Characteristics of High- and Low-Performing Students

Rezana Vrapı, Agim Alia, and Falk Brese

Abstract Many governments are interested in improving the overall attainment of their school students and in delivering quality education for all that improves the life opportunities of their populations. In addition to comparing average student achievement with similar economies, looking in depth at the factors that affect variation in student performance and underlie student achievement gaps can provide important information to support educational improvement. Students that find it difficult to perform even basic mathematical computations or understand elementary scientific concepts may be left behind if they do not receive specific help in the early years of education to lay the foundations for later school years. At the same time, it is also important to foster the talents of students that are gifted in mathematics and science, as this group are likely to become an important part of the future work force. IEA's Trends in International Mathematics and Science Study (TIMSS) can be used to analyze aspects of student achievement and the background factors that influence how students learn about mathematics and science. Such data can be used to evaluate the proportions, competencies, and characteristics of these groups of high- and low-performing students across the Dinaric region. The competencies of the two groups can be established by analyzing student proficiency levels relative to the TIMSS international benchmarks in mathematics and science. Analyzing the characteristics of these high- and low-performing students revealed that there were considerable differences in the proportions of grade four students lying at either end of the TIMSS achievement distribution across the Dinaric region. For mathematics, boys tended form a higher proportion of the group of high-achieving students in three of the Dinaric systems, but conversely, in science, boys were more often found in the low-achieving group in three systems. The availability of home resources for

R. Vrapı (✉) · A. Alia
Center of Educational Services (CES), Tirane, Albania
e-mail: rezana.vrapi@qsha.gov.al

A. Alia
e-mail: agim.alia@qsha.gov.al

F. Brese
International Association for the Evaluation of Educational Achievement (IEA), Hamburg,
Germany
e-mail: falk.brese@iea-hamburg.de

learning varied significantly across the participating Dinaric education systems and was found to be positively related to student attainment. Student attitudes towards learning the subjects and student reports of their physical wellbeing on arrival at school were also found to be related to student achievement across the region.

Keywords Dinaric region · High achievers · Low performers · Mathematics instruction · Primary education · Science instruction · Trends in International Mathematics and Science Study (TIMSS)

1 Introduction

Raising the number of high performing students and reducing the proportion of low performers is considered an important educational goal for every country. Fostering higher order thinking among students of all ages is considered another critical educational objective. However, teachers often believe that this latter ambition is not intended for or applicable to all their students; a common belief among teachers is that tasks requiring higher order thinking are appropriate only for high-achieving students, whereas low-achieving students, who can barely master the basics, are unable to deal with such tasks (Zohar et al., 2001). We examined the proportions and characteristics of the two groups of students identified as the high and low performers across the Dinaric region. Our aim was to identify the obstacles related to their performance, in order to understand what teaching strategies or changes in the education system might best support their learning and achievement. The achievement of those students should be viewed as the result of their efforts, despite the barriers that might impede their performance. Our second objective was to provide evidenced analyses of the regional goals related to these groups of high- and low-achieving students, with the aim of helping the Dinaric education systems to identify practical measures that support both teachers and other stakeholders in achieving desired results. While the average achievement of students in an education system is interesting, investigating the extremes of the achievement distribution in more depth carries the potential to identify tailored and distinct solutions to support both academic excellence and those students who are struggle with the basic concepts of mathematics or science (see Meinck & Brese, 2019).

Seven participants from the Dinaric region took part in TIMSS 2019, namely Albania, Bosnia and Herzegovina, Croatia, Kosovo,¹ Montenegro, North Macedonia, and Serbia. Data from the 2019 cycle of IEA's Trends in International Mathematics and Science Study (TIMSS) thus provide a unique opportunity to study the mathematics and science performance of these two groups of grade four students across the Dinaric region. Our initial research questions were:

¹ This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 (United Nations, 1999) and the International Court of Justice (ICJ) Opinion on the Kosovo declaration of independence (ICJ, 2010).

- (1) *Across the Dinaric region, what percentage of students can be categorized as high achievers? What percentage of students can be considered the low achievers?*
- (2) *What are the characteristics of high- and low-performing students? Do these characteristics differ across the region, and, if so, what causes these characteristics to differ?*

Students performing at the top level of academic achievement demonstrate a deeper understanding of a subject than their peers and can apply their skills and knowledge to more complex situations. In examining the differences between these two groups of different competencies, it is important to question why there are these differences both within and across education systems; differences between education systems may reflect their diversity, and differing strengths and weaknesses.

A vast amount of literature provides evidence that differences in student achievement are related to many factors (Atar and Atar, 2012; Aypay et al., 2007; Papanastasiou, 2008; Papanastasiou & Papanastasiou, 2004; Papanastasiou et al., 2004; Yayan & Berberoğlu, 2004). According to Mullis et al. (2020), variables related to home background, resources at school and school climate, teaching methods, and students' attitudes towards learning and towards the subjects are all significantly related to student achievement in many countries around the world.

According to the TIMSS reports, some countries have a considerable proportion of students that perform at an academically advanced level, while others do not, which naturally leads educational policymakers and researchers to question why such differences arise. Understanding the policies and practices that lead to high-quality learning outcomes is clearly valuable, and many studies have investigated the nature of the relationship between students' attitudes and their achievement (Atar and Atar, 2012; Aypay et al., 2007; Ceylan & Berberoğlu, 2007). Student attitudes toward science were identified as being significantly positively correlated with science achievement (Papanastasiou et al., 2004). Gibson and Chase (2002) found that activities that invited students to actively engage in science using a hands-on inquiry-based approach helped middle school students to develop an interest in science that they tended to maintain during their years in high school education. Thus, strong science reasoning scores and positive attitudes toward science in high-performing schools may be partially attributed to the type of implemented instructional practices used in the science classrooms in these schools.

A student's socioeconomic status (SES), which is also generally related to the educational background of their family members, has been identified as a factor that may also be related to their school performance (Papanastasiou, 2008). Although researchers may define SES in slightly different ways, robust relationships between student SES and test scores have been well replicated by social scientists (Konstantopoulos, 2005; White et al., 1993).

However, it is not always easy to determine definitely which factors make the critical difference. We thus opted to focus on student-centered factors rather than system-level factors or policies; these include gender, home resources for learning, student attitudes towards mathematics and science, and their assessment of their physical

ability to attentively follow lessons at school. Gender, home resources for learning, and (positive) attitudes towards the subject are characteristics that are frequently and regularly checked for their associations with student achievement (see, for example, Mullis et al., 2020). Home resources for learning are sometimes used as a proxy for the wealth and/or social status of the student's family. Gender equity is perceived as a universal goal, and therefore one of the major aims of the sustainable development goals set by the United Nations (2018). Students' positive attitudes toward learning mathematics and science have been shown as strongly related to academic achievement in those subjects (Mullis et al., 2020). Finally, the physical well-being of the student has been hypothesized as having an effect on their achievement; research has shown that the students that reported getting more hours sleep than their peers also tended exhibit significantly less daytime-sleepiness-related behaviors (Owens et al., 2010). Recently, Lin et al. (2020) found a direct association between reported sleep duration and the mathematics achievement scores of adolescent female students.

2 Data and Methods

The TIMSS assessment sets four benchmark levels for both mathematics and science achievement (Mullis et al., 2020) depending on student performance on the TIMSS mathematics and science test. These benchmarks are defined in terms of cut points on the continuous achievement scale as follows: "advanced" (students scoring at or above 625 points), "high" (students at or above 550 and below 625 score points), "intermediate" (students at or above 475 and below 550 score points), and "low" (students at or above 400 and below 475 score points). For example, a student scored 460 points on the mathematics test is categorized as having reached the TIMSS low international benchmark of mathematics achievement (at or above 400 and below 475 score points). A student whose performance was more than one standard deviation below the scale center point (i.e., below 400 points) is described as not reaching the TIMSS low international benchmark.

These benchmarks provide a simplified picture of the variation in student achievement across different educational systems. Our focus was on the grade four students at both ends of the achievement distribution in mathematics and science. Thus, according to the performance benchmarks determined by TIMSS, we distinguished two groups for our research analyses: the students that fell below the TIMSS low international benchmarks (scoring less than 400 score points, hereinafter referred to as the low achievers), and the students that scored at or above the TIMSS high international benchmark (550 or more score points, hereinafter referred to as the high achievers). For both groups, we computed and compared their proportions in each education system across the Dinaric region.

We aimed to investigate whether a particular set of contextual factors was particularly related to the achievement of these two groups. TIMSS administers a number of background context questionnaires. Responses to these questionnaires may be used to identify specific factors that seem to be related to high and low achievement

across the Dinaric region, providing important evidence on the contexts of learning that can inform our analyses. We selected a number of variables and indices derived from data collected by the TIMSS 2019 student, teacher, and school questionnaires (Table 1), which we used to assess student gender (male/female), student access to home resources for learning, and their attitudes toward mathematics and science. In TIMSS 2019, students were also asked to assess how often they felt tired when they arrived at school. We used student responses to this question to assess whether their physical well-being on arrival at school was related to achievement in these two groups of students.

We used simple statistical indicators, such as means and percentages, to describe the characteristics of the groups of high- and low-achieving students (please refer to Sect. 5 for further information on the data and methods used in our analyses).

2.1 Benchmark Performance: Grade Four Mathematics

Each of the four benchmarks in mathematics are defined by the typical skills displayed by students who reach a particular benchmark (see Mullis et al., 2020). Students at higher benchmarks show a better understanding of the respective subject and the ability to solve more complex problems than students at lower benchmarks. More specifically, students at the TIMSS low benchmark in mathematics could provide evidence of basic mathematical knowledge, while those at the high benchmark could solve increasingly complex problems using more advanced skills, particularly the ability to complete multi-step problems (Table 2). In our analyses, we focused on the students performing below the low benchmark and at or above the high international benchmark in mathematics.

2.2 Benchmark Performance: Grade Four Science

As with mathematics, the characteristics for the TIMSS international benchmarks for science at grade four define increasing levels of scientific knowledge and understanding from the low to the advanced benchmarks (Mullis et al., 2020). Students at the low benchmark could demonstrate basic knowledge of the life sciences and physics, and were able to interpret simple tables and diagrams. Again, students that did not reach this benchmark failed to answer even simple questions related to the subject and had not understood very elementary natural concepts. By contrast, students at the high benchmark could communicate and apply knowledge of life, physical, and earth science concepts in everyday and abstract contexts (Table 3).

Table 1 List of the variables and scales used in our analyses

Variables/Scale	Description	Values/Response options	References
Home resources for learning scale ^a	Based on students' and parents' reports regarding the availability of five resources: <ul style="list-style-type: none">• Number of books in the home (students)• Number of home study support (students)• Number of children's books in the home (parents)• Highest level of education of either parent (parents)• Highest level of occupation of either parent (parents)	Higher values mean more home resources for learning This scale was divided using scale cut scores into an index with three categories [†] : (1) Many resources (2) Some resources (3) Few resources	Yin and Fishbein (2020, p. 16,39)

(continued)

Table 1 (continued)

Variables/Scale	Description	Values/Response options	References
Students like learning mathematics/science scale ^a	Scale of students' agreement to nine statements about learning mathematics/science: I enjoy learning mathematics/science; I wish I did not have to study mathematics/science; Mathematics/science is boring; I learn many interesting things in mathematics/science; I like mathematics/science; I like any schoolwork that involves numbers/I look forward to learning science in school; I like to solve mathematics problems/Science teaches me how things in the world work; I look forward to mathematics lessons/I like to do science experiments; Mathematics/science is one of my favorite subjects	Index with three categories (1) Very much like (2) Somewhat like (3) Do not like Students who "very much like learning" mathematics/science had a score at or above the cut score corresponding to "agreeing a lot" with five of the nine statements and "agreeing a little" with the other four, on average Students who "do not like learning" mathematics or science had a score at or below the cut score corresponding to "disagreeing a little" with five of the nine statements and "agreeing a little" with the other four, on average All other students "somewhat like learning" mathematics or science	Yin and Fishbein (2020, p. 16.89 and p. 16.96)
Student gender	Information on students' gender provided by the students	Girl Boy	Fishbein et al. (2021, Supplement 1, p. 11)

(continued)

Table 1 (continued)

Variables/Scale	Description	Values/Response options	References
Student condition	Students' reports on frequency of feeling tired when arriving at school	Four response categories: (1) Every day (2) Almost every day (3) Sometimes (4) Never	Fishbein et al. (2021, Supplement 1, p. 16)

Notes ^aThese TIMSS scales are constructed so that the scale center point of 10 is located at the mean score of the combined distribution of all TIMSS 2019 grade four participants. The units of the scale are chosen so that the standard deviation of the distribution corresponds to two scale score points.
[†]For more general information on scale construction, scaling methodology, and scale cut scores, please see Martin et al. (2020)

Table 2 Descriptions of the TIMSS 2019 high and low international benchmarks of mathematics achievement

Benchmark	Score	Students typically
High Students can apply conceptual understanding to solve problems	At least 550 TIMSS points	Can apply conceptual understanding of whole numbers to solve two-step word problems Show understanding of the number line, multiples, factors, and rounding numbers, and operations with fractions and decimals Can solve simple measurement problems Demonstrate understanding of geometric properties of shapes and angles Can interpret and use data in tables and a variety of graphs to solve problems
Low Students have some basic mathematical knowledge	Below 400 TIMSS points	Can add, subtract, multiply, and divide one- and two-digit whole numbers Can solve simple word problems Have some knowledge of simple fractions and common geometric shapes Can read and complete simple bar graphs and tables

Source Mullis et al. (2020, exhibit 1.7)

3 Percentages of High- and Low-Achieving Students

Percentages of grade four students at or above the TIMSS high international benchmark and below the TIMSS low international benchmark in mathematics varied substantially across the Dinaric region (Fig. 1). Croatia has by far the lowest percentage of low-achieving students (5%); there were also relatively low proportions of low-achieving students in Serbia (11%) and Albania (14%). However, across the remainder of the region, about a quarter of students fell into this group, which clearly demands remedial action as there is potential for this achievement gap to further widen during subsequent education, permanently affecting students' future life opportunities.

At the other end of the achievement distribution, the variation between systems was also substantial (Fig. 1). Serbia, Croatia, and Albania had the highest proportion of high achievers (i.e., students at or above the TIMSS high international benchmark in mathematics at grade four; 32%, 28%, and 26%, respectively). In all other systems across the region, only about a tenth of students mastered this level of achievement. A comparison between the percentages of low achievers and of high achievers showed

Table 3 Descriptions of the TIMSS 2019 high and low international benchmarks of science achievement

Benchmark	Score	Students typically
High Students communicate and apply knowledge of life, physical, and Earth science	At least 550 TIMSS points	Communicate knowledge of characteristics of plants, animals, and their life cycles, and apply knowledge of ecosystems and of humans’ and organisms’ interactions with their environment Demonstrate knowledge of states and properties of matter and of energy transfer in practical contexts, and show some understanding of forces and motion Know various facts about the Earth’s physical characteristics and show basic understanding of the Earth-Moon-Sun system
Low Students show limited understanding of scientific concepts and limited knowledge of foundational science facts	Below 400 TIMSS points	Can recognize that some animals have backbones, that some materials conduct heat better than others, and that water and soil are natural resources

Source Mullis et al. (2020, exhibit 2.7)

Fig. 1 Percentages of high- and low-achieving students in TIMSS 2019 mathematics. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

Fig. 2 Percentages of high- and low-achieving students in science TIMSS 2019. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

that there were more high achievers than low achievers in only three participants: Croatia (23% more), Serbia (21% more), and Albania (12% more). In North Macedonia, the percentages of both groups were similar. The percentage of low achievers was higher than the percentage of high achievers in Bosnia and Herzegovina (15% higher), Kosovo (19% higher) and Montenegro (13% higher). These data indicate that the education systems of the Dinaric region need to consider action, as it is possible that nations with low proportions of high achievers in their schools may subsequently lack sufficiently qualified staff in the workplace.

Percentages of grade four students at or above the TIMSS high international benchmark and below the TIMSS low international benchmark in science also varied substantially across the Dinaric region (Fig. 2). It was an especially noteworthy achievement that few students in Croatia failed to achieve the low TIMSS benchmark. Serbia also only had relatively few low achievers in science (8%), followed by Albania (14%). Worryingly, however, nearly a fifth of students in Bosnia and Herzegovina (22%) seemed to find it difficult to answer questions on natural phenomena that should be familiar to grade four students. This problem was apparently even more severe in Montenegro (25% of students), North Macedonia (38% of students), and, finally, Kosovo (41%), where four out of ten students were categorized as low achievers (Fig. 2).

Serbia and Croatia showed the highest percentages of students at or above the TIMSS high international benchmark in science (36% and 34% of their students were high achievers, respectively). There was quite a large apparent difference between these two systems and other systems across the Dinaric region. In Albania, 24% of students were high achievers, but the proportions of high achievers were much lower in Montenegro (12%), Bosnia and Herzegovina (12%), and North Macedonia (11%), while, in Kosovo, only four percent of students scored at or above high TIMSS

benchmark. Comparisons of the percentages of students below the low TIMSS benchmark with those at or above the high TIMSS benchmark showed that, in Croatia, Serbia, and Albania, there were more high achievers than low achievers. In Kosovo, North Macedonia, Montenegro, and Bosnia and Herzegovina, there were more low achievers than high achievers (Fig. 2).

Considering the proportion of students lying at the extreme ends of the achievement distribution, it becomes evident that, across the region, fewer students perform at an intermediate level (i.e., at or above the low TIMSS benchmark but below the high TIMSS benchmark) in science than in mathematics. Hence, educational inequities seem to be more pronounced in science than in mathematics across the region. In comparison to other systems in the Dinaric region, Serbia and North Macedonia had higher proportions of students in these extreme performance categories in both subjects; this finding also suggests underlying issues of equity exist in these particular education systems.

4 High and Low Achievers by Gender

In general, across the seven Dinaric participants, gender did not seem to be significantly related to high or low student achievement in mathematics or science. There were either no gender gaps in the proportions of high and low achievers at grade four, or, in the few cases where gender gaps were noted, these were rather small and not of consequence.

The high achievers in mathematics showed no gender gaps in four of the seven Dinaric systems. In three participants, proportionally more boys reached the TIMSS high international benchmark in mathematics than girls (Fig. 3). The largest difference between the proportions of girls and boys at or above the high TIMSS benchmark

Fig. 3 Distribution of female and male students across the TIMSS international benchmarks in mathematics. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

Fig. 4 Distribution of female and male students across the TIMSS international benchmark in science. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

was in Croatia (8%). For the low achievers, only Serbia showed a significant difference between the proportions of girls and boys, with a higher proportion of male students not reaching the low TIMSS benchmark. The other six participants showed no gender gaps for the students below the low TIMSS benchmark for mathematics.

In general, TIMSS has consistently shown that boys have had an almost universal advantage in mathematics since the first cycle of TIMSS in 1995; the few exceptions have tended to be Middle Eastern and North African countries. In many countries, the gender gaps only increase between grades four to eight (Meinck & Brese, 2019), suggesting that gender gaps may increase over time if not tackled.

The gender distribution of the low achievers in science suggested that, in most of the participating systems, higher proportions of boys than girls failed to achieve the TIMSS low international benchmark in science (Fig. 4). These differences were significant in Kosovo (6%), Montenegro (3%), and North Macedonia (6%). Albania was the only participant that showed a small but significant gender difference among the high achievers in science (3% in favor of girls). In all other participants, there were no substantial gender differences among the high achievers in science.

5 Attitudes of High and Low Achievers Toward Learning Mathematics and Science

To investigate whether students' attitudes were related to their achievement, we compared the proportions of students with specific attitudes in the groups of high and low achievers.

We first established general distributions of student attitudes toward the subjects under investigation within each participating system (Figs. 5 and 6) While the response patterns were similar for both mathematics and science, we found that there

Fig. 5 Attitudes of grade four students toward learning mathematics. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

Fig. 6 Attitudes of grade four students toward learning science. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

was considerable variation among the participants. In four of the participating Dinaric systems, the (vast) majority of students reported that they very much liked learning mathematics and science. Albania (83% for mathematics and 83% for science) and Kosovo (78% for mathematics and 72% for science) had the highest percentages of students who reported that they very much liking to learn mathematics and science. In Bosnia and Herzegovina, Croatia, and Serbia, more than half of the students said they only somewhat liked or did not like learning mathematics and science at all. Croatia

had the largest proportion of students reporting that they did not like learning mathematics (75%), as well as the largest proportion of students who disliked learning science (66%).

We then combined these attitudes toward liking to learn the subjects with student achievement (Figs. 7 and 8). As we anticipated, we found that students who said that they did not like or only somewhat liked to learn the subject were more likely to fall into the group of low achievers than students who said that they very much liked learning the subject. Conversely, those who liked the subject a lot were more likely to be high achievers than those who disliked or only liked learning the subject to some extent. For example, in Albania, 10% of the students who very much liked to learn mathematics did not achieve the low TIMSS benchmark (Fig. 7), while 29% of the students who did not like to learn mathematics so much belonged to this group of low

Fig. 7 Distribution of students across the TIMSS international benchmarks in mathematics and their attitudes toward learning mathematics. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

Fig. 8 Distribution of students across the TIMSS international benchmarks in science and their attitudes toward learning science. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

achievers. We also found that the proportion of low achievers among the students, who responded that they only somewhat liked or did not like learning mathematics was quite high in five of the seven Dinaric participants. The largest proportion was in Kosovo (50%) and the lowest proportion was in Croatia (6%). We noted the largest proportion of low achievers among students who answered that they very much liked learning mathematics was in Kosovo (20%).

Comparing the differences in percentages of those students who liked learning mathematics and those that did not like learning mathematics among the low achievers, we found the biggest difference in Kosovo (30%). This difference was smaller across the other participants in the region, with Croatia (4%) and Serbia (3%) reporting the smallest differences. However, all seven participants showed differences, indicating that positive attitudes toward mathematics were related to high achievement in mathematics in every system.

Among the high achievers in mathematics, the proportion of those who liked learning mathematics a lot was substantially higher than the proportion of students that did not like learning mathematics as much (see Fig. 7). The largest percentages of students at or above the high benchmark who liked learning mathematics were found in Serbia (42%) and Croatia (41%). Out of all the participants in the Dinaric region, these two systems also contained the largest proportions of students who only somewhat or did not like learning mathematics within their groups of high achievers. Croatia reported the biggest difference in attitudes within the group of high achievers (17% more students who reported very much liking to learn mathematics); in Bosnia and Herzegovina, only five percent more of the high achievers reported that they very much liked learning mathematics. Again, all seven participants showed differences, indicating that positive attitudes toward mathematics were also related with high achievement in mathematics in every system.

In summary, we found that, among high achievers, the proportion of students who reported liking to learn mathematics a lot was much higher than the proportion of students who reported not liking to learn mathematics as much, while, among low achievers, the converse was true. Positive attitudes toward learning thus tend to accompany high achievement in mathematics.

In the science domain, we found that the proportion of low achievers was quite high among students who responded that they did not like learning science (Fig. 8). The largest proportions of low achievers in this group were in Kosovo (57%) and North Macedonia (52%), whereas the lowest proportion was in Serbia (9%). We also noted that the proportion of low achievers in the group of students who somewhat liked or did not like learning science tended to be larger than the proportion of low achievers among those who said that they liked learning science very much. The largest differences between these two groups were in North Macedonia (26%) and Kosovo (23%). Serbia was the only system with no reported difference between these groups. As observed for mathematics, these results indicate that negative attitudes toward learning science were related to low achievement in science across the Dinaric region. Students who did not like learning science much or not at all were more likely to be among the low achievers in science than their peers who liked learning science a lot.

Among high achievers, we found that the differences between the percentages of students who said that they very much liked learning science and those that said that they only somewhat liked or did not like learning science were small. The largest difference was in North Macedonia (8%), but only three participants reported any differences (North Macedonia, Albania, and Kosovo). Attitudes toward learning science do not seem to affect achievement in science among high achievers in the Dinaric region.

Despite this, the higher proportion of negative attitudes toward learning among the lower achievers indicates that positive student attitudes toward science have a positive effect on science achievement.

6 Student Well-Being and Its Relation to Achievement

We also looked at how often grade four students reported feeling tired when they arrived at school (Fig. 9). Across the Dinaric region, feeling tired on arrival at school is an issue for a worryingly significant percentage of students. The percentage of students that reported feeling tired at the start of school every day or almost every day ranged from 13% in Albania to nearly a third of grade four students in Croatia (30%), North Macedonia (31%), and Bosnia and Herzegovina (32%).

We found that, in mathematics, low achievers were significantly more likely to report feeling tired on arrival at school (Fig. 10). The proportion of low achievers was smaller and the proportion of high achievers larger in the group of students that answered that they never or only sometimes felt tired at the start of the school day than in the group of students who said they arrived tired at school every day or

Fig. 9 Grade four students’ reports of the frequency of feeling tired on arrival at school. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

Fig. 10 Distribution of students across the TIMSS international benchmarks in mathematics and their frequency of feeling tired on arrival at school. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

almost every day. This difference was significant in six of the seven participating Dinaric systems and the differences in the group proportions were especially large in Albania, North Macedonia, and Kosovo. Feeling tired at the start of the school day thus seems to play an important role in mathematics achievement. We identified very similar patterns for science achievement (Fig. 11), although we note that the larger proportions of students who reported feeling tired in the group of science low achievers may be also related to the generally higher numbers in this group in some of the participants (e.g., Kosovo) rather than larger proportions of students feeling tired.

Several factors may underlie the varying percentages of students that feel tired on arrival at school. The varying school starting times across the region may be one explanation for differences between the participating systems. Other factors may be

Fig. 11 Distribution of students across the TIMSS international benchmarks in science and their frequency of feeling tired on arrival at school. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

the distances that students need to travel to get to school and the means of transport that they have to use. For students from rural areas, the need to catch a bus to get to school may involve rising much earlier than their peers to reach school in time. Other obligations at home may also induce tiredness. A study carried out in Albania in 2017 highlighted several reasons for absenteeism. These included, among other factors, the distance between school and home, particularly at the lower secondary education level; pressure to contribute toward the family income; additional family obligations, such as helping to care for other children and elders, and doing housework; and early marriage (Maghnouj et al., 2020). Many of these factors may also lead to tiredness in school, and consequently may be related to achievement.

7 Discussion and Conclusions

We aimed to provide an overview of the characteristics of high- and low-performing grade four students across the Dinaric region and to establish what could be learned from analyzing any observed similarities and differences. Evidence-based data can enable participants to formulate and implement policies and practices that support improvement in mathematics and science achievement.

We found that, across the Dinaric region, there were considerable differences in the proportions of high- and low-achieving students in each participating system. The results for mathematics showed that there were more high achievers than low achievers in three of the participants, and the converse was true for the remainder. The results for science showed the same pattern.

We analyzed a number of factors that were potentially related to the differences between high and low achievers in mathematics and science. A key finding was that there were no gender differences among low-achieving students in mathematics in six of the seven Dinaric participants. For science, we found that in three of the seven Dinaric participants the low-achieving group contained higher percentages of boys than girls. Among high-achieving students in mathematics, we found that, in four of the seven Dinaric participants, there were higher percentages of boys than girls. For science, the percentage of girls was higher than boys in one of the seven Dinaric participants.

We also observed that, across the Dinaric region, there was a large percentage of students performing below the low TIMSS benchmarks, who responded that they did not like learning mathematics and science. However, it is also true that there was a considerable percentage of high achievers who said that they did not like learning mathematics or science. A large proportion of students felt tired on arrival at school; reports of feeling tired tends to be more prevalent among students belonging to the low achievers group. As feeling tired affects an individual's ability to listen attentively or work independently on specific tasks, the physical well-being of the student undoubtedly has an effect on their potential achievement. The relatively high incidence of such reports from grade four students across the Dinaric region indicates

that this is an issue that needs to be addressed; more research is needed to investigate the underlying factors.

It is very important to reduce the number of low achievers in the student population. If these students do not reach minimum competencies in literacy, mathematics and science, this may have an impact on their future life opportunities. Government intervention with appropriate policies and educational practices is needed to avoid with future excluded citizens and a polarized society. From our perspective, all students should have access to similar opportunities to learn, and where conditions are less favorable (e.g., where students lack adequate support at home) some may need higher support levels in school to compensate. High achievers tend to come from families with high SES, where their parents invest early in creating their future opportunities because they are conscious of the importance of education. Efforts are needed to identify highly talented students with low socioeconomic status, and to bring or retain them in the category of high-achieving students. Education systems should implement special programs to ensure that these talents are not needlessly squandered on their journey through school; their success also affects the future human capital of the region, and academic success and life opportunities should not be determined by SES or home background.

The existence of such large achievement differences at grade four is a critical issue that should be addressed by all Dinaric participants. Grade four students are at an age where they are consolidating the foundational skills provided by basic education to move into another level of education. If students have failed to reach minimum competencies by grade four then their future learning is endangered. Once left behind, the achievement gaps continue to develop, and it becomes almost impossible to compensate for the lack of good foundations. This may have an impact on students' psychological development, potentially causing some of them to abandon school or complete only basic compulsory education.

As the future learning of low achievers is in danger, it is very important to identify these students as early as possible and to implement measures and policies, including concrete teaching strategies and learning support, dedicated to better supporting their progress.

References

- Atar, H. Y., & Atar, B. (2012). Examining the effects of Turkish education reform on students' TIMSS 2007 science achievements. *Kuram ve Uygulamada Eğitim Bilimleri*, 12(4), 2621–2636. <https://files.eric.ed.gov/fulltext/EJ1002867.pdf>
- Aypay, A., Erdogan, M., & Sozer, M. A. (2007). Variation among schools on classroom practices in science based on TIMSS-1999 in Turkey. *Journal of Research in Science Teaching*, 44(10), 1417–1435. <https://doi.org/10.1002/tea.20202>
- Ceylan, E., & Berberoğlu, G. (2007). Öğrencilerin fen başarılarını açıklayan etmenler: Bir modelleme çalışması [Factors explaining the science achievement of students: A modeling study]. *Eğitim Ve Bilim*, 32, 36–48.
- Fishbein, B., Foy, P., & Yin, L. (2021). *TIMSS 2019 user guide for the international database*. TIMSS & PIRLS International Study Center, Boston College. <https://timssandpirls.bc.edu/timss2019/international-database/>
- Gibson, H. L., & Chase, C. (2002). Longitudinal impact of an inquiry-based science program on middle school students' attitudes toward science. *Science Education*, 86, 693–705. <https://doi.org/10.1002/sce.10039>
- ICJ. (2010). *Accordance with International Law of the Unilateral Declaration of Independence in Respect of Kosovo, Advisory Opinion, I.C.J. Reports 2010*. International Court of Justice. <https://www.icj-cij.org/public/files/case-related/141/141-20100722-ADV-01-00-EN.pdf>
- Konstantopoulos, S. (2005). *Trends of school effects on student achievement: Evidence from Nls:72, Hsb:82, and Nels:92*. IZA Discussion Paper No. 1749. IZA Institute of Labor Economics, Boston College. <https://ssrn.com/abstract=822350>
- Lin, L., Somerville, G., Boursier, J., Santisteban, J. A., & Gruber, R. (2020). Sleep duration is associated with academic achievement of adolescent girls in mathematics. *Nature and Science of Sleep*, 2020(12), 173–182. <https://doi.org/10.2147/NSS.S237267>
- Magnhounj, S., Fordham, E., Guthrie, C., Henderson, K., & Trujillo, D. (2020). *OECD reviews of evaluation and assessment in education: Albania*. OECD Publishing. <https://doi.org/10.1787/d267dc93-en>
- Martin, M. O., von Davier, M., & Mullis, I. V. S. (Eds.). (2020). *Methods and procedures: TIMSS 2019 technical report*. TIMSS & PIRLS International Study Center, Boston College. <https://timssandpirls.bc.edu/timss2019/methods>
- Meinck, S., & Brese, F. (2019). Trends in gender gaps: Using 20 years of evidence from TIMSS. *Large-Scale Assessments in Education*, 7, 8. <https://doi.org/10.1186/s40536-019-0076-3>
- Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 international results in mathematics and science*. TIMSS & PIRLS International Study Center, Boston College. <https://timssandpirls.bc.edu/timss2019/international-results/>
- Owens, J. A., Belon, K., & Moss, P. (2010). Impact of delaying school start time on adolescent sleep, mood, and behavior. *Archives of Pediatrics and Adolescent Medicine*, 164(7), 608–614. <https://doi.org/10.1001/archpediatrics.2010.96>
- Papanastasiou, C. (2008). A residual analysis of effective schools and effective teaching in mathematics. *Studies in Educational Evaluation*, 34, 24–30. <https://doi.org/10.1016/j.stueduc.2008.01.005>
- Papanastasiou, C., & Papanastasiou, E. C. (2004). Major influences on attitudes towards science. *Educational Research and Evaluation*, 10, 239–257. <https://doi.org/10.1076/edre.10.3.239.30267>
- Papanastasiou, E. C., Zembylas, M., & Vrasidas, C. (2004). Can computer use hurt science achievement? The USA results from PISA. *Journal of Science Education and Technology*, 12, 325–332. <https://doi.org/10.1023/A:1025093225753>
- United Nations. (1999). *Resolution 1244 (1999). Adopted by the Security Council at its 4011th meeting, on 10 June 1999*. United Nations Security Council. <https://digitallibrary.un.org/record/274488?ln=en>
- United Nations. (2018). *Sustainable development goals*. United Nations. <http://www.un.org/sustainabledevelopment/sustainable-development-goals/>

- White, S. W., Reynolds, P. D., Thomas, M. M., & Gitzlaff, N. J. (1993). Socioeconomic status and achievement revisited. *Urban Education*, 28, 328–343. <https://doi.org/10.1177%2F0042085993028003007>
- Yayan, B., & Berberoğlu, G. (2004). A re-analysis of the TIMSS 1999 mathematics assessment data of the Turkish students. *Studies in Educational Evaluation*, 30, 87–104. [https://doi.org/10.1016/S0191-491X\(04\)90005-3](https://doi.org/10.1016/S0191-491X(04)90005-3)
- Yin, L., & Fishbein, B. (2020). Creating and interpreting the TIMSS 2019 context questionnaire scales. In M. O. Martin, M. von Davier, & I. V. S. Mullis (Eds.), *Methods and procedures: TIMSS 2019 technical report* (pp. 16.1–16.331). TIMSS & PIRLS International Study Center, Boston College. <https://timssandpirls.bc.edu/timss2019/methods/chapter-16.html>
- Zohar, A., Degani, A., & Vaaknin, E. (2001). Teachers' beliefs about low-achieving students and higher order thinking. *Teaching and Teacher Education*, 17(4), 469–485. [https://doi.org/10.1016/S0742-051X\(01\)00007-5](https://doi.org/10.1016/S0742-051X(01)00007-5)

Rezana Vrapı was appointed as Director General of the Education Services Centre in 2014. Prior to that, she worked as an Assessment Specialist of the Albanian Language and Literature at the National Agency of Examinations, for a period of 16 years. She is an expert in the field of assessment, test design, and test scoring of national assessments/exams. Ms. Vrapı is an external lecturer at the University of Tirana. She has published numerous articles in the field of assessment and language.

Agim Alia was appointed as the head of the Assessment Directory of the Education Services Centre in 2016. Prior to that, he worked for two years as the attorney of National Agency of Examinations and for four years at the Institute of Educational Development. He is specialized in education legislation and policies. Mr. Alia is an external lecturer at the University Aleksandër Moisiu, Durrës.

Falk Brese is a senior research analyst at IEA's Research and Analysis Unit. His research interests are in social inequalities and immigration, the transition of research results from reporting to policy implementation, as well as international large-scale assessment (ILSA) methodology. He has worked at IEA since 2000 and has ample experience with the implementation of ILSAs and analyzing respective data. He has a background in political science with a focus on policy formation and implementation.

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