from themes considered important within the text, allowing inferences about specific phenomena (Gül & Nizam, 2021). Rather than focusing on the visible aspects of the content, the aim is to reach the latent messages and communications that are not superficially apparent (Yüksel, 2019). The technique of quantitative content analysis, on the other hand, aims to identify the frequency of repetition of words or concepts determined during the category creation process. In quantitative content analysis, since the focus is on coding the content on the visible surface of the written text, open coding is more commonly used. In this study, both methods were employed in the analysis of the collected data. Content analysis is frequently used in educational research to analyze interviews (Çepni, 2012).

First, the recorded interviews were transcribed verbatim into text documents. The data were categorized into themes during the content analysis. Participants were coded as P1, P2, P3, and so on, with "P" derived from the word "participant."The participants verified transcribed data to ensure accuracy and data security. The coding process was independently reviewed by researchers and an assessment specialist. Intercoder reliability was calculated using the formula provided by Miles and Huberman (1994): Reliability = Agreement / (Agreement + Disagreement), resulting in an intercoder reliability of 89%. Additionally, direct quotes were included in the findings to ensure clarity and avoid misinterpretation.

Findings and discussion

In this section, the findings obtained from the analysis of the data collected during the study are presented and interpreted under thematic headings. In line with the research objective, the experiences and opinions of teachers regarding the science curriculum were examined in depth using both qualitative and quantitative content analysis methods. The findings were evaluated within the context of the curriculum's alignment with 21st-century educational goals and interpreted based on the teachers' recommendations.

The findings and discussion related to the first research question

Participants were first asked: "*What are your views on the applicability of the current learning outcomes in the 21st-century science curriculum and their benefits for students? How do these outcomes affect the teaching process, and what recommendations can you provide in this regard?*" The findings based on their responses are summarized in Table 2.

Table 2. Applicability of current learning outcomes in the 21st-century science curriculum

Theme	Sub-Themes	Participants
Curriculum Intensity and Time Constraints	Excessive Learning Outcomes and Time Management Issues	P1, P8, P9, P12, P16
	Insufficient Class Hours	P1, P9, P12, P16
	Fast and Superficial Coverage of Topics	P1, P9, P12, P16
Lack of Concretization and Experiential Learning	Lack of Concrete Materials and Tools	P3, P4, P6, P13, P15
	Difficulties in Understanding Abstract Concepts	P3, P7, P13, P15
	Failure to Implement Experiential Learning Techniques	P3, P6, P8, P10, P15
Class Size and Infrastructure Issues	Impact of Large Class Sizes on Individual Learning	P4, P11, P15
	Insufficient Infrastructure	P4, P13, P15
Development of 21st-Century Skills	Supporting Critical Thinking and Problem-Solving Skills	P10, P18
	Need for Practice-Oriented Teaching Instead of Theoretical Knowledge	P10, P17, P18
	Strengthening the Connection Between the Curriculum and Real Life	P2, P10, P18
Program Design and Balance of Learning Outcomes	Simplification of Learning Outcomes	P2, P8, P16, P18
	Suitability for Grade Levels	P5, P10, P20
Individual Differences and Flexibility in the Curriculum	Adjustments for Individual Differences Among Students	P11, P20
	Need for a Flexible Curriculum	P11, P20

When participant teachers were asked about the challenges they faced with the curriculum, five themes and a total of 15 sub-themes were identified. Among these, the sub-theme of "*excessive learning outcomes and time management issues*" emerged as the most emphasized topic. Additionally, problems related to "*lack of concrete materials*" and "*failure to implement experiential learning techniques*" were frequently mentioned as issues of concretization. Less commonly expressed sub-themes included "*critical thinking skills in the development of 21st-century skills*" and "*adjustments for individual differences.*" Some of the participants' views are presented below:

P1: "The current topics taught in primary school result in an excessive number of learning outcomes relative to the available class hours, causing them to fall short. The content in textbooks is insufficient to prepare students for new-generation questions. Either the weekly class hours should be increased beyond five lessons, or the curriculum content should be reduced to fit this timeframe. It is necessary to either decrease the number of learning outcomes or increase the time allocated for their coverage."

P8: "The curriculum includes too many learning outcomes, creating constant pressure to keep up. As a result, sufficient concrete activities cannot be conducted. Opportunities for experiential learning are necessarily kept to a minimum."

P15: "The curriculum has a positive impact. However, due to crowded classrooms, class hours are insufficient. Primary school students struggle with abstract thinking and rely on concrete thinking; hence, both informal and formal experiential learning opportunities are inadequate."

P20: "Our primary school mathematics curriculum is designed in alignment with student expectations, developmental stages, school vision, and the contemporary world. Our measure of success here is how effectively we can implement this system. If the education delivered is tailored to address individual differences among students at the class level, success in achieving the goals will be attainable. By ensuring students grasp the steps of comprehension and analysis and correctly completing each stage of the model, I believe the expected process will conclude successfully."

When the responses were examined in greater detail, it was determined that participants held both differing and common views. These differences and similarities can be interpreted as follows:

P1 focused on time management and content deficiencies, highlighting the need for material development, particularly for new-generation questions. While presenting a more specific perspective in their approach, P1 emphasized the relationship between time and content with concrete suggestions. P9, on the other hand, argued that covering all outcomes is a priority but stated that this restricts the application of different methods and techniques. P12 mentioned that the intensity of the science curriculum leads to fast and

superficial coverage of topics, negatively affecting the learning process. P16 acknowledged that the curriculum helps in developing 21st-century skills but expressed that overall efficiency remains low. While the focus of P1 and P9 revolves around the relationship between outcomes and time, P12 emphasized the impact of rapid transitions on learning, and P16 drew attention to general efficiency issues.

P3stated that the abstract structure of the science curriculum shifts it away from being student-centered and turns it into a teacher-centered approach. They explained that insufficient use of experiential learning techniques negatively affects learning processes. P4 associated the lack of concretization with overcrowded classrooms and insufficient infrastructure, emphasizing that these conditions hinder effective learning. P6 advocated for the development of concrete materials for every topic, drawing attention to the need to address material deficiencies. P13 linked the lack of concretization to insufficient laboratory and activity spaces. P15 stated that overcrowded classrooms prevent sufficient time from being allocated to individual learning. While P3 focused on the general effects of the abstract curriculum structure, P4 pointed to physical infrastructure issues. P6 proposed the development of concrete materials, P13 associated the problem more specifically with infrastructure, and P15 emphasized the negative effects on individual learning processes.

P10 stated that the current program is better than before but needs improvement. They suggested increasing examples from daily life and advocated for making science classes more practical. P14 stated that the program is insufficient in fostering 21st-century skills and does not adequately support student development. P17 noted semi-positive progress in developing these skills but stated that practical applications remain inadequate. P18 emphasized the necessity of a curriculum structure that is less theoretical and more practice-based, particularly pointing out deficiencies in developing critical thinking and problem-solving skills.

P11 mentioned that differences in student levels create problems in grasping outcomes, negatively reflecting on the teaching process. P20 emphasized the importance of transforming the program into a more flexible structure that takes individual differences into account. While P11 discussed the impact of level differences on teaching, P20 highlighted the necessity of designing a program tailored to individual needs. P15, meanwhile, focused on how classroom arrangements affect individual learning, noting that overcrowded classrooms limit opportunities to address individual needs.

P2 advocated for simplifying education, increasing concrete outcomes, and making the program more adaptable to real life. They stated that the curriculum should be supported with practical applications. P5 mentioned that the program creates an imbalance in outcomes during grade transitions, negatively affecting learning processes. P10, similar to P2, proposed a science curriculum more aligned with daily life, arguing that incorporating real-life examples could make outcomes more effective.

P2 emphasized the need for overall simplification and establishing a connection with real life, while P5 discussed the misalignment of learning outcomes across grade levels. P10 focused on enhancing the program's effectiveness through examples adapted to daily life. Overall, participants converged on key issues such as curriculum intensity, time constraints, lack of concretization, deficiencies in fostering 21st-century skills, and neglect of individual differences. However, differences emerged in their perspectives on these issues and their proposed solutions. For instance, P1 focused on material deficiencies, while P4 emphasized infrastructure inadequacies. P10 provided a comparative evaluation with the past, whereas P18 advocated for reducing theoretical emphasis. P11 highlighted the challenges posed by level differences, and P20 stressed the need for a flexible structure tailored to individual needs.

This analysis demonstrates that participants prioritize different aspects, indicating a need for a multidimensional approach to improving the science curriculum. While P10 noted positive progress compared to the past, P14 offered a critique of overall inadequacy. P17 focused on deficiencies in practical applications, and P18 emphasized the need to reduce the theoretical burden.

b. The findings and discussion related to the second research question.

Participants were asked the second question: "*What challenges do you encounter in implementing the learning outcomes of the science curriculum during the teaching process? What solutions or recommendations can you propose to overcome these challenges?*" The findings based on their responses are presented in Table 3.

Table 3. Challenges encountered in implementing the learning outcomes of the science curriculum during the teaching process and proposed solutions

Theme	Sub-Themes	Participants
Curriculum Intensity and Time Constraints	Increasing Weekly Class Hours	P1, P11, P16
	Simplification of the Curriculum	P3, P4, P9, P16
	Reduction of Learning Outcomes	P4, P9, P11, P15
Lack of Materials and Technology	Insufficiency of Educational Materials	P8, P12, P18
	Increasing the Use of Digital Technology	P5, P7, P14, P17

	Lack of Concrete Materials	P6, P12, P15, P19
Teaching Methods and Techniques	Promoting Game- and Activity-Based Learning	P7, P14, P15
	Increasing Opportunities for Experiential Learning	P3, P6, P18
	Directing Teachers to In-Service Training	P2, P10, P15
Physical and Regional Differences	Addressing Physical and Regional Disparities in Schools	P13, P19
	Reducing Class Sizes	P13, P18
	Developing Region-Specific Curricula	P18, P20
Development of 21st-Century Skills	Developing Digital and Practical Programs	P5, P14, P17, P20
	Supporting Critical Thinking and Problem-Solving Skills	P10, P14, P17
	Aligning the Curriculum with Real-Life Applications	P5, P9, P20

When participants were asked about the challenges they encounter in the science curriculum and their proposed solutions, five themes and a total of 15 sub-themes were identified. Among the most frequently mentioned sub-themes were "simplification of the curriculum" and "increasing the use of digital technology." Participants particularly focused on suggestions such as reducing learning outcomes and increasing weekly class hours. Additionally, issues such as material shortages and the lack of concrete learning materials were frequently emphasized. Less commonly expressed sub-themes included "reducing class sizes" and "developing region-specific curricula." Furthermore, under the theme of "developing 21st-century skills," the proposal to create digital and practical programs also garnered attention.

In conclusion, participants' opinions highlighted the need for a curriculum that is simpler, more practical, supported by technology, and rich in resources. It was clearly emphasized that a more flexible and effective system that addresses the needs of both teachers and students should be established in educational processes. Below are some of the participants' views:

P2: "To ensure teachers can impart these skills effectively, training should be increased, and surveys should be conducted to identify the most suitable (practical) educational model for our country. These models should be integrated into teachers' professional development programs."

P4: "By reducing the number of learning outcomes, more time can be allocated to practical activities. These can be further reinforced with examples."

P9: "In science programs, prioritizing changes to learning outcomes is essential. Once this is achieved, teachers will have more time within lesson hours. Teachers can then utilize this time for various activities and games, especially those aligned with modern times, technology-focused, and aimed at fostering students' development and preparing them for the future. This will make teachers more effective in helping students acquire necessary skills."

P13: "There should be activity laboratories. Homework does not ensure equality in learning, as parents' educational backgrounds and students' study environments vary greatly."

When analyzed in more detail, participants demonstrated both shared and differing opinions. These differences and similarities can be interpreted as follows:

Material shortages and exclusion of teachers' opinions in the process were identified as fundamental issues. P1 stated that teachers' opinions are often overlooked, and due to material shortages, teachers attempt to support their classrooms with self-prepared content. This creates challenges in time management for teachers and prevents a standardized learning experience for students. P13 mentioned that current textbooks are insufficient and that original materials prepared by teachers contribute more effectively to the learning process. However, the process of creating materials independently is limited due to time and resource constraints. P15 and P16 emphasized the need for simplifying educational materials and supporting them with technological tools, stating that these adjustments would facilitate students' learning processes. To resolve the issue of material shortages, it is crucial to actively involve teachers in the process and for the Ministry of Education to support material development initiatives. Enhancing educational materials with contemporary methods and digital content will play a critical role in improving student success.

21st-century skills are competencies that not only ensure academic success but also support individuals' lifelong learning processes. P6 emphasized the significant role parents play in fostering these skills and stated that families should be more involved in the educational process. Supporting students' learning processes at home emerges as an effective method for acquiring these skills. P7 pointed out that activities based on multiple intelligence theory and visual materials are effective in developing 21st-century skills. Specifically, creative and practical activities should be emphasized to enhance critical thinking and problem-solving skills. P17 highlighted the critical importance of professional development for teachers in imparting these skills and emphasized the necessity of educational programs tailored for teachers.

In this context, increasing teacher training, employing innovative teaching techniques, and encouraging active parental participation will effectively support the development of 21st-century skills.

The integration of technological tools into educational processes has the potential to make learning more effective. P3 mentioned that the use of smart boards and other technological tools in the classroom increases student motivation. Technology serves as a crucial tool for helping students concretize abstract concepts. P4 noted that supplementary books and the effective use of technology in education make lessons more engaging. Increased interaction with these tools enhances learning retention. P16 and P20 emphasized that Web 2.0 tools and digital content, especially in subjects like science, create an effective learning environment.

Developing technological infrastructure and effectively utilizing digital tools can create new opportunities for both teachers and students in education. The widespread use of these tools stands out as one of the fundamental components of modern education.

The impact of social support and educational policies on teaching processes was frequently mentioned by participants. P11 stated that family support and government-initiated projects contribute to student success. Specifically, strengthening the collaboration among students, parents, and teachers emerges as a supportive approach for overall success in the education system. P12 suggested that training programs organized by the Ministry of Education for teachers would enhance their knowledge and skills. Additionally, a nationwide awareness campaign during the educational process was recommended to positively change perceptions, particularly regarding science and mathematics courses.

c. The findings and discussion related to the third research question.

Participants were then asked the third question: "*What are your thoughts on the effects of materials used in teaching science and the current material shortages? What recommendations can you make to address these deficiencies?*" The findings based on their responses are presented in Table 4.

Table 4. Effects of materials used in education

Theme	Sub-Themes	Participants
Educational Materials and Infrastructure	Material Shortages and the Need for Simplification	P1, P13, P15, P16
	Strengthening Technological Infrastructure	P3, P4, P16, P20
	Effective Use of Digital Tools	P4, P16, P20
Development of 21st-Century Skills	Fostering Critical Thinking and Problem-Solving Skills	P7, P10, P17
	Ensuring Active Parental Participation in the Process	P6, P11
	Implementing Creative and Innovative Teaching Methods	P7, P15, P17
Social Support and Policy	The Impact of Ministry Projects on Teacher Development	P11, P12
	Increasing Collaboration with Parents	P6, P11
Teacher Training and Development	Increasing In-Service Trainings	P1, P10, P17
	Active Participation of Teachers in the Processes	P1, P13, P16
General Solution Recommendations	Simplification of Materials	P1, P13, P16
	Development of Contemporary and Applicable Programs	P6, P12, P20

In Table 4, the challenges in the education system and proposed solutions have been classified thematically according to the participants' views. Issues such as "material shortages" and "strengthening technological infrastructure" have emerged as primary problems in the teaching process. Participants have suggested the effective use of digital tools and creative teaching methods as solutions to these issues. Less frequently mentioned topics include "active parental involvement" and "the impact of ministry projects on teacher development." These findings indicate that a multidimensional approach is needed to improve the quality of education. Some of the participants' views are listed below:

P4: "*Overcrowded class sizes, insufficient school facilities, ineffective classroom environments, and a lack of examples to convey learning outcomes*."

P10: *"The excessive number of learning outcomes, teachers' efforts to prove themselves, insufficient support from families, and lack of time."*

P17: *"The most significant obstacle is curriculum-related issues, as discussed with teachers directly in the field. Socioeconomic conditions and the inadequacy of physical education mechanisms are also major barriers."*

Upon closer examination of the responses, both differing and shared views among the participants were identified. These differences and similarities can be interpreted as follows:

Many participants emphasized the importance of considering teachers' opinions for more effective educational processes. P1 stated that teachers' opinions are often overlooked and that textbooks are content-wise inadequate. This has led teachers to prepare their own materials, and this process is limited by time and resource constraints. P1 also mentioned that the current system increases the burden on students and stressed that materials should be simplified. P13 defined the lack of educational materials as a major factor slowing down the teaching process and highlighted the significant impact of teacher-prepared

documents on learning. P15 and P16 emphasized the supportive role of supplementary resources and technological tools in students' learning processes. P16 specifically mentioned that materials should be aligned with contemporary requirements.

The acquisition of 21st-century skills is critical not only for individual development but also for societal progress. P6 emphasized that parents should play an active role in this process and underscored the importance of family support on students' development. In particular, it was stated that parents should be involved in acquiring skills such as cooperation, problem-solving, and communication alongside their children. P7 noted that activities based on multiple intelligence theory and visual materials could be effective in imparting these skills. This approach indicates that learning is not only about acquiring knowledge but also about connecting with life and developing skills. P17 emphasized that teachers' professional development is a determining factor in imparting 21st-century skills to students.

The integration of technological tools into educational processes plays a critical role in supporting students' learning. P3 expressed that the use of smart boards and other technological tools in classroom applications could increase students' interest in lessons. P4 emphasized that supplementary books and technological tools make lessons more engaging, and this positively influences students' academic performance.

P16 stated that Web 2.0 tools and digital games enriched students' learning processes. P20 argued that to adapt to the evolving world, it is necessary to strengthen technological infrastructure and use digital resources effectively.

The role of social support and ministry policies in the success of the education system was frequently mentioned by participants. P11 highlighted the impact of family support and projects initiated by the Ministry of National Education on student success and emphasized the importance of increasing parent-teacher collaboration. P12 stated that teacher training programs organized by the Ministry of Education would contribute to teachers' professional development, thereby improving the overall quality of education.

d. The findings and discussion related to the fourth research question.

Participants were asked the fourth question: "*What are the main issues you encounter in the education system and curriculum? What steps do you think should be taken to address these issues?*" The findings based on their responses are presented in Table 5.

Table 5. Teacher views on solutions to key issues encountered in the curriculum

Theme	Sub-Themes	Participants
Student Development and Engagement	Increasing Student Motivation	P3, P4, P16
	Personalized Learning Opportunities for Students	P13, P19
	Innovative Practices to Increase Classroom Participation	P4, P6, P10
Curriculum and Program Alignment	Adapting the Curriculum to Local Needs	P11, P20
	Updating and Simplifying Lesson Content	P1, P13, P15, P16
	Flexible Programs Tailored to Different Learning Needs	P12, P18
Equality and Justice in Education	Addressing Regional Disparities	P11, P19
	Implementing Teaching Methods Suited to Socioeconomic Conditions	P6, P20
	Equitable Distribution of Educational Resources	P15, P18
Equity and Justice in Education	Widespread Implementation of Digital Transformation Projects in Education	P3, P16, P20
	Increasing Teachers' Digital Competencies	P12, P17
	Use of Web 2.0 Tools and Digital Games in Lessons	P4, P16, P20

In Table 5, the challenges in the education system and proposed solutions have been organized thematically based on the participants' views. Issues such as "increasing student motivation" and "adapting the curriculum to local needs" were highlighted as the most frequently mentioned problems by the participants. They suggested that the solution to these issues involves increasing personalized learning opportunities and developing flexible programs. Less frequently mentioned topics include "methods suited to socioeconomic conditions" and "increasing teachers' digital competencies." These findings suggest that a more equity-focused and technology-supported approach is needed to address the challenges in the education system. Some of the participants' views are listed below:

P7: *"The most significant support when imparting 21st-century skills to students comes from applications based on multiple intelligences, such as those provided by platforms like Morpa Campus and Vitamin V."*

P12: "The Ministry should provide training programs for teachers, and the negative perception of science subjects in our country should be broken. Science is life. A nationwide mobilization should be launched in schools. While the

Ministry organizes this, a commission of teachers should be formed, and the process should move forward with their input."

P16: "The training provided by educational platforms, Web 2.0 tools, and brain and intelligence games are the most important supporting factors."

Upon further examination of the responses, it was determined that participants had both differing and shared views. These differences and similarities can be interpreted as follows:

The importance of considering teachers' opinions in educational processes was emphasized by many participants. P1 mentioned that teachers' opinions are often overlooked, and that the lack of material negatively impacts the teaching process. This leads teachers to prepare their own materials, which is constrained by time and resource shortages. P1 also pointed out that the simplification of materials is necessary, as the current system increases the burden on students. P13 defined the lack of educational materials as a major factor that slows down the learning process and emphasized the significant impact of materials prepared by teachers on student learning. P15 and P16 emphasized that the use of supplementary resources and technological tools contributes positively to the educational process. P16 specifically argued that teaching materials should be developed to meet contemporary needs.

Participants drew attention to the challenges encountered in imparting 21st-century skills to students. P6 highlighted the role of parents in this process, emphasizing that family support is a fundamental factor in student development. P7 stated that the integration of activities based on multiple intelligence theory and visual support into the learning process could be effective in developing these skills. In particular, it was emphasized that skills such as critical thinking, problem-solving, and communication should be supported not only by classroom activities but also by real-life-related activities. P17 argued that teachers' professional development plays a central role in the acquisition of these skills by students.

Participants also noted that insufficient technological infrastructure negatively impacts the teaching process. P3 stated that the integration of smart boards and other technological tools into the teaching process could increase students' interest in the lessons. P4 emphasized that the effective use of supplementary books and technology makes lessons more engaging and positively affects the learning process. P16 specifically mentioned that Web 2.0 tools and brain and intelligence games increased students' participation in lessons. The widespread use of digital tools in education could enhance students' motivation and academic performance.

The importance of social support and ministry policies in the success of the education system was frequently mentioned by participants. P11 emphasized the positive effects of family support and projects initiated by the Ministry of National Education on the education process. In particular, increasing coordination between students, parents, and teachers was seen as a way to contribute to solving the current issues in the education system. P12 stated that the teacher training programs organized by the Ministry would enhance teachers' professional skills and contribute to improving the quality of education. Furthermore, raising awareness about mathematics and science subjects in society through a public awareness campaign was suggested to break the negative perceptions surrounding these subjects.

Discussion and conclusion

The aim of this study is to examine science teachers' perceptions and views regarding the curriculum, identify the strengths and weaknesses of the current curriculum, and pinpoint areas for development. The research findings reveal that a significant portion of the teachers believes the current curriculum does not meet the goals of 21st-century education. Key issues, such as "material shortages," "weak technological infrastructure," "time management problems," and "neglecting individual differences," have emerged as the main concerns.

Teachers indicated that they face challenges in the applicability of the learning outcomes in the science curriculum, particularly with issues like time constraints and curriculum density. They suggested that simplifying the outcomes and increasing weekly class hours could help address these problems. Furthermore, the importance of concretizing abstract concepts and using practical teaching methods was emphasized. This suggests that innovative approaches need to be adopted to make the educational processes more effective. Laurillard (2012) also stresses the importance of designing pedagogical strategies that can help students engage with abstract concepts through technology, aligning with the findings of this study.

The findings of this study align with existing literature while also offering some differences. For instance, the need for "material shortages" and the "strengthening of technological infrastructure" were also highlighted by Çepni (2020). Çepni (2020) specifically noted that the lack of concrete materials in science

subjects makes it difficult for students to understand abstract concepts, which is similar to the findings of this study (Çepni, 2020). However, the emphasis in this study on teachers' more active participation in material development is rarely addressed in the literature. Beetham and Sharpe (2013) also emphasize that effective teaching requires both material and methodological innovation, which can be achieved by actively involving teachers in the material development process.

Regarding the "development of 21st-century skills," the need for creative and innovative teaching methods was also emphasized in studies by Ülger (2021) and Uysal (2021). Ülger (2021) noted that project-based learning methods help students develop critical thinking and problem-solving skills, while this study particularly highlighted that parents' more active involvement is a crucial factor in fostering these skills (Uysal, 2021; Ülger, 2021). Saavedra and Opfer (2012) argue that teaching methods should be adaptable to foster critical thinking and problem-solving skills, which aligns with the study's focus on creativity and active learning approaches. Hattie and Yates (2013) also support this by noting that visible learning techniques—such as collaborative projects—are crucial for developing these competencies.

Another key finding from this study is the "integration of technological tools into educational processes." Literature on this topic shows that digital tools support learning processes and increase student motivation (Aksoy & Küçükdemir, 2019; Metin et al., 2023). Similarly, this study recommended the effective use of Web 2.0 tools and digital content. The use of smart boards and digital games in science lessons, particularly, can contribute to concretizing abstract concepts (Metin et al., 2023). This is consistent with the work of Thai et al. (2017), who found that integrating digital tools in education can enhance student engagement and improve learning outcomes. Schleicher (2018) also highlights that the effective use of technology in classrooms can drive student motivation and engagement, which aligns with the results of this study.

The theme of "equity and justice in education" is another notable aspect of this study. The need to address regional disparities and develop teaching methods suited to socioeconomic conditions was emphasized. This finding is also reflected in the study by Kaymaz and Atmaca (2022), which similarly stressed the importance of equitable resource distribution. However, this study took a more comprehensive approach in discussing the impact of fair distribution of educational resources on student success (Ilgar, 2023; Kaymaz & Atmaca, 2022). UNESCO (2015) supports this perspective by advocating for equitable access to resources in order to create equal learning opportunities for all students, regardless of their backgrounds.

Finally, the need for teachers' professional development and making educational policies more inclusive was frequently mentioned by participants. This result is supported by Bümen et al. (2012), who suggested that professional development programs and awareness campaigns for teachers could positively contribute to teaching processes (Bümen et al., 2012). Darling-Hammond et al. (2017) also stress that sustained professional development is essential for improving teaching quality, particularly in the context of integrating innovative teaching methods and technologies into classrooms.

This study emphasizes the need to transform the science curriculum into a more flexible, practical, and technology-supported structure. It also highlights the necessity of implementing policies that encourage more active participation from teachers and parents, address material shortages, and promote the widespread use of digital content. Improving the education system in this way is critical to equipping students with the 21st-century skills necessary for future success. Future research could experimentally assess the feasibility and impact of the proposed solutions and compare the views of teachers from different geographical regions.

Declarations

Availability of data and materials

The data that support the findings of this study are available upon request from the corresponding author.

Competing interests

The authors declare that they have no competing interests.

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