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Revisiting science education frameworks: Implications from PISA literacy findings in Türkiye, China, and OECD countries

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ABSTRACT

Scientific literacy is crucial for making informed decisions about health, nutrition, and environmental issues, without needing a science degree. For instance, individuals should choose products like detergents or cars wisely to address environmental concerns. Teachers must foster scientific literacy, helping students understand natural phenomena, make informed decisions, critically evaluate claims, and seek answers to pressing questions. The science curriculum should emphasize this aspect. In the 2018 PISA rankings, Türkiye was 39th out of 79 countries and 30th out of 37 Organization for Economic Co-operation and Development (OECD) nations, scoring below the OECD average. While Türkiye's average score of 468 is above the global average of 458, it lags the OECD average of 489. Turkish students perform well at lower proficiency levels, such as below level 2, but their performance drops significantly at higher levels, with only 0.1% reaching level 6 compared to 31.5% in China and 6.8% among OECD countries. These results highlight Türkiye's need to enhance its science education, focusing on improving scientific literacy. Despite progress since 2015, Türkiye's performance indicates persistent issues that require attention to boost scientific literacy effectively.

Keywords: OECD, PISA 2018, PISA Türkiye, science education, scientific literacy, students' performance

INTRODUCTION

PISA 2018 results revealed that Turkish 15-year-old students are not adequately scientifically literate to meet the demands of a knowledge-based society, where scientific and technological participation is crucial. According to PISA 2018, Türkiye ranked 30th out of 37 Organization for Economic Co-operation and Development (OECD) countries and 39th out of 79 participating countries in scientific literacy (Milli Eğitim Bakanlığı [MEB], 2019).

Despite the Turkish science curriculum's goal of fostering scientific literacy (MEB, 2004, 2013, 2017, 2018), only 2.5% of Turkish students performed at an advanced level in scientific reasoning, well below the OECD average. PISA measures proficiency across seven levels, with top performers in levels 5 & 6 demonstrating advanced scientific thinking, while low achievers, categorized in level 1a and level 1b, show limited proficiency (OECD, 2019a). The disappointing performance suggests that although students have completed the national science curriculum, many do not attain the expected level of scientific literacy.

Several factors contribute to Türkiye's low PISA performance, including disparities in school types and regions (MEB, 2019), limited parental support (Şad, 2012), inadequate educational resources, and low teacher job satisfaction (Blandford, 2000; Cansız & Cansız, 2019). For instance, students in Eastern Marmara, Western Anatolia, and Istanbul performed better in science compared to other regions, while students in science high schools achieved the highest science scores (584.9), contrasting with low scores in multi-program Anatolian high schools (403) (MEB, 2019).

The Turkish science curriculum may be a key factor, as it has been critiqued for its inadequacy in fostering scientific literacy (Effendi et al., 2021; Irez, 2009). Since the curriculum serves as a major guide for teachers in setting instructional objectives and assessment methods, it is essential to analyze whether it effectively aligns with the PISA framework for scientific literacy. Investigating these deficiencies could offer valuable insights for curriculum developers and educators, potentially leading to improvements in students' scientific literacy.

LITERATURE REVIEW

Scientific Literacy

For over 50 years, many countries, particularly developed ones, have prioritized scientific literacy, aiming to equip future citizens with the skills and knowledge to make informed decisions about the natural world (European Education and Culture Executive Agency: Eurydice, 2011). OECD (2003) defines scientific literacy as "the capacity to use scientific knowledge, to identify questions, and to draw evidence-based conclusions" about the natural world and human impact on it (p. 133). It emphasizes applying scientific skills over mere knowledge recall (Sadler & Zeidler, 2009). Research shows that various factors, including family background, socio-economic status, teacher practices, and school resources, significantly influence students' scientific literacy (Günaydin, 2022; You et al., 2021). Studies have also demonstrated that engaging students in scientific inquiry enhances their literacy and attitudes toward science (Genç, 2015), while well-integrated teaching resources can significantly improve science learning outcomes (Indriayu, 2018). However, in countries like Indonesia, lower PISA scores have been linked to inadequate classroom resources and environments (Ramli et al., 2021). Additionally, Günaydin (2022) highlights the positive correlation between students' reading comprehension, subject matter knowledge, and literacy, advocating for strategies that strengthen students' understanding of scientific terminology and cognitive problem-solving skills.

Scientific Literacy and the Curriculum

Scientific literacy has been highlighted as a critical element to be addressed within school science curricula (Cansız & Cansız, 2019; Tamassia & Frans, 2013). Research emphasizes that science curricula must cover all components of scientific literacy, focusing on applying science in everyday life and society (Cansız & Cansız, 2019). Scholars argue that scientific literacy should be introduced in early education (Vahey et al., 2019), where students are encouraged to think, predict, and explore under the guidance of teachers or parents. Although many educators and parents find integrating scientific literacy into lessons challenging, Vahey et al. (2019) suggest that it can be effectively incorporated through literacy, media, and simple informal experiments, which offer meaningful opportunities to develop these skills.

Studies have also examined how different curricular approaches impact the development of scientific literacy. Tamassia and Frans (2013) discuss the benefits and drawbacks of various teaching methods, with integrative approaches boosting students' motivation by connecting different knowledge areas. However, while this approach is seen as beneficial, it has not been empirically supported by PISA test results and may not be practical for all teachers (Tamassia & Frans, 2013). Similarly, studies have explored the effects of inquiry-based learning on PISA scores, finding a surprising negative correlation between frequent inquiry-based instruction and scientific literacy (McConney et al., 2014; She et al., 2018). These findings underscore the need for more critical evaluation of how inquiry is implemented. Moreover, curriculum reforms emphasizing scientific literacy highlight the importance of teacher training, as there is often a gap between teachers' intentions and their understanding of effective implementation (Dragoş & Mih, 2015). Finally, the structure and focus of national curricula, as seen in Thailand and Finland, do not necessarily correlate with higher PISA scores, indicating that teacher expertise and a balanced curriculum are critical factors (Sothayapetch et al., 2013).

PISA Examinations and Science Education

PISA examinations, developed by OECD (2007), emphasize assessing scientific literacy through real-life science processes rather than focusing on content mastery and recall. While the PISA assessment is comprehensive and useful for advancing science education, some authors caution against over-relying on its results, as it is just one part of a broader educational system (Sadler & Zeidler, 2009). Sadler and Zeidler (2009) advocate for integrating socio-scientific approaches that encourage civic engagement and critical thinking, which are difficult to assess. Nevertheless, research into PISA assessments offers valuable insights into students' scientific literacy skills, helping to refine curriculum and instructional practices (Sholikah & Pertiwi, 2021). For instance, Sholikah and Pertiwi (2021) found that students performed better in evaluating and designing inquiry activities than in explaining scientific phenomena, suggesting a need to reconsider curricular emphasis on scientific explanation. These studies underscore the importance of aligning curricula with PISA assessment outcomes to enhance scientific literacy (McConney et al., 2014; Sholikah & Pertiwi, 2021; Sothayapetch et al., 2013).

A Brief Glance at the Science Curriculum in Türkiye

Since the academic year 2012-2013, compulsory education in Türkiye has been 12 years with three stages. The first stage is primary school which is from grade 1 to grade 4. It covers children of 66 months to 10 years old. Middle school is the second stage that is from grade 5 to grade 8 and covers children from 10 to 14 years old. High school, which is from grade 9 to grade 12, is the last one before higher education. Children aged 14 to 18 years old go to high school. Middle and high schools may have different types of schools. Distribution of PISA 2018 Türkiye sample by school types are middle school (0.3%), Anatolian high school (43.7%), science high school (4.2%), social science high school (2.4%), Anatolian fine arts high school (0.6%), vocational and technical Anatolian high school (31.1%), multi-program Anatolian high school (4.0%), and Anatolian religious high school (13.7%) (MEB, 2019). However, all students take the same science courses in regular public schools. Science education starts in the 3rd grade in primary school then continues until the 8th grade. In each grade level, all students should follow the same national curriculum. Prior to the most current one, the topics were organized using a spiral curriculum (Harden & Stamper, 1999), whereby each grade's coverage of the topics increases in complexity while reinforcing prior knowledge (Cansız & Cansız, 2019). In 2017, the science curriculum was updated, and the order of the topics was changed so that topics start from the universe towards the human body (MEB, 2017). Furthermore, in 2018, the science curriculum was updated again with slight changes such as more emphasis on science, engineering, and entrepreneurship applications (MEB, 2018). Since the 2000s, there have been multiple updates to the science curriculum, with the most recent updates occurring in 2018. A significant paradigm shift emerged in numerous fields, including science, in the year 2000 because of international reforms in science education in the world. Therefore, the national educational system has shifted from the traditional teacher-centered teaching and learning approach to a more contemporary student-centered teaching and learning approach. According to this new teaching and learning approach, constructing knowledge in science education based on experiences has been more underlined rather than passively obtaining the knowledge. With all changes in science education, the science education aims to prepare and equip students with discovering knowledge, forming and testing hypotheses, evaluating results, discussion results and making evidence-based decisions based on results (MEB, 2004, 2013, 2017, 2018). In 2013, the science curriculum underwent yet another revision to cover socio-scientific topics, such as controversial issues pertaining to society, science, and technology. Science, technology, engineering, and mathematics (STEM) are new trends that have emerged as a result of ongoing improvements in science education. For the first time, the current science curriculum places a strong emphasis on STEM education and entrepreneurship applications (MEB, 2017, 2018). Values are implicitly incorporated into the curriculum, and it emphasizes the importance of the teacher in education (MEB, 2017, 2018). Furthermore, In the 2024-2025 academic year, Türkiye launched the Türkiye century maarif model curriculum, promoting a comprehensive educational approach that prioritizes values, essential skills, and streamlined content. This new model is applied to pre-schools, 1st grade in primary school, 5th grade in middle school, preparatory classes, and 9th grade. Its goal is to ease students' workload by simplifying learning materials while incorporating digital literacy, hands-on skills, and critical thinking (Can, 2025).

Purpose of the Study and Research Questions

The purpose of the study is to investigate students' performance on scientific literacy aspects which are contexts, knowledge, and competencies in Türkiye in PISA 2018. Implications for science curriculum could be deduced by examining the students' performance in aspects of scientific literacy. Türkiye, China, and OECD countries were selected for comparison in this study for specific and purposeful reasons. Türkiye is the primary focus of the research, as the study aims to evaluate and draw implications for its science curriculum based on students' performance in PISA 2018. China was chosen because it consistently ranks among the top-performing countries in scientific literacy, offering a benchmark for high achievement. The OECD countries represent a broader international average, providing a meaningful context for comparing Türkiye's performance within a global framework. Together, these comparisons allow for a well-rounded analysis of Türkiye's standing and help identify areas for improvement in its science education framework. This study was guided by the following research questions:

1. What were the findings regarding students' scientific literacy in the PISA 2018 survey?
2. What insights do the PISA 2018 findings provide about the science curriculum in Türkiye?
3. How does the scientific literacy performance of students in Türkiye compare to students in China and OECD countries?

RESEARCH METHODOLOGY

This study attempts to discover what the results of the PISA 2018 assessment in Türkiye reveal about the science curriculum, particularly in relation to scientific literacy. Guided by three main research questions, the study first explores the overall findings of students' scientific literacy in the PISA 2018 survey. It then examines how these findings reflect on and inform the science curriculum in Türkiye. To provide deeper insights, the study focuses on three key aspects of scientific literacy as defined in PISA which are context, knowledge, and competencies. Additionally, by comparing Türkiye's performance with that of China and OECD countries, the study addresses how Türkiye's science education outcomes align with both top-performing and average international benchmarks. This comparative lens strengthens the implications drawn for improving science curriculum design and implementation in Türkiye.

Data Collection

This research employs secondary data from Türkiye of the PISA 2018 database (OECD, 2019a). The secondary data is from cognitive item data (OECD, 2019b) for students' scientific literacy performance. The secondary data were from 6890 15-year-old students from 186 schools in Türkiye who participated in PISA 2018 (MEB, 2019).

Instrument: Scientific Literacy Framework of PISA 2018

For the purpose of this study, three aspects of PISA 2018, which are scientific literacy as the contexts, the knowledge, and the competencies, are used (OECD, 2019c). Contexts Include personal, local/national, and global issues, both current and historical, necessitating a grasp of science and technology. Knowledge Comprehension of essential facts, concepts, and explanatory theories that underpin scientific understanding. This encompasses knowledge of the natural world and technological innovations (content knowledge), awareness of how ideas are generated (procedural knowledge), and insight into the fundamental principles supporting these processes and the reasoning behind their application (epistemic knowledge). Competencies proficiency in scientifically explaining phenomena, assessing and formulating scientific investigations, and interpreting data and evidence in a scientific manner. The elements of scientific literacy have also sub-dimensions for each aspect.

Aspect 1. Contexts: PISA 2018 assesses scientific knowledge through a variety of contexts relevant to both science education curricula and broader real-life situations, including personal, communal, and global issues (OECD, 2019a). These various levels of influence across personal, local/national, and global scales in key areas are as follows:

Table 1. Distribution of PISA 2018 science items by context, knowledge, competencies, question format, and content knowledge systems–Number and percentage (%)

Items		Number (N)	Percentage (%)
Context	Global	34	29.6
	Local/national	70	60.9
	Personal	11	9.6
	Health and disease	17	14.8
	Natural resources	32	27.8
	Environmental quality	24	20.9
	Hazards	12	10.4
	Frontiers of science & technology	30	26.1
Knowledge	Content	49	42.6
	Procedural	47	40.9
	Epistemic	19	165
Competencies	Explaining phenomena scientifically	49	42.6
	Evaluating and designing scientific inquiry	30	26.1
	Interpreting data and evidence scientifically	36	31.3
Question format	Simple multiple choice–Computer scored	33	28.7
	Complex multiple choice–Computer scored	47	40.9
	Open constructed response–Human coded	32	27.8
	Open constructed response–Computer scored	3	2.6
Content knowledge systems	Physical	38	33.0
	Living	47	40.9
	Earth & space	30	26.1

- **Health and disease:** Ranges from personal health maintenance to global epidemics.
- **Natural resources:** Includes personal consumption, local/national production, and global sustainability.
- **Environmental quality:** Encompasses personal actions, local/national waste management, and global ecological sustainability.
- **Hazards:** From lifestyle risk assessments to global issues like climate change.
- **Frontiers of science and technology:** Spanning personal interests to global advancements like space exploration and the study of the Universe.

Aspect 2. Knowledge: PISA 2018 evaluates scientific knowledge across three categories: Content knowledge in physics, chemistry, biology, and earth and space sciences; procedural knowledge related to conducting experiments and solving problems; and epistemic knowledge on thinking and acting like a scientist (OECD, 2019a). The following shows the categories and some examples of content knowledge, procedural knowledge, and epistemic knowledge.

- **Physical systems:** Covers matter structure, properties, chemical changes, motion, forces, energy, and their interactions.
- **Living systems:** Encompasses cells, organisms, human systems, populations, ecosystems, and the biosphere.
- **Earth and space systems**: Includes earth's structures, energy, changes, history, space relations, and Universe concepts.
- **Procedural knowledge:** Focuses on variables, measurement concepts, uncertainty assessment, data representation, experimental design, and scientific questioning.
- **Epistemic knowledge:** Explores scientific constructs, reasoning, empirical inquiry forms, model usage, collaboration, peer review importance, and the societal impact of scientific knowledge.

Aspect 3. Competencies: Scientific competency involves conducting research, critically analyzing results, explaining phenomena, evaluating and designing inquiries, and interpreting data scientifically (OECD, 2019a). These are the key aspects of scientific inquiry:

- **Explaining phenomena scientifically:** Involves applying scientific knowledge, using models, making predictions, proposing hypotheses, and considering societal implications.
- **Evaluating and designing scientific inquiry:** Includes identifying research questions, proposing investigational approaches, assessing scientific methods, and ensuring data reliability and objectivity.
- **Interpreting data and evidence scientifically:** Encompasses data analysis, interpretation, transforming data representations, recognizing scientific arguments, evaluating evidence quality, and distinguishing between scientific and non-scientific reasoning sources.

In PISA 2018, interactive tasks are included among 24 items in five units (e.g., a student makes decisions when changing variables in a simulated scientific inquiry). Such responses are typically scored as complex multiple-choice items, or, if sufficiently open-ended, as constructed responses. **Table 1** demonstrates the distribution of the 115 science items with dimensions of the framework. 42.6% of the items in the science competency dimension are classified as explain phenomena scientifically, 26.1% are classified as evaluate and design scientific inquiry, and 31.3% are described as interpret evidence and data scientifically. For scientific knowledge type, the same 115 items are classified as content (42.6%), procedural (40.9%), and epistemic (16.5%). With

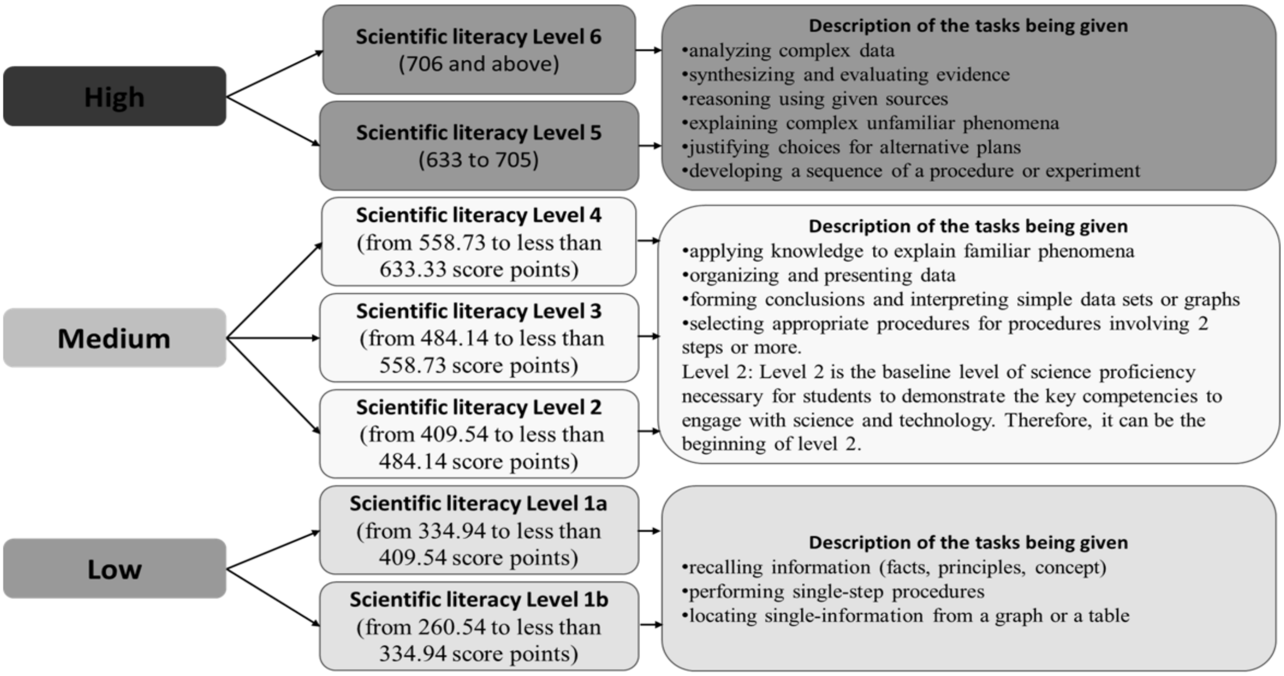

Figure 1. Categorizing levels in high, medium, and low levels in scientific literacy proficiency in science in PISA 2018 (Adapted from OECD, 2016, p. 60)

Table 2. Mean country scores, standard deviations and standard errors for the overall science scale for Türkiye, OECD countries, and China (OECD, 2019a)

Country	Mean	Standard error	Standard deviation	Standard error
Türkiye	468.0	2.0	83.5	1.6
OECD	*__489.0__	0.4	96.0	0.2
China	*__590.5__	2.7	83.2	1.7

Note. *Significant differences in **bold**

regard to classification of content knowledge systems, 33% are in the physical systems domain, 40.9% in living systems, and 26.1% are in earth and space systems. The science items are also classified by context dimensions which 29.6% are in a global context, 60.9% are in a local/national context, and 9.6% are in a personal context. As seen in **Table 1**, 28.7% of items are considered as simple multiple choice, 40.9% as complex multiple choice, 27.8% as open-constructed response (human coded), and 2.6% as open-constructed response (computer coded).

Data Analysis

Our analysis involves secondary data analysis using data collected in PISA 2018. Secondary data analysis is the process of examining previously collected data for new purposes (Khine et al., 2022). Analyzing secondary data can form new hypotheses or answer research questions. Using secondary data is advantageous because it provides a higher quality sample set and the data has significantly wider access which is made available through databases such as PISA and TIMSS databases. Moreover, secondary data analysis has the ethical advantage of not having to gather data from specific individuals, and saves a lot of time, money, response burden on participants, and other resources. Furthermore, data from large samples can be higher quality as it is more representative of the population (Tripathy, 2013).

The framework in **Figure 1** is used to find out the level of scientific literacy of students in PISA 2018. It has a total of 7 levels, where level 6 indicates the highest level of scientific literacy proficiency and level 1a and level 1b are representative of low levels of scientific literacy. The 7 levels can be divided into high, medium, and low-level proficiency as follows:

Table 2 provides the percentages of students in Türkiye, and on average across OECD and China performing at each scientific literacy proficiency level. China (scored 590 in science) was chosen because China had the first place in PISA 2018. We used t-test for two independent means to compare the means of Türkiye, OECD countries average, and China to find out how Türkiye performed in PISA 2018. Also, z-cores were used to find whether there is a statistically significant difference between these countries in terms of scientific literacy levels.

RESEARCH RESULTS

This study aims to shed light on the scientific literacy of the Turkish science curriculum based on the PISA 2018 results. According to PISA 2018, the research investigates three facets of scientific literacy: Context, knowledge, and competence. For this reason, scientific literacy levels are formed in seven levels starting from low level to high level. The percentages of students who

Table 3. Percentages of students below level 2, level 2, 3, 4, and levels 5 & 6 on the overall scientific literacy scale, Türkiye, OECD, and China

Country	Below level 2		Level 2		Level 3		Level 4		Levels 5 & 6	
	%	SE	%	SE	%	SE	%	SE	%	SE
Türkiye	25.1	1.1	32.8	1.0	27.3	1.0	12.3	0.7	2.5	0.5
OECD	21.9	0.2	25.8	0.1	27.4	0.1	18.1	0.1	6.8	0.1
China	11.5	0.3	21.7	0.6	33.8	0.9	25.0	0.9	31.5	1.3
Difference										
Türkiye-OECD	**3.2**	1.1	**7.0**	1.0	-0.8	1.0	**-5.8**	0.7	**-4.3**	0.5
Türkiye-China	**13.6**	1.1	**11.1**	1.2	**-6.5**	1.4	**-12.7**	1.1	**-29.0**	1.4

Note. SE: Standard error & *Significant differences in **bold**

performed below level 2, level 2, 3, 4, and levels 5 & 6 on the overall scientific literacy scale are investigated for Türkiye. Then, the results are compared with China which performed at the first place in PISA and OECD countries average to find out how Türkiye performed in science in PISA 2018.

As seen in **Table 2**, the mean score of China (590.5) is significantly higher than the mean score of Türkiye (468). Moreover, the mean score of OECD countries average (489) is significantly higher than the mean score of Türkiye (468). Türkiye's standard deviation on science – a measure of the spread of scores–was 83.5 score as seen in **Table 2**. This is lower than the OECD average standard deviation of 96, indicating a wider range of achievement across OECD countries than in Türkiye. China with the highest mean score had standard deviation that was almost the same as Türkiye. Also, it indicates a wider range of achievement in China than in Türkiye.

In PISA, students performing at level 1a, level 1b and below level 1b are often referred to as lower-achieving students or low performers. The prerequisites for achieving the minimum level of science competency are described in proficiency level 1a and level 1b. Students at level 1b, the lowest scientific literacy proficiency level, score from 260.54 to less than 334.94 score points. These students can demonstrate necessary skills to answer correctly only the most basic science questions. PISA does not specify the competencies of participants whose results are below level 1b (below 260.54). Students at level 1a, who receive scores between 334.94 and 409.54 score points, are able to recognize or pinpoint explanations for basic scientific phenomena using basic or everyday content and procedural knowledge. Additionally, they are able to recognize straightforward causal or correlational links and analyze graphic data. In Türkiye, 25.1% of students perform below level 2, with the majority of these (20.1%) performing at level 1a. The rest of most of the others (4.7%) perform at level 1b. On average across OECD countries, 21.9% of students perform below level 2. Moreover, 2.1% of students in China perform below level 2. The percentage of students below level 2 in Türkiye is significantly higher than the percentages in OECD countries and also significantly much higher than the percentages in China as seen in **Table 3**.

Students at scientific literacy proficiency level 2 are those who score from 409.54 to less than 484.14 score points on PISA science. At level 2, students are starting to demonstrate the essential skills necessary to participate successfully and productively in everyday activities connected to science and technology as well as in future education in these disciplines (OECD, 2019a). Therefore, level 2 is regarded as the minimum level of science competence required for students to interact critically with challenges in science and technology. 32.8% of students in Türkiye perform at level 2. On average across OECD countries, 25.8% of students perform at level 2. In addition, 8.4% of students in China perform at level 2. The difference between Türkiye and OECD average is significant. In other words, the percentage of students at level 2 in Türkiye is significantly higher than the percentages in OECD countries and also significantly much higher than the percentages in China as seen in **Table 3**.

Students performing at level 3 are referred to as medium level achievers. Students at level 3, the medium scientific literacy proficiency level, score from 484.14 to less than 558.73 points. Students at level 3 can demonstrate moderately complex content knowledge to construct explanations with support. They are not proficient in working on complex phenomena. In Türkiye, 27.3% of students perform at level 3. On average across OECD countries, 27.4% of students perform at level 3. In addition, 33.8% of students in China perform at level 3. The difference between Türkiye and OECD average is not significant. In other words, the percentage of students at level 3 in Türkiye is not significantly higher than the percentages in OECD countries. There is a significant difference between Türkiye and China. The percentage of students at level 3 is significantly higher than in Türkiye as seen in **Table 3**.

Students performing at level 4 are considered as medium level achievers. Students at level 4, the medium scientific literacy proficiency level, score from 484.14 to less than 558.73 points. They are at the upper level of the middle level. Students can apply knowledge to explain familiar phenomena. In Türkiye, 12.3% of students perform at level 4. On average across OECD countries, 18.1% of students perform at level 4, and 25% of students in China attain a level 4 performance. The difference between Türkiye and OECD average is statistically significant. Also, there is a significant difference between Türkiye and China. The percentage of students at level 4 in China is significantly higher than in Türkiye as seen in **Table 3**.

The highest proficiency level is level 6 (708 points and above) and students at this level demonstrate the competencies necessary to answer the most complex science items. Those at level 5 (from 633 score points up to 708) can use abstract scientific ideas or concepts to explain unfamiliar and more complex phenomena, events and processes involving multiple causal links. The term 'high achievers' is often used to describe the combined percentages of students at levels 5 & 6. **Table 3** also demonstrates that, in Türkiye, 2.5% of students perform at levels 5 & 6. On average across OECD countries, 6.8% perform at this level. The difference is statistically significant. Students performing in levels 5 & 6 in OECD countries have higher percentages than in Türkiye. In addition, 31.5% of students in China achieve levels 5 & 6 proficiency. There is a statistically significant difference between

Table 4. Summary description of the seven levels of scientific literacy proficiency in science in PISA 2018, and percentages of students achieving each level in Türkiye, on average OECD, and China (OECD, 2019a)

Level (cut-point)	Characteristics of tasks	Türkiye		OECD		China	
		%	SE	%	SE	%	SE
Level 6 (above 707.93 points)	Level 6 students skillfully integrate interdisciplinary scientific concepts to hypothesize, predict, and interpret data, distinguish relevant from irrelevant information, and evaluate and justify complex experimental designs.	0.1	(0.1)	0.8	(0.0)	7.2	(0.7)
Level 5 (from 633.33 to less than 707.93 points)	Level 5 students exhibit advanced scientific proficiency by using abstract concepts to explain complex phenomena, critically assessing experimental designs, and evaluating data limitations and uncertainties with sophisticated epistemic skills.	2.3	(0.4)	5.9	(0.1)	24.3	(1.1)
Level 4 (from 558.73 to less than 633.33 points)	Level 4 students demonstrate proficiency by using intricate content knowledge to explain unfamiliar events, conduct experiments with multiple variables, interpret complex data, and justify their conclusions with detailed reasoning.	12.3	(0.7)	18.1	(0.1)	25.0	(0.9)
Level 3 (from 484.14 to less than 558.73 points)	Level 3 students demonstrate proficiency by using moderately complex content knowledge to explain familiar phenomena, conduct basic experiments, and distinguish between scientific and non-scientific matters with evidence-based reasoning.	27.3	(1.0)	27.4	(0.1)	33.8	(0.9)
Level 2 (from 409.54 to less than 484.14 points)	Level 2 students use everyday content and basic procedural knowledge to identify scientific explanations, interpret simple data, and recognize investigable questions, applying fundamental scientific understanding to draw valid conclusions.	32.8	(1.0)	25.8	(0.1)	21.7	(0.8)
Level 1a (from 334.94 to less than 409.54 points)	Level 1a students use basic knowledge to identify simple scientific explanations, conduct straightforward investigations with guidance, interpret visual data, and select suitable explanations within familiar contexts.	20.1	(0.8)	16.0	(0.1)	8.9	(0.6)
Level 1b (from 260.54 to less than 334.94 points)	Students at level 1b use elementary scientific understanding to identify components of simple phenomena, recognize basic data patterns, understand fundamental terminology, and follow clear instructions to perform scientific procedures.	4.7	(0.4)	5.2	(0.1)	2.4	(0.3)
Below 1b (below 260.54 points)	No definition of the competencies and skills of those scoring below level 1b.	0.3	(0.1)	0.7	(0.0)	0.2	(0.1)

students' performance in Türkiye and China. As seen in **Table 3**, China has a significantly higher percentage of levels 5 &6 students than Türkiye.

The percentage of students in Türkiye performing below level 2, at level 2, level 3, level 4, and level 5 and above compared to OECD countries and China (**Table 4**). There are more students below level 2 in Türkiye (25.1%) with mean scores that are significantly higher than OECD (21.9%) and China (11.5%). In level 2, again there are more students in level 2 in Türkiye when compared to OECD average, and China. Türkiye has a significantly higher percentage (32.8%) than OECD average (25.8%), and China (21.7%). In level 3, China has the highest number of students with a percentage of 33.8%. There is a significant difference between Türkiye (27.3%) and China (33.8%). Türkiye and OECD countries (27.4%) perform similarly in level 3. So, there is no significant difference between Türkiye and OECD countries. In level 4, 25% of students performed well in China. OECD countries with 18.1% follow China. Türkiye has the low percentage, only 12.3% of students performed well. Thus, there is a significant difference between Türkiye and OECD. Regarding the difference between Türkiye and China, it is much more than OECD. In level 5 and above, 31.5% of students performed well in China which is much more than OECD and Türkiye. The difference between Türkiye and China is huge and significant. The difference between Türkiye and OECD is also statistically significant.

DISCUSSION

This study aims to uncover what the PISA 2018 results reveal about the effectiveness of Türkiye's science curriculum, with a particular focus on scientific literacy. Framed around three central research questions, the research begins by analyzing the overall performance of Turkish students in the PISA 2018 assessment. It then considers how these outcomes reflect the strengths and weaknesses of the national science curriculum. To gain more comprehensive insights, the study examines three fundamental dimensions of scientific literacy as outlined in the PISA framework which are context, knowledge, and competencies. Furthermore, by comparing Türkiye's performance with that of China and the OECD average, the study evaluates how the country's science education aligns with both leading and average international standards. This comparative approach offers valuable implications for enhancing the structure and delivery of science education in Türkiye. The findings from PISA 2018 reveal critical insights into the Turkish science curriculum's effectiveness, particularly in cultivating well-rounded scientific literacy. Turkish students demonstrated relative proficiency in content knowledge but struggled in areas related to scientific competencies and procedural or epistemic understanding. These findings suggest that while factual knowledge is sufficiently addressed, students are underprepared in applying scientific concepts to real-world contexts or engaging in scientific inquiry and reasoning at deeper levels (Cansız & Cansız, 2019; OECD, 2019a).

This imbalance becomes even more evident when comparing Türkiye's performance with that of China and the OECD average. The significantly lower proportion of Turkish students achieving at higher proficiency levels (levels 5 & 6) indicates a gap in developing advanced cognitive and inquiry-based competencies. The overrepresentation of students in level 2 considered the minimum threshold for scientific engagement suggests that the curriculum may prioritize coverage over conceptual depth and application.

The introduction of the Türkiye century maarif model (Can, 2025) presents a timely opportunity to address these curricular gaps. This model emphasizes value-based learning, digital literacy, simplified content, and critical thinking, aligning well with international frameworks for scientific literacy that prioritize practical application and reasoning over rote memorization. By emphasizing competencies such as problem-solving and digital fluency, this new curriculum can help reposition science education in Türkiye to be more in tune with global trends and societal needs.

However, for the new model to have meaningful impact, specific implementation strategies must be adopted. For example, science teachers should receive professional development on integrating procedural and epistemic knowledge into everyday instruction. Curricular materials should also be revised to emphasize local and global real-life contexts–climate change, health, and sustainability which are central to the PISA framework (Kollas & Halkia, 2020; OECD, 2019a; Tal & Dierking, 2014).

CONCLUSIONS AND RECOMMENDATIONS

This study sought to evaluate the Turkish science curriculum through the lens of PISA 2018 results, particularly focusing on scientific literacy's three core dimensions: Context, knowledge, and competency. It was found that while Turkish students have a foundational understanding of scientific content, they lack the depth and critical reasoning skills necessary for higher-order scientific literacy. Comparisons with China and OECD countries further underscore the urgent need for curriculum reform that goes beyond knowledge acquisition and fosters inquiry, analysis, and application.

The findings align with prior critiques of the Turkish science curriculum, which emphasize a narrow focus on content to the exclusion of reasoning and investigation (Effendi et al., 2021; Irez, 2009). These issues have contributed to the disproportionately low number of Turkish students reaching high proficiency levels in science, a trend that undermines national education goals and the vision for a science-literate population (Planipolis, n. d.).

To enhance scientific literacy in alignment with international benchmarks, it is essential that the Turkish science curriculum be revised to place equal emphasis on all three dimensions of scientific literacy: Content, procedural, and epistemic knowledge. The current curriculum places a strong focus on content knowledge, often at the expense of developing students' abilities to reason scientifically, evaluate evidence, and engage in inquiry-based learning. Addressing this imbalance will require restructuring learning outcomes and classroom practices to cultivate higher-order thinking skills that are essential for success in a science-driven global society.

The introduction of the Türkiye century maarif model offers a strategic opportunity to embed scientific literacy more deeply within the curriculum. This model promotes a holistic educational approach centered on values, digital competence, critical thinking, and simplified content delivery. By integrating scientific inquiry, real-world problem-solving, and interdisciplinary thinking into this new model, students can be better prepared to meet the challenges highlighted in the PISA framework. Special emphasis should be placed on enabling students to apply scientific knowledge in everyday life and global contexts, in line with PISA's emphasis on relevance and application (Kostøl & Remmen, 2022).

Furthermore, teacher professional development must be prioritized to ensure successful implementation of the reformed curriculum. Teachers need sustained training in how to teach procedural and epistemic components of science effectively, as well as support in applying context-based and inquiry-oriented instructional strategies (DeWitt & Storksdieck, 2008; Fensham, 2009). Without building teacher capacity, curriculum changes alone will not yield the desired improvements in student outcomes (L'Heureux et al., 2021; Lupión-Cobos et al., 2017). Teachers must also be equipped to make use of modern technologies and digital tools to enhance science teaching and foster 21st century competencies.

In addition, national assessment systems should be realigned to reflect the competencies measured by PISA. Evaluation tools must go beyond factual recall and assess students' ability to reason scientifically, analyze data, and design investigations. This alignment will create coherence between teaching goals, learning activities, and assessment, making it easier to monitor progress and drive improvement.

Lastly, the implementation of the new curriculum and its outcomes should be systematically monitored and evaluated. Ongoing research and feedback loops involving teachers, school leaders, and policymakers are necessary to ensure the curriculum remains responsive to both national goals and global standards. Regular data collection and analysis will allow for timely adjustments and sustained improvement in students' scientific literacy across all grade levels.

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