Evaluation of TIMSS 2019 and PISA 2018 Science Findings in Turkey Perspective

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Introduction

In the 21st century, we are in a period where new reforms are introduced in schools and education to meet the social and economic needs of students and society. Organization for Economic Co-operation and Development (OECD) (2018) expresses this new understanding as creating a "new normal" in education in its "Future of Education and Skills 2030" report. In the same report, it is emphasized that an innovation made in the past is now commonplace, and an innovation made in the present will be normalized in the future (p,14). The 21st century differs greatly from the 20th century in terms of the skills people need for work, citizenship, and self-actualization. For example, computers and telecommunication constantly improve the capability to perform human tasks and constantly change the job types available to humans. Looking from the OECD point of view, "How can we prepare students for jobs that have not yet been created, to tackle social challenges that we cannot yet imagine, and to use technologies that have not yet been invented?" (OECD, 2019a, p.5). And "Students need support in developing not only knowledge and skills but also attitude and values, which can guide them towards taking ethical and responsible actions. This draws attention to the active role of a science literate society in shaping the future. In the 21st century, science literacy has become the basic step of the science education paradigm and the prerequisite of science curricula. One of the most important driving forces in revealing these inferences is the international education indicators that provide a data-based evaluation of the education systems and outcomes of the nations. Determining the performance of the students and the related variables have an important place in educational research (Yildirim & Aybek, 2019). It can be said that the most important studies to shed light on the science education of countries in the international context are the Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). In this article, findings related to science achievement in Turkey testament will be evaluated in light of PISA and TIMSS and interpreted within science education policies.

What Do PISA "Science" Findings Say for Turkey?

PISA, which is held every three years since 2000, and which is necessary for 15-year-old students to take an active role in society, is international educational research that evaluates students' reading comprehension and competence in, Science, Mathematics, and different innovative fields. PISA stands out as an international indicator of education by ensuring the participation of countries that make up approximately 90% of the world economy. The OECD defines the PISA survey not only as a comprehensive and reliable indicator of students' abilities but also as a powerful tool that countries can use to adjust their education policies (OECD, 2019b). Within this framework, OECD bears evidence of being the best policy and practice to help countries provide the best possible education to all their students. 2018 findings in Turkey regarding science, which is a dimension of the PISA research, show that students have a score below the OECD average. While Turkey is ranked 39th among 79 countries taking part in the research, it ranks 30th among 37 OECD member countries in science achievement. The science performance trend of Turkey in the PISA research between the years 2006-2018 is shown in Figure 1.

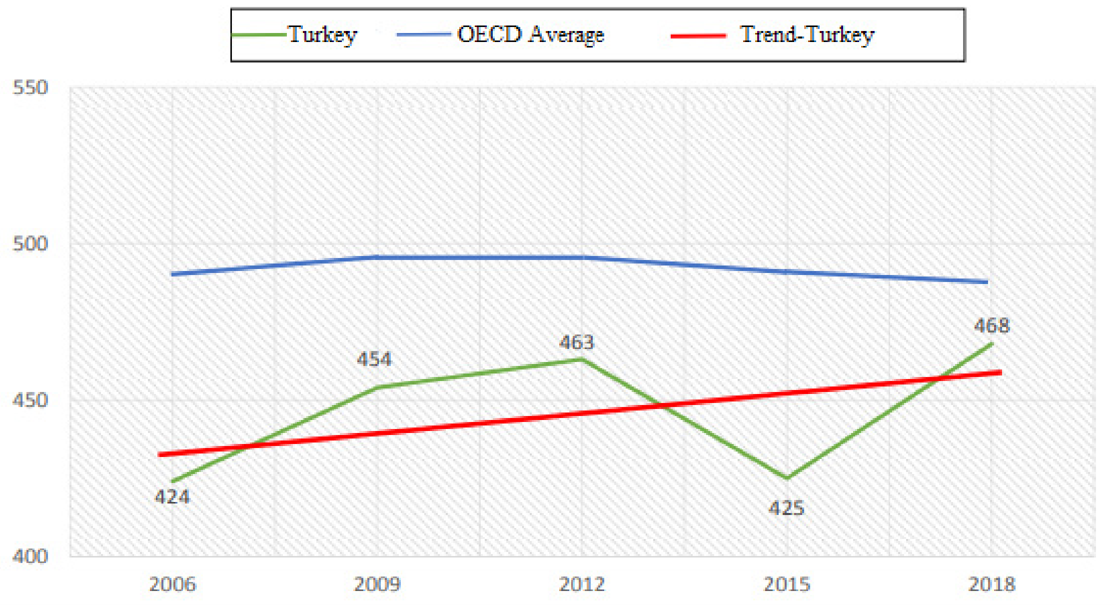

Figure 1. Science Performance Trend between 2006-2018 (Turkey)

When science scores since 2006 are examined, it can be said that Turkey achieved an increasing trend until 2015 but experienced a serious crash in 2015. 2018 findings show that we have reached a score band close to the 2012 science scores. According to the PISA report, PISA 2015 results–which were considerably lower–are "abnormal, and neither the decline between 2012 and 2015, nor the recovery between 2015 and 2018, reflect the long-term trajectory" (OECD, 2019c, p.3). In summary, Turkey's tendency to fluctuate over the years reveal a limitation to make clear predictions for the future. However, 2018 findings show that there is a decrease in the rate of students who fall below the basic proficiency level in science compared to previous years, and that there is an increasing trend in the rate of high-performing students. As a matter of fact, OECD (2019c, p.4) states that Turkey's tendency for science (2006-18) is positive. From the Science Education perspective, OECD emphasizes students' ability to think scientifically and to be a "reflective" individual, referring to their ability to comprehend science-related issues (OECD, 2019b, p.27). The concept of being a "reflective" individual here refers to a scientifically literate individual. In this context, PISA focuses on students' competency in scientific literacy. Scientific literacy means knowledge and understanding of scientific concepts and processes necessary for personal decision making, participation in civic and cultural affairs, and economic productivity (Turiman et al., 2012). NCREL (2003) reinforces scientific literacy by the question; “Do students have the knowledge and understanding of scientific concepts and processes required for personal decision making and participation in social systems?”. As for PISA, beyond knowing science concepts, science literacy focuses on the extent to which students can creatively use this conceptual knowledge in different contexts they encounter (daily life situations, past and present situations, and problems) and in real life (OECD, 2019b). In short, the focus is on what the student knows and can do. In line with this focus, the questions consist of seven proficiency levels. According to OECD data, the ratio of 2018 science scores in Turkey based on proficiency levels are presented in Figure 2.

*Adapted from OECD (2019b) Turkey data.

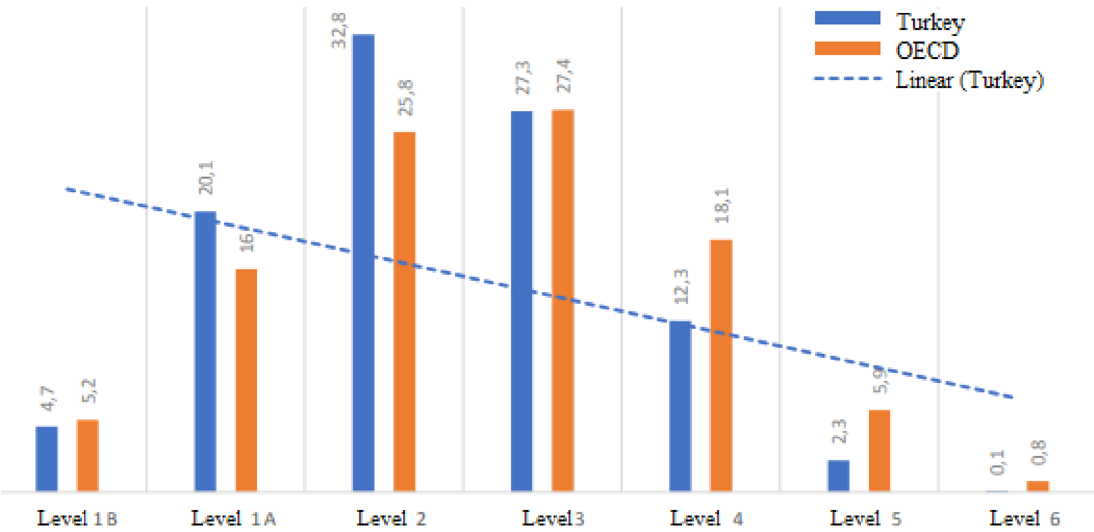

Figure 2. Ratios of 2018 PISA Research Science Scores by Proficiency Levels (%)

Each level stated in Figure 2 aims to determine what the scores of the students mean and to interpret them meaningfully. Each proficiency level defines the types of knowledge and skills required to successfully complete the tasks it contains. The closer you get to Level 6, the harder the skills required to successfully complete each level. Each proficiency level corresponds to a range of 80 points. Therefore, a difference of 80 points can be interpreted as the difference between consecutive proficiency levels. In the PISA 2019 report, it is stated that there is an average of 40 points difference between each grade level between countries. OECD emphasizes that this point value can be expressed as “learning in one school year” in making a meaningful and practical contribution to interpretation, but it is necessary to consider the limitations created by the many variables that affect the performance of countries (OECD, 2019b). In this direction, seven proficiency levels in the context of science literacy and the characteristic features of the levels are presented in Table 1.

Table1. Summary Description of the Seven Levels of Science Proficiency in PISA 2018

Level	Characteristics of tasks
6	At Level 6, students able to draw on a range of interrelated scientific ideas and concepts from the physical, life, earth and space sciences and use content, procedural and epistemic knowledge to offer explanatory hypotheses of novel scientific phenomena, events, and processes or to make predictions. In interpreting data and evidence, they can discriminate between relevant and irrelevant information and can draw on knowledge external to the normal school curriculum. They able to distinguish between arguments that are based on scientific evidence and theory and those based on other considerations. Level 6 students able to evaluate competing designs of complex experiments, field studies or simulations and justify their choices.
5	At Level 5, students able to use abstract scientific ideas or concepts to explain unfamiliar and more complex phenomena, events and processes involving multiple causal links. They can apply more sophisticated epistemic knowledge to evaluate alternative experimental designs, justify their choices and use theoretical knowledge to interpret information or make predictions. Level 5 students able to evaluate ways of exploring a given question scientifically and identify limitations in interpretations of data sets, including sources and the effects of uncertainty in scientific data.
4	At Level 4, students able to use more complex or more abstract content knowledge, which is either provided or recalled, to construct explanations of more complex or less familiar events and processes. They can conduct experiments involving two or more independent variables in a constrained context. They can justify an experimental design by drawing on elements of procedural and epistemic knowledge. Level 4 students can interpret data drawn from a moderately complex data set or less familiar context, draw appropriate conclusions that go beyond the data and provide justifications for their choices.
3	At Level 3, students able to draw upon moderately complex content knowledge to identify or construct explanations of familiar phenomena. In less familiar or more complex situations, they can construct explanations with relevant cueing or support. They can draw on elements of procedural or epistemic knowledge to carry out a simple experiment in a constrained context. Level 3 students can distinguish between scientific and non-scientific issues and identify the evidence supporting a scientific claim.

2	At Level 2, students able to draw on everyday content knowledge and basic procedural knowledge to identify an appropriate scientific explanation, interpret data and identify the question being addressed in a simple experimental design. They can use basic or everyday scientific knowledge to identify a valid conclusion from a simple data set. Level 2 students demonstrate basic epistemic knowledge by being able to identify questions that can be investigated scientifically.
1a	At Level 1a, students able to use basic or everyday content and procedural knowledge to recognize or identify explanations of simple scientific phenomena. With support, they can undertake structured scientific enquiries with no more than two variables. They can identify simple causal or correlational relationships and interpret graphical and visual data that require a low level of cognitive demand. Level 1a students can select the best scientific explanation for given data in familiar personal, local and global contexts.
1b	At Level 1b, students able to use basic or everyday scientific knowledge to recognize aspects of familiar or simple phenomena. They can identify simple patterns in data, recognize basic scientific terms and follow explicit instructions to carry out a scientific procedure.

*(OECD, 2019b, p.113)

According to OECD, when we look at the levels of proficiency in science literacy, Level 2 is the basic proficiency level and represents the level of achievement in PISA. Level 2 can be regarded as the science proficiency level at which students demonstrate competencies that will enable them to interact effectively and efficiently with science and technology-related subjects. "Level 2, however, does not define an adequate level of science literacy and sets a key threshold at which students typically need some support to engage with science-related questions, even in familiar contexts" (OECD, 2019b, p.114). From this point of view, considering that the PISA results are evaluated within the framework of science literacy, it is necessary to discuss our position according to the proficiency levels in PISA rather than how many points have been increased compared to 2015.

High-level competencies in the context of science literacy, on the other hand, indicate the ability of students to use their science knowledge creatively and autonomously by employing scientific process skills in a wide variety of contexts (what they know or do not know). OECD defines students who perform below PISA level 2 as "low achievers". The rate of students performing below level 2 in Turkey is 25.1%. The rate of students with a high level of performance (Level 5-6) is 2.4%. This ratio can be described as a small ratio when compared to the countries that are in the top rankings in PISA. However, it is noteworthy that there is an increasing trend compared to previous years.

When Figure 2 is examined, it is important to note that there has been a significant decrease in the performance rates of Turkish students, especially from Level 4, compared to the OECD average. From this point of view, it can be said that students in Turkey did not have sufficient success in science literacy in the below proficiencies:

• Using more complex context information to structure descriptions of less familiar events or processes.

• Designing experiments involving two or more independent variables in a limited context and proving an experimental design.

• Interpreting the data obtained from a data set, obtaining appropriate results based on justifications.

• Ability to use abstract scientific ideas or concepts to explain unknown and complex events, situations, and processes.

• Applying epistemic knowledge to evaluate alternative experimental designs, make predictions, verify their decisions, and interpret information.

• Being able to evaluate ways to explore a problem scientifically and identify limitations in interpreting datasets, including uncertain influences and sources in scientific data.

• Ability to use epistemic knowledge to present hypotheses of scientific phenomena, events and processes that require multiple steps or require predictions,

• To distinguish between relevant and irrelevant information and to use information outside the school curriculum when interpreting data and evidence.

• To distinguish between arguments based on scientific evidence and theory and arguments based on other considerations,

• To evaluate complex experiments, field studies or simulations and justify their selection.

The rate of students who do not have the skills listed above is 85.3%.

These findings are compatible with the national data of Turkey. The Evaluation and Examination of Academic Skills (ABIDE), conducted by MoNE (2019a, 2019b) and sampled from 4th and 8th grade students in Turkey, is a comprehensive national research. When the ABIDE 4th grade level is examined, it can be seen that the rate of students performing at the Advanced proficiency level is as low as 3.2%. When the scope of the questions at the advanced proficiency level is examined (MoNE, 2019a, p. 100), it can be said that the proficiency of the 4th grade students in Turkey is low in establishing relationships between scientific concepts, analyzing alternative explanations or predictions, designing controlled experiments that can explain science-related phenomena and events as well as explaining the reason, using science knowledge and skills to produce solutions to the problems they encounter, collecting data about the problems they encounter in daily life - presenting appropriate suggestions to solve the problem, adapting the scientific concept to other situations in daily life. In the 8th grade level of the same research, it is seen that the rate of students with advanced proficiency (the level that points to higher-order thinking processes in science) is 2.5%, which is significantly low. It is also noteworthy that the rate of students reaching advanced proficiency level has decreased when compared to 2016 (MoNE, 2019b, pp.111-112). This national finding is also in line with the PISA 2018 findings.

Although the sample of the PISA research comprises of 15-year-old students, approaching the subject only from the perspective of secondary education will lead to misconceptions in interpreting the findings obtained from the research of science education in Turkey. As a matter of fact, the acquisition of competencies in the context of science literacy are based on primary education and even pre-school period. At this point, it is necessary to interpret the trend that Turkey has revealed in science over the years with the PISA research, according to the MoNE Science Curriculum (2018) and the practices in this direction. The 2013 Science Curriculum in Turkey was based on the research-inquiry approach. With the curriculum revised in 2017, an understanding of developing field-specific skills is observed in terms of scientific process, life and engineering-design skills. From this point of view, that Turkish students could not reach the desired proficiency in PISA science literacy skills may be because the basic dynamics of the curriculum could not be reflected in the application processes in the field. This finding also points out that there is a need to reconsider all aspects of curriculum implementation.

When the PISA research findings are analyzed in terms of the gender factor, among OECD countries, girls performed slightly better than boys with 2 points in science, while in Turkey girls outperformed boys with 7 points in science. Among high-performing students in mathematics or science, one in three children in Turkey expects to work as an engineer or in a science-related profession, compared to about one in five girls. This finding shows that female students with high science achievement are less interested in choosing professions in engineering or science-related fields. However, the findings also reveal that approximately one in two high-performing girls expects to work in health professions, and approximately one in four high-performing boys wants to choose health-related occupations. 2% of boys and a negligible percentage of girls in Turkey expect to work in ICT-related occupations (OECD, 2019a). Institutions operating in educational sciences argue that specialization in STEM professions and interest in these professions should begin in secondary school (Kier et al., 2013). Research in this field reveals the importance of the 10-14 age range in shaping the career choices of children regarding STEM in the following years (Dejarnette, 2012, DeBacker & Nelson, 1999;Murphy & Beggs 2005). When primary school science education policies in Turkey are examined, it is important to note that STEM applications and field-specific skills were included in the curriculum updated in 2018. When the national studies examining the interest in STEM professions in the secondary school period are examined, it is observed that male students show more interest in STEM professions (Koyunlu-Ünlü & Dokme, 2018; Uğras, 2019).

In this context, socio-economic status is expressed by the OECD as a powerful indicator of performance in mathematics and science in all countries taking part in PISA (OECD, 2019d). So much so that 11% of the change in science performance in Turkey in PISA 2018 (with the OECD average of 13%) is explained by the socio-economic status difference (OECD, 2019c). This finding points to the school ecosystem that will minimize the disadvantages of students arising from their socio-economic status. The relationship between success differences between schools and socioeconomic characteristics and student achievement has been taking place in education debates in Turkey for many years. In the studies on the subject, it is seen that the relationship between socioeconomic characteristics and academic achievement is moderately intensified, and the socioeconomic factor is stronger than other variables whose relations with academic achievement are examined (Suna & Özer, 2021). Regarding this issue, OECD Secretary General Angel Gurria stated that; " While students from well-off families will often find a path to success in life, those from disadvantaged families have only one single chance in life, and that is a great teacher and a good school. If they miss that boat, subsequent education opportunities will tend to reinforce, rather than mitigate, initial differences in learning outcomes" (OECD, 2019d, p.4).

Geographical region differences are another powerful factor affecting success in PISA. According to geographical regions in Turkey, the highest average score in science in PISA 2018 is in Western Anatolia with 489 points, which is equivalent to the OECD science average. The lowest average score is in Middle East Anatolia with 423.5 points (OECD, 2019c). These findings show that the score difference (65.5) arising from the differences between geographical regions in science in Turkey is significantly high (considering that a difference of 40 points corresponds to one year of learning).

Implications and Recommendations for Turkey in the Context of PISA

Based on all these, some suggestions are given below for policy makers, educators, teachers, and school administrators in Science Education. In a general framework, PISA 2018 ranked the top 10 in science, China, Singapore, Macau, Estonia, Japan, Finland, South Korea, Canada, Hong Kong, and Taiwan. It is thought that examining the basic dynamics of these countries in raising science literate individuals and making inferences in our Science Education will strengthen the current policies. As a matter of fact, the PISA research reveals findings toward providing feedback by drawing attention to the aspects of education and training practices that need improvement. Science, Physics, Chemistry and Biology Curriculums in Turkey are being renewed and developed within the framework of today's science education approach. However, PISA findings show that very few of the students can show high-level competencies in science. When the studies that attach importance to 21st century skills for the future of societies are examined, it is seen that there is a great emphasis on cognitive skills, which we can call high-level thinking skills, as well as social skills that include global communication and cooperation (EURYDICE, 2020; NcREL, 2003; OECD, 2018; World Economic Forum [WEF], 2020). However, PISA findings show that very few of the students can show a high level of performance in science. From this point of view, science education in Turkey should be reconsidered based on the questions given below.

- How many does it serve a process (curriculum, teacher, and school dimensions) where the student can transform the knowledge they have into a skill in real life?
- Can they make science knowledge a necessity?
- Does it provide a need to know and learn?
- Functional, versatile, and flexible in developing scientific process skills, higher-order thinking skills, engineering, and design skills?
- Can he/she handle regional differences flexibly at the level of contexts (real-life situations and problems)?
- Is it far from a conceptual understanding isolated from the real lives of students?
- Does it have a structure that includes every student in the scientific research process, experiment and observation, and technical-technological environments inside and outside the school?

PISA research focuses on what students can do with their knowledge and to measure their skills in the most appropriate way in science. The Science course can be described as a real-life workshop, based on experimentation and observation, in which research-inquiry, scientific thinking and design skills are employed. So much so that students are always intertwined with scientific concepts in their daily lives. We can talk about in-depth learning and high-level skills if the student can use the scientific knowledge, he has gained here to solve or understand a problem-situation he/she encounters in real life, transfer it to other situations and produce creative solutions. The measurement and evaluation dimension of such a learning process should have a function that appeals to the individual differences of the student, reveals the high-level competencies, and can reveal the individual performance beyond the classical methods at all levels, from the evaluation made by the teacher in the classroom to the national exams.

PISA 2018 findings reveal that girls in Turkey are seven points ahead of boys in science scores. However, it is a striking finding that female students are less willing to choose engineering and science-related professions than male students. At this point, it is thought that it will be beneficial to carry out applications and projects that will positively increase the attitudes of girls towards the professions related to engineering and science. However, it would be beneficial to emphasize gender equality in all components of the learning ecosystem, especially in textbooks. As a matter of fact, many countries have developed policies and implemented projects (Educational Advancement campaign in Germany, Girls and technology initiative-Women in Engineering in Austria, Girls and Technology in Netherlands) based on the importance of STEM professions in social development (European Commission/EACEA/Eurydice, 2010).

According to the PISA research data, the disadvantage of students in Turkey depending on their socio-economic status is an important factor affecting science achievement. The only place where the student can minimize their disadvantage is the school and the only person who can eliminate this negative effect is the teacher. From the point of view of science education, science laboratories are an integral part of science lessons. In this sense, it is necessary to establish and develop science laboratories in every school, and to offer equal opportunities and learning opportunities to every student in a fair manner. It is important to increase teacher training and invest in teacher professional development within the framework of scientific research, new teaching approaches and practices in science education.

According to PISA 2018 findings, one of the primary factors affecting science achievement in Turkey is the disadvantages arising from geographical region differences. Although the sources of this disadvantage are various, it is necessary to investigate the factors that may cause the difference in success between geographical regions and to develop data-based solutions. In the context of science education, increasing the facilities such as science laboratories and design workshops in schools in disadvantaged regions, developing science and art schools in the region, and establishing science centers should be the primary goals. Encouraging and supporting teachers in making use of these centers with equal opportunities, participation in scientific activities and increasing projects will minimize the problems arising from the mentioned disadvantages.

TIMSS Scope of Evaluation

Another international indicator that we can make inferences for Turkey in the dimension of Science Education is the Trends in International Mathematics and Science Study (TIMSS) conducted by the International Association for the Evaluation of Educational Achievement (IEA). Over 60 countries are actively involved in the IEA network, and over 100 education systems take part in IEA's studies. TIMSS 2019 marks the seventh cycle of the study and provides 24 years of trends. Conducted every four years since 1995, TIMSS has been a valuable tool for monitoring international trends in mathematics and science achievement at the fourth and eighth grades (https://www.iea.nl/studies/iea/timss/2019). According to the Ministry of National Education (MoNE, 2020) data, Turkey has been taking part in TIMSS research since 1999. 58 countries at the fourth-grade level and 39 countries at the eighth-grade level took part in the TIMSS 2019 application (TIMSS, 2020). Turkey took part in the TIMSS 2019 cycle, with 180 schools, 4,028 students at the fourth-grade level and with 181 schools, 4,077 students at the eighth-grade level (MoNE, 2020). When TIMSS (2020) Turkey science findings are considered, we see that first, 5th grade students from Turkey are included. It can be said that participation at the 5th grade level is appropriate in terms of its overlap with the international averages of age and the achievements in our curriculum.

TIMSS research uses three basic dynamics to evaluate science achievement. The first of these is content areas. TIMSS 2019 assessed three content areas in science at the fourth grade: life science, physical science, Earth science and eigth grade: Biology, Chemistry, Physics and Earth Science (TIMSS, 2020, p.235). Questions evaluating science achievement consist of questions covering these learning areas. Within the scope of the assessment, the second basic dynamic is "Cognitive Fields". TIMSS emphasizes that students should benefit from a range of cognitive skills while solving questions. Cognitive domains consist of Knowing, Applying, Reasoning cognitive process skills. Knowing covers scientific facts, concepts and procedures that the student should know. The application requires the student to transform the knowledge and concept into practice and the ability to develop a conceptual understanding. Reasoning includes higher-order thinking processes, such as research design, synthesis, analysis, making, and providing creative and critical solutions (TIMSS, 2020).

The third fundamental dynamic is International Benchmarks. TIMSS describes achievement at four points along the scale as International Benchmarks: Advanced International Benchmark (625), High International Benchmark (550), Intermediate International Benchmark (475), and Low International Benchmark (400) (TIMSS, 2020, p.106). The TIMSS sub-proficiency level shows the lowest benchmark to be achieved, according to the United Nations Sustainable Development Goal (MoNE, 2020, p. 32). Based on this basic structure, evaluating Turkey's science achievement in terms of proficiency levels and content areas rather than ranking based on average will provide more enlightening information.

What Do TIMSS "Science" Findings Say for Turkey?

In the TIMSS(2020) fourth-grade level science assessment, Turkey ranks 19th among 58 taking part countries, with an average score of 526 (p.80). At the eighth-grade level, it was ranked 15th among 39 countries, with an average science score of 515 (p.213). These rankings are above the midpoint of the scale in the TIMSS cycle. Turkey has been taking part in TIMSS in both grade levels since 2011. Therefore, for a healthy and comparative interpretation, it would be more accurate to refer to the year 2011 at both grade levels. TIMSS findings are valuable because students who were in the 4th grade in 2015 are in the eighth grade in 2019, allowing a longitudinal assessment. In this context, it is seen that eighth graders have increased their scores by 22 points compared to 2015. In an education system like Turkey, where the student population is higher than the total population of many countries, achieving meaningful performance increases is undoubtedly an important achievement. That there is a continuous upward trend in the 2011, 2015 and 2019 TIMSS cycles and this increase is brought to the top in the 2019 cycle is a clear indicator of this performance increase (Suna & Özer, 2021, p. 12). However, as stated in the previous section, it would be more beneficial to examine the findings according to proficiency levels, cognitive domains, and content areas rather than country rankings. In this context, prominent findings in science achievement and evaluations in the context of Turkey are presented below, respectively;

- There is an increase in the number of students who can reach advanced proficiency level in both fourth and eighth grades compared to 2015. There is a decrease in the number of students who fall below the basic competencies level. However, a non-negligible rate (10% in 5s, 12% in 8%) is below the basic proficiency level.

- When analyzed according to Content Domain, the field with the highest achievement in both the fourth and eighth grades is physics. However, the field with the lowest achievement at both grade levels is earth sciences. When the MoNE Science Curriculum (2018) is examined, Earth Sciences makes up 13.9% of all achievements in the fourth grades, while there is no acquisition related to this content area in the eighth grades. This situation may cause Turkish students to perform at a lower level in Earth sciences than in other content areas.

- In the context of Cognitive Domain, it is observed that eighth graders increased their reasoning scores by 12 points and their Applying scores by 15 points compared to 2015. These score increases can be considered as the widespread effect of MoNE Science Curriculum (2018), which was revised in 2017 within the framework of research-inquiry approach. However, in the fourth grade, Reasoning scores are 6 points behind the TIMSS average, while Applying scores are 2 points above the average. In addition, it is noteworthy that fourth-year students have a lower level of success in “Reasoning” cognitive than applying. This emphasizes the need to focus on higher-order thinking skills during the primary school period.

• In the context of gender; While boys are ahead of girls in the fourth grades in terms of points, it is observed that there is a difference in favor of girls in the eighth grades.

• When examined in terms of access to Home Educational Resources (number of books in their homes, other study supports, number of children’s books, the educational status of the parents and the professions of the parents) are examined, there is a dramatic difference between the advantaged and the disadvantaged student groups (153 point in the fourth grade and 145 points in eighth grade). The TIMSS success average of Turkish children, who are advantaged in terms of home resources, is higher than Singapore’s points. At this point, one of the main variables affecting science achievement in Turkey is socio-economic differences among students. For this reason, it comes to the fore that it is necessary to seriously support disadvantaged student groups in Turkey.

• When examined in the context of Students Attended Preprimary Education, the science success of Turkish students increases as the primary education year increases. The science achievement of students who cannot reach pre-school education is 74 points less than students who are advantaged in this regard. This finding reveals that pre-school education has a direct relationship with the success of the child in the following years.

• Socioeconomic Background of the Student Body: It is seen that there is an average of 55 points difference between the science achievement scores of children from families with high income and those from poor families in both the fourth and eighth grades (in favor of children from high-income families). It is noteworthy that 44% of the students participating from Turkey have a low-income level. For example, in Finland, this rate is around 10%. Based on this finding, the economic opportunities of families in Turkey have an active role in science achievement.

• The Instruction Affected by Science Resource Shortages includes principals’ reports about two kinds of resource shortages affecting instruction: general school resources (Instructional materials, Supplies, School buildings and grounds, Heating/cooling and lighting systems, Instructional space, Technologically competent staff, Audio -visual resources for delivery of instruction, Computer technology for teaching and learning) and resources specific to science instruction (Teachers with a specialization in science, Computer software/applications for science instruction, Library resources relevant to science instruction, Calculators for science instruction, Science equipment and materials for experiments) (TIMSS, 2020, pp. 329-330).

In Turkey, the science achievement scores of students in schools with insufficient scientific resources are quite low compared to schools rich in these resources (49 points in the fourth grades, 57 points in the eighth grades). This finding shows that the school's being equipped with scientific resources is a factor that directly affects science achievement.

• It is seen that fourth-grade students with a high level of Students' Sense of School Belonging have a 27-point difference in success compared to students with a low sense of belonging to school. However, the variable of feeling belonging to school in eighth grades did not make any difference in science achievement.

• Students' science achievement scores increase if teachers include the scientific research process in their lessons. When the number of experiments in the lesson's scope is compared between the fifth and eighth grades, it is observed that the frequency of experimentation in science lessons in the eighth grades decreases. The reason for this may be the anxiety of science teachers to be able to train their curriculum and their preparation for the high school entrance exam.

• Access to technology within the scope of science lessons is 20% in the fourth grade and 15% in the eighth grade. These rates are well below the TIMSS average.

• While the rate of liking the science, lesson is 69% in the fourth grade, this rate is 52% in the eighth grade. However, the value given to science is well above the TIMSS average in eighth grades (46%). It is observed that this rate is quite low in countries such as South Korea, Japan, and China, which are at the top of TIMSS science achievement. In the scope of the value given to science, the high mean score in the eighth grades may be related to the fact that science scores are effective in getting a good high school in our country.

•In terms of self-confidence rates in science lessons, a rate of 58% in the fourth grade and 38% in the eighth grade draws attention.

•When the experience of teachers in terms of professional years is examined, it is seen that there is an increase in the success of the students as the years of professional experience increase. Especially the students of science teachers with 20 years or more experience got the highest scores. It is noteworthy that the average science score of the students of teachers who have five years or less experience is low. This finding draws attention to the necessity of increasing studies on the training and development of teachers.

•The most successful region in terms of science achievement is East Marmara in both the fifth and eighth grades. The most unsuccessful region is the Southeast

Anatolia Region in both grades. However, the Southeast Anatolia Region is one region that increased the Science Achievement score the most compared with 2015. Compared to 2015, there is a 14-point decline in the Western Black Sea Region in terms of science achievement scores in eighth grades. The necessity of evaluating the reasons for this situation specific to the region comes to the fore.

•When examined in terms of the frequency of feeling tired and hungry; The rate of students who feel hungry every day in the fourth grade is 40%, and 46% in the eighth grade. How efficient can the educational process be in terms of improving student success in an environment where basic needs are not met?

Implications and Recommendations for Turkey in the Context of TIMSS 2019

Based on all these, some suggestions are given below for policy makers, educators, teachers, and school administrators in the context of Science Education. In a general framework. In a general framework, TIMSS 2019 data shows that Turkey has made significant progress in science achievement compared to the previous cycle. Besides this positive development, the rate of children who are below the basic proficiency level is still at a level that we cannot ignore. This finding points to a science education approach focused on developing high-level competencies. When we consider it from the perspective of Turkey, it is stated in the MoNE (2018) Science Curriculum that the role of teachers is to guide students to integrate science, technology, engineering, and mathematics and to bring students to the level of high-level thinking, product development, invention, and innovation. In other words, the emphasis that the effective factor in gaining these skills is the teacher draws attention. However, it is also important to design a science education system that will empower the teacher in increasing high-level skills and competencies. The necessity of empowering teachers with curriculum, textbooks, applications that provide science-technology integration, school resources (laboratory, technological integration, materials, etc.), out-of-school resources and qualified training in the profession is revealed by the findings of TIMSS 2019 and PISA 2018.

In interpreting the TIMSS findings, it is possible to consider the differences in science achievement in two dimensions: student (home-family characteristics) and school-related differences. According to TIMSS-2019 data, one of the main variables that causes student-based achievement differences in Turkey is socioeconomic differences among students. According to the TIMSS (2020) findings, the rates of socioeconomic differences in affecting science achievement are very close to each other in both fourth and eighth grades. This finding shows us that children from low-income families at both primary and secondary school levels should be supported academically and socially. Another important finding that provides a basis for supporting socioeconomically disadvantaged children is pre-school education. As a matter of fact, according to the

TIMSS findings, there is a direct positive relationship between the duration of the child's pre-school education and his success in the following years. According to the research of Magnuson et al. (2004) in most instances, the effects are largest for disadvantaged groups, raising the possibility that policies promoting preschool enrollment of children from disadvantaged families might help to narrow the school readiness gap. Preschool education reduces social inequalities in educational achievement (Cebolla-Boado et al., 2017). Supporting children with pre-school education is an important force that can tolerate socioeconomic disadvantages. For this reason, pre-school education in Turkey should be made compulsory, albeit late.

Another student-based success factor is the home-related dimension. In Turkey, there is a dramatic difference between the science achievements of children with advantaged about Home Educational Resources (number of books in their homes, other study supports, number of children's books, the educational status of the parents and the professions of the parents) and those with scarce resources. When the ABIDE 2018 data is analyzed, similar results are reached, but another striking finding is that 49.8% of the students in Turkey do not have their own tablet or computer, and 54.5% do not have an internet connection (MoNE, 2019a). At this point, it should be aimed to reduce inequality in education and measures should be taken at the level of country policies in favor of disadvantaged students in terms of household resources. In Turkey, the education program in primary school (IYEP-third grades) and Support and Training Courses (DYK) in secondary school period and programs to provide students with the opportunity to make up for their deficiencies are carried out by MoNE (MoNE, 2019; MoNE, 2021). However, there is a need for official assessment and evaluation findings and feedback on the scope, competencies, and effects of these programs. Considering the secondary school period, the technical infrastructure of the schools for science lessons is an important dimension. Because of the nature of the science lesson, it is a field that requires being involved in research-inquiry-problem solving and learning through experimentation, and access to laboratory equipment, scientific and technological resources is necessary. For this reason, the equipment of schools is important in closing the inequality between students. As a matter of fact, according to the findings of TIMSS (2020), the science achievement scores of the students in schools with insufficient scientific resources in Turkey are quite low compared to the students at schools rich in these resources (49 points in the fourth grades, 57 points in the eighth grades). This finding shows that the school's being equipped with scientific resources is a factor that directly affects science achievement.

On the other hand, in Turkey, students' science achievement scores increase to the extent that teachers include the scientific research process in their lessons. It is observed that the frequency of experimentation in science lessons in eighth grades is much less than in fifth grades (TIMSS, 2020). In the context of Turkey, there may be different reasons why less experiments are done in lessons as the grade level increases. The first of these is that compared to the MoNE (2018) science curriculum, the number of achievements is higher in 8th grades. Teachers may be giving less time to scientific research and experiments to complete the achievements and to prepare for the 8th grade high school entrance exams in Turkey. In addition, researches have shown that teachers' competencies in the implementation and conduct of science experiments (Demir et al., 2011; Nakiboğlu & Sarıkaya, 2000; Ültay et al., 2020), their beliefs and thoughts about science (Kılıç et al., 2015) also shows that it can be effective. In addition, the science laboratories of the schools do not have sufficient technical equipment (Akıncı et al., 2015; Soğukpınar & Gündoğdu 2020; Şimşek et al., 2012), the number of students in the classrooms is high (Akıncı et al., 2015; Ayvacı & Durmuş, 2013) are the findings in the literature in such cases. It can be said that the competence and self-confidence of science teachers in Turkey has increased compared to previous years. This situation can be seen in proportion to the increase in the number of more applied training and laboratory courses in the teacher training process. At the same time, it can be considered as a reflection of the responsibility imposed on teachers by the changing curriculum (Celik et al., 2021). The most important feature that distinguishes science education from other branches of science; It gives importance to experiment, observation, and discovery, develops students' questioning and research skills, and provides students with the opportunity to form hypotheses and interpret the results (Yazıcı & Özmen, 2015). For this reason, in the light of TIMSS findings, it is necessary to take necessary measures in terms of school, teacher and curriculum to conduct secondary school science lessons based on experiment, observation and practice. According to TIMSS (2020) findings, it is observed that students of science teachers with 20 years or more experience reach the highest scores. It is noteworthy that the average score of the students of teachers who have five years or less experience is low. This finding brings to the fore the increase of studies on the training and development of teachers. Another dimension that TIMSS findings point to in science achievement differences is the geographical region factor. This finding brings up the inequalities in access to education and the quality of education according to geographical regions in Turkey. Kıbrıslıoglu-Uysal and Gelbal (2019) evaluating equality of opportunity in education longitudinally within the framework of PISA findings and TUIK data, they stated that the distribution of limited resources and quality allocated to education in Turkey is not balanced within the country. Based on the TIMSS 2019 findings, the average score of Turkish students, who are advantageous in terms of socioeconomic, home and school resources, approaches the ceiling score in TIMSS ranking. However, children who have scarce resources at home and school, and who are socio-economically disadvantaged, slip into the bottom line in science achievement. Reducing inequalities in education will minimize the risk factors for students to take active roles in society. It is inevitable for all students to be successful when children have a more equal and fair system in access to education and distribution of resources.

Final Say

The COVID-19 pandemic, which our world is facing at the beginning of 2020, reminded the necessity and importance of the ability to create virtual work environments by combining technology and virtual environments in education. The Covid-19 pandemic has opened the door to a new education paradigm where education is continued with "distance education". In addition, inequalities in access to education have deepened with the pandemic. The coronavirus crisis has revealed deep inequalities not just in the digital divide but also who has the skills to self-direct their learning, and whose parents have the time to help (Soler & Dadlani, 2020). According to TIMSS (2020) and OECD (2019b, 2019c, 2019d) PISA reports, access to education and equal distribution of resources are the primary factors affecting success in science education in Turkey. The fact that inequalities in education cause serious learning differences will lead to more dire consequences with the prolongation of the closure of schools in Turkey in covid-19. In this process, accessible and inclusive learning is gradually increasing the responsibilities of all education systems. As education continues to be a key driver of social mobility and well-being, learning systems must shift toward more accessible, and therefore more inclusive, methods to ensure access to opportunity for everyone. Without such a transformation, current trends risk further exacerbating inequality (WEF, 2020). In this process, which carries a significant risk for disadvantaged children (in terms of socioeconomic, access to education, home, and school resources) in Turkey, identifying and compensating learning losses, supporting students socially and psychologically should be the most important agenda topic for the education policies of the country.

With this, since the Science Course is a course that mostly includes experiments, observations, laboratory applications and real-life contexts, teachers in Turkey face some difficulties in teaching this course via distance education and in this way gaining field-specific skills (Bakioğlu & Çevik, 2020; Pınar & Dönel- Akgül, 2020). According to UNESCO, "science teaching is a strategic imperative for a country to meet the basic needs of its people." (WEF, 2020). Science education, by its nature, is a field that requires being involved in research-inquiry-problem solving and learning through experimentation, and access to laboratory equipment, scientific and technological resources is necessary. For this reason, starting from preschool with a more democratic approach in science education, it is important to create school/out-of-school systems where every child can access scientific resources, to encourage students to learn science, to develop their creativity, innovation, and reasoning skills, and to inspire them to use what they have learned on a social level. Researches such as TIMSS and PISA have a key role in identifying our deficiencies and strengthening the system. Monitoring current trends in the education systems of nations can enable teachers, school administrators, parents, and policy makers to draw conclusions and make more effective decisions in revising education.

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