Students' Interests, Motivation, and Self-beliefs

Barbara Japelj Pavešić, Marina Radović, and Falk Brese

Abstract Effective teaching of mathematics and science includes understanding the importance of positive attitudes toward learning, and fostering their development among students. Many studies have shown that students' motivation to learn is related to higher achievement, but when making decisions to improve learning and practice, it is important to recognize that cultural influences may also play a role, and establishing links between achievement and motivation are thus especially complex. As well as measuring student achievement, IEA's Trends in International Mathematics and Science Study (TIMSS) thus collects data about these contexts for learning through questionnaires completed by students and their parents, teachers, and school principals. Data gathered by TIMSS 2019 at grade four indicate that relationships between motivation and achievement show many similarities across the Dinaric region, and reveal characteristics of the underlying structure of relations between attitudes, achievement, and learning support to students in the region. As expected, students with more home learning resources tended to show higher mathematics and science achievement. Students' confidence in their mathematics or science abilities tended to be positively correlated with their achievement. Associations between mathematics or science achievement and liking learning mathematics and science were weaker than the links with reported confidence, but students who reported feeling more confident in mathematics or science and those who reported stronger feelings of belonging to their school were also more likely to report that they liked mathematics and science. There was no strong association between students' home learning resources and liking learning subjects; thus indicates that school environment plays an important role in supporting motivation for learning. Although similar

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relations were found across the region, student attitudes in education systems where achievement was high tended to be more negative; this is known as the attitudes-achievement paradox. The results suggest that further studies of national attitudes are needed to better understand local relations between student motivations and achievement.

Keywords Attitudes toward learning · Dinaric region · Grade four education · Mathematics · Science · Student achievement · Student motivation · Student self-efficacy · Teaching · Trends in International Mathematics and Science Study (TIMSS)

1 Introduction

Effective teaching of mathematics and science includes understanding the importance of developing and fostering positive attitudes toward learning among students. Many studies show that students' motivation to learn is associated with higher achievement. According to Ryan and Deci (2002), self-determined, or autonomous motivation is related to positive academic and emotional outcomes (Um, 2008). Studies in schools (Ma & Kishor, 1997; Nicolaidou & Philippou, 2004) indicated that better motivation leads to better knowledge of mathematics. However, the connection between attitudes and achievement is complex, and measuring motivation across studies is also complex (Lee & Stankov, 2018). IEA's Trends in International Mathematics and Science Study (TIMSS) has shown, for example, that there were large differences among countries in the relationship between mean values on the scales measuring student attitudes toward learning and their average achievement over twenty year period from TIMSS 1995 to 2015 (Mullis et al., 2016b). TIMSS has recognized enjoyment-achievement and confidence-achievement paradoxes (Mullis et al., 2016b). In any TIMSS assessment, there will always be some education systems where mean attitudes toward learning and means for the scales measuring student self-confidence are well above the TIMSS international average, yet mean student achievement is close to or below the TIMSS international average. Conversely, in other education systems, means for measures of attitudes toward learning may be relatively low, despite high mean student achievement.

As the number of education systems participating in TIMSS has grown over more than two decades, TIMSS has noted that in some high-achieving countries, the percentages of students disliking mathematics have increased as achievement increased, while in some low-achieving countries, the percentage of students who disliked mathematics and achievement both decreased. TIMSS 2015 reported that the average correlation coefficient between student confidence and TIMSS mathematics achievement for grade four students was high (0.67), indicating that high-achieving countries also contained larger numbers of students who felt they did not usually do well in mathematics (Mullis et al., 2016b). Therefore, to improve education internationally, an understanding of the within-country relationship between

students' attitudes toward learning and their achievement is essential to identify which particular aspects of attitudes are most strongly linked to achievement and conceive possible explanations for observed relationships. Such in-depth analyses can inform strategies designed to help teachers improve specific aspects of student motivation.

2   Background and Research Questions

We explored the relations between student achievement, student attitudes toward mathematics and science, and the support provided by schools and families. When making decisions designed to improve learning and practice, identifying which factors of motivation are nationally important is an essential first step. Learning from other systems with similar cultural backgrounds can help to inform decisions, based on effective practices that already exist in the region. Seven participants from the Dinaric region took part in TIMSS 2019, namely Albania, Bosnia and Herzegovina, Croatia, Kosovo,[1] Montenegro, North Macedonia, and Serbia.

Across the Dinaric region, only Serbia and Croatia had participated in both of the two previous cycles of TIMSS (2011 and 2015). In TIMSS 2015, the mean mathematics achievement of grade four students in Serbia was above the TIMSS international average (scale center point); in Croatia, the mean mathematics achievement of grade four students was close to the TIMSS international average (the scale center point), and hence lower than Serbia (Mullis et al., 2016a). The mean science achievement of grade four students was also above the TIMSS 2015 average for both entities, while higher in Croatia than in Serbia (Martin et al., 2016).

TIMSS traditionally measures also trends in student engagement and attitudes toward learning of mathematics and science. To accomplish this, data about the contexts for learning are collected through questionnaires completed by students and their parents, teachers, and school principals (for more information, see TIMSS & PIRLS International Study Center, 2018). Responses to items on the student questionnaire are used to build the TIMSS scales of liking learning mathematics and science (see Yin & Fishbein, 2020, pp. 16.89–16.102). These two scales are each modeled from students' agreements with nine statements on his/her attitudes toward mathematics or science, the categories that students can select from being "agree a lot," "agree a little," "disagree a little," or "disagree a lot." The resulting continuous scales allocate higher scale values for the students who report more positive attitudes toward learning mathematics or science; these are divided into three sequential scale intervals and, consequently, students who mostly or always "agree a lot" were categorized as "very much like learning mathematics/science," those who generally "agreed a little" as "like learning mathematics/science," and all others as "do not like

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[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).

learning mathematics/science," depending on the score they achieved on the scale (see Yin & Fishbein, 2020).

In TIMSS 2015, about half of the students reported liking mathematics very much in Serbia, while this applied only to 29% of students in Croatia, although, for both Serbia and Croatia, the mean score on the liking learning mathematics scale increased between TIMSS 2011 and TIMSS 2015. This last point is interesting because an increase in the mean score for liking learning mathematics was evident in only eight of the 49 school systems that participated in both TIMSS 2011 and TIMSS 2015. Achievement has increased consistently across all the groups of students by their reports of liking learning mathematics (those who do not like, like, or very much like) in both school systems.

TIMSS similarly uses responses to the student questionnaire to define categories of students as being "very confident," "confident," or "less confident" in mathematics or science, based on the ranges of scores on international TIMSS confidence scale (see Yin & Fishbein, 2020). Among all the countries and systems participating in TIMSS 2015, Serbia had the highest percentage of grade four students who reported feeling very confident in mathematics and science (45 and 54%; Mullis et al., 2016a; Martin et al., 2016). In Croatia, only about a third of the students were found to be very confident in mathematics, a value close to the TIMSS average, although nearly half of students were very confident in science.

Serbia's mean score on the liking to learn science scale was at the international mean in 2015 and had increased between the TIMSS 2011 cycle and the TIMSS 2015 cycle, while Croatia's mean score was below the international mean in 2015 (Martin et al., 2016). Mean achievement increased more among the students who did not like learning or merely liked learning science (in Serbia, by 16 points and 15 points, respectively, and, in Croatia, by 18 points and 21 points, respectively, on a scale with mean of 500 and standard deviation of 100) than among students who reported that they liked learning science very much (in Serbia, this increase was three points and, in Croatia, 16 points) (Martin et al., 2012). Mean scores on the confident in science scale were very high; these were above the TIMSS average both in Serbia and Croatia, although Croatia's mean score decreased between 2011 and 2015. In both systems, better achievement was associated with higher confidence in science (Martin et al., 2016). Therefore, in these two systems of the Dinaric region, patterns of attitudes and achievement appear to differ. Across all the education systems that participated in TIMSS 2015, confidence in mathematics was also found to be a moderately strong correlate of mathematics achievement for grade four, but liking to learn mathematics was only associated with mathematics achievement in some systems. Another general attitude toward school, sense of school belonging, was weakly related to grade four students' achievement across all education systems that participated in TIMSS 2015 (Lee & Chen, 2019).

Many researchers have focused on the relationships between student motivation and knowledge, especially regarding mathematics. Mata et al. (2012) undertook a large meta-analysis study, and found that mathematics achievement was influenced by many factors, with student attitudes explaining a significant part of the variance.

In another meta-analysis of 113 studies, Ma and Kishor (1997) concluded that relations between attitudes toward mathematics and knowledge are generally weak, but increase in strength with the age of students. Another study showed that motivation could explain almost a third of the variance in mathematics achievement (Lipnevich et al., 2011). In Singapore, where the average achievement scores and attitude scale scores for students in grade eight are traditionally among the highest of all the education systems that participate in TIMSS, researchers believe that the reasons for those positive relations lie within their national curriculum (Fan et al., 2005). Developing strong positive attitudes toward learning mathematics is one of the five components of Singapore's mathematics framework and an important goal of teaching mathematics.

In previous TIMSS studies, comparisons of relations between attitudes and achievement in all participating entities revealed that positive associations at the student level become negative associations in between-country comparisons of mean achievement and attitudes; this is termed the attitudes-achievement paradox (first described by Bertling and Kyllonen 2013 in connection with international large-scale assessment). The attitudes-achievement paradox has been documented across domains and replicated across assessment cohorts (Kennedy & Trong, 2006; Kyllonen & Bertling, 2014). Differing explanations have been proposed to explain this paradox. In some of the highest achieving participants, this has been related to cultural differences reflected in students' responses to the questions; modesty bias or negativity toward the high expectations and academic pressures widely may be prevalent in high-achieving Asian countries (Min et al., 2016). Others have suggested that a "big-fish-little-pond" effect may be present, where the student's answers to such questions can only be judged relative to the expectations and performance of their immediate peers; a student within a group of high-achieving peers may tend to report relatively lower confidence and enjoyment in a subject, while the same student might report more positive attitudes toward learning if they were placed in an environment with lower expectations (Mullis et al., 2016b). Given TIMSS 2019 provided a unique opportunity to make regional comparisons, we were interested to learn whether this paradox was also present across the culturally relatively similar Dinaric region; namely, whether higher achievement was associated with less positive attitudes toward mathematics and science in comparisons between these education systems.

Seven TIMSS participants from the Dinaric region took part in TIMSS 2019. The study data can therefore provide a comprehensive summary of students' attitudes and achievement (and their relationship) across this region. Our main hypotheses were that: (a) student achievement was most strongly linked to student motivation for learning the subject, and (b) family and school support was positively related to attitudes toward learning and student achievement, but (c) there are differences in mean achievement, in attitudes, or in relationships between attitudes and achievement among participants from the Dinaric region. Our goal was to discover the relationships between students' enjoyment of learning about mathematics and science and their respective mathematics and science achievement. Identifying the factors related to whether or not students like to learn mathematics and science, and which of these factors are related to achievement in each participating education system from the

Dinaric region provides a critical understanding of differences and commonalities among TIMSS participants in the Dinaric region. Better knowledge of the issues can support the development of strategies for empowering teachers with an appreciation of best methods to enhance positive student motivation within the context of their individual education systems.

Our work was thus guided by four key research questions:

(1) *Do students across the Dinaric region differ in their attitudes toward mathematics and science?*
(2) *Which student attitudes are related to their achievement?*
(3) *How are student attitudes related to support provided by their parents/guardians and schools?*
(4) *Across the Dinaric region, which particular elements of all observed attitudes are most strongly linked with student attitudes toward learning mathematics and science, and their TIMSS 2019 mathematics and science achievement?*

3   Data and Methods

We used data collected from students and their parents/guardians from seven participants from the Dinaric region as part of TIMSS 2019. Data includes mathematics and science achievement scores, scaled from the students' answers to the TIMSS 2019 mathematics and science test items, as well as students' and parents'/guardians' responses to questions or statements in the TIMSS context questionnaires (see TIMSS & PIRLS International Study Center, 2018) about their learning of mathematics and science (Table 1). All these items had four answer categories: "agree a lot," "agree a little," "disagree a little," and "disagree a lot." The answers from all participating students in TIMSS were modeled using item response theory (IRT) methods (see Sect. 5 and Yin & Fishbein, 2020 for further details) to create different attitudinal scales and indexes.

Socioeconomic status was assessed by collecting information on the learning support materials that students could access at home. Students and/or parents were asked whether the student had their own room, a study desk, a computer or tablet, a mobile telephone for the student to use, family access to internet, and to assess the number of books in the home (TIMSS & PIRLS International Study Center, 2018). The TIMSS home resources for learning (HRL) scale was derived from students' and parents' answers (Yin and Fishbein 2020, pp. 15.33–15.37). This scale can be used to describe learning conditions of students at home in a condensed way. Similar to other TIMSS scales, the HRL scale was further simplified by translating it to an index variable comprising three levels: "many," "some," and "few" resources. We used the index variables in the descriptive statistical analyses and the continuous variables of scales for the regression analyses. In all our statistical analyses, we followed specific requirements for working with international large-scale assessment data, such as using weights, sampling errors and procedures for calculations with plausible values (see Sect. 5).

Table 1 List of variables used in our analyses

TIMSS attitude scale	Questions (items) used to form the attitude scale	Description of the scale categories	Reference
Students like learning mathematics/science[a]	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	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	Mullis et al. (2020), exhibits 11.1 and 11.4

(continued)

Table 1 (continued)

TIMSS attitude scale	Questions (items) used to form the attitude scale	Description of the scale categories	Reference
Students confident in mathematics/science[a]	I usually do well in mathematics/science Mathematics/science is harder for me than for many of my classmates I am just not good at mathematics/science I learn things quickly in mathematics/science Mathematics makes me nervous/- I am good at working out difficult mathematics problems/- My teacher tells me I am good at mathematics/science Mathematics/science is harder for me than any other subject Mathematics/science makes me confused	Students were defined as "very confident" in mathematics and science when they had a score at or above the cut score corresponding to "agreeing a lot" with five of the nine statements for mathematics and four of the seven statements for science, and "agreeing a little" with the other four statements for mathematics and three for science, on average Students who were "not confident" in mathematics or science had a score at or below the cut score corresponding to "disagreeing a little" with five of the nine statements for mathematics and four of the seven statements for science and "agreeing a little" with the other four for mathematics and three for science, on average All other students were "somewhat confident" in mathematics or science	Mullis et al. (2020), exhibits 11.7 and 11.10

(continued)

Table 1 (continued)

TIMSS attitude scale	Questions (items) used to form the attitude scale	Description of the scale categories	Reference
Students' sense of school belonging[a]	I like being in school I feel safe when I am at school I feel like I belong at this school Teachers at my school are fair to me I am proud to go to this school	Students with a "high sense of school belonging" had a score at or above the cut score corresponding to "agreeing a lot" with three of the five statements and "agreeing a little" with the other two statements, on average Students with "little sense of school belonging" had a score at or below the cut score corresponding to "disagreeing a little" to three of the five statements and "agreeing a little" with the other two statements, on average All other students had "some sense of school belonging"	Mullis et al. (2020), exhibit 7.9

Table 1 (continued)

TIMSS attitude scale	Questions (items) used to form the attitude scale	Description of the scale categories	Reference
Parents' perceptions of their child's school[a]	My child's school does a good job including me in my child's education	Students were scored according to their parents' responses to eight statements on the scale	Mullis et al. (2020), exhibit 7.6
	My child's school provides a safe environment	Students whose parents are "very satisfied" with their child's school had a score at or above the cut score	
	My child's school cares about my child's progress in school	corresponding to their parents "agreeing a lot" with four of the eight statements and "agreeing a little" with the other four, on average	
	My child's school does a good job informing me of his/her progress	Students whose parents are "less than satisfied" had a score at or below the cut score corresponding to their parents	
	My child's school promotes high academic standards	"disagreeing a little" with four of the eight statements and "agreeing a little" with the other four, on average	
	My child's school does a good job helping him/her become better in reading	All other students had parents who are "somewhat satisfied"	
	My child's school does a good job helping him/her become better in mathematics		
	My child's school does a good job helping him/her become better in science		

Notes [a]This TIMSS scale is 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 information on scale construction, please see Yin and Fishbein (2020)

In some of our descriptive analyses, we combined students assigned to the high- and medium-attitude scale categories into one group; students in the lowest attitude scale category comprised the comparison group. For example, for many of our analyses, we simplified things by combined the group of students reporting they liked learning mathematics with the group of students that reported they liked learning mathematics very much, to form the combined group "students who like learning mathematics." We applied a similar recoding scheme to the indices for students like learning science, students confident in mathematics/science, students' sense of belonging, and parents' perceptions of school performance.

4 Results

4.1 Attitudes Across the Dinaric Region

Among grade four students in the seven TIMSS 2019 participants from the Dinaric region, we found that student reports of liking to learn mathematics and science and feeling confident in these subjects differed across the region, while students' sense of school belonging and parental perceptions about their child's school were largely similar. In all seven participants from the Dinaric region, almost all students reported that they felt that they belonged to their school, and nearly all parents/guardians reported positive perceptions of school performance.

When we separated the data by education system (Fig. 1; see also Table S.3 in the supplementary materials available for download at www.iea.nl/publications/RfEVol13), we noted similar patterns across attitudes. In Albania, Kosovo, North Macedonia, and Montenegro, more students reported liking to learn mathematics and science than feeling confident in these subjects. Conversely, in Croatia and Serbia, more students reported that they felt confident in mathematics than liking to learn mathematics. In Bosnia and Herzegovina, the percentages for these two categories did not differ. Overall, in Croatia and Serbia, fewer students reported positive attitudes towards learning mathematics than in other Dinaric education systems (65% and 74%, respectively, versus >90% in Albania, Kosovo, North Macedonia, and Montenegro). It is encouraging that around 80% of all students across the Dinaric region liked learning mathematics and science and also felt confident in these subjects. However, there seems to be some discrepancy between confidence and achievement, at least in a cross-comparative context, as students' mean performance scores in Albania, Croatia, and Serbia were around the TIMSS 2019 international average, while students in the other four education systems performed significantly below the TIMSS 2019 international average (Mullis et al., 2020).

When we disaggregated the student distributions within each education system, we found that the differences in the relative sizes of the extreme and moderate groups were noteworthy. In Croatia and Serbia, the percentages of students who
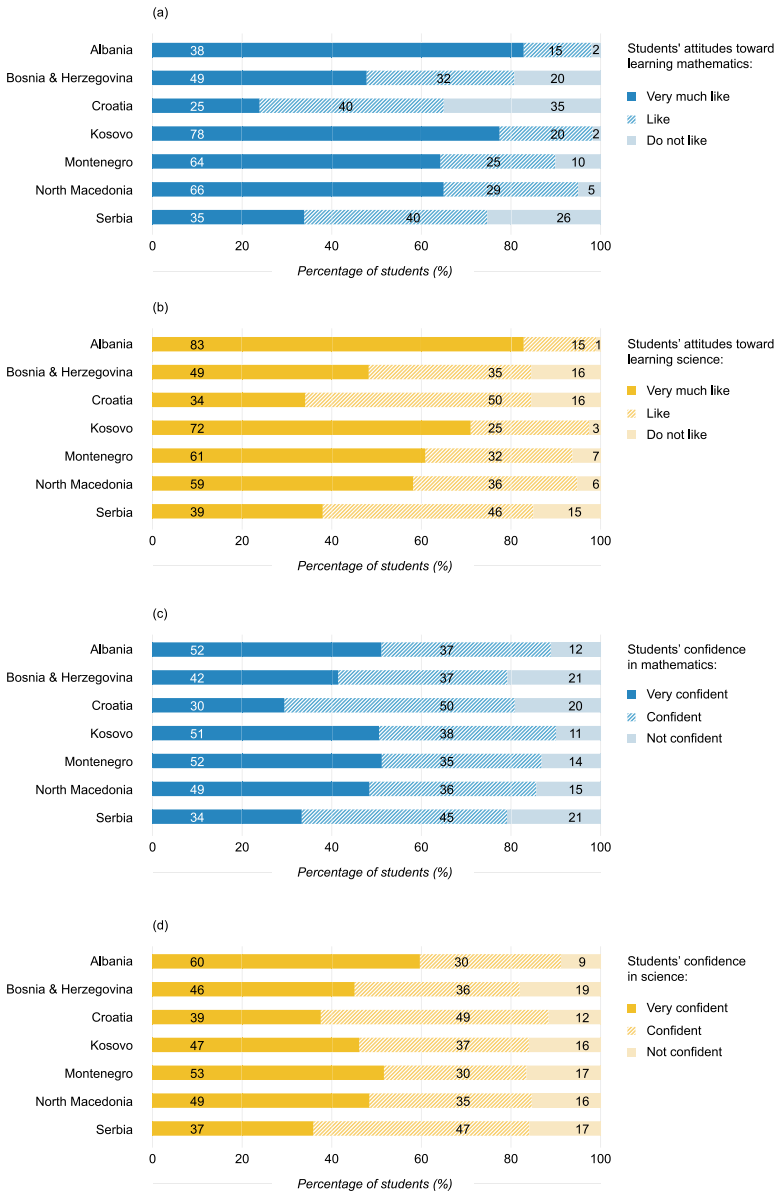
Fig. 1 Percentages of students in each category of six TIMSS 2019 attitude scales: **a** students like learning mathematics, **b** students like learning science, **c** students confident in mathematics, **d** students confident in science, **e** students' sense of school belonging, and **f** parents' perceptions of their child's school. *Notes* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population (See Table 1 for more information about the TIMSS 2019 attitude scales (see also Table S.3 in the supplementary materials available for download at www.iea.nl/pub lications/RfEVol13)

(e)

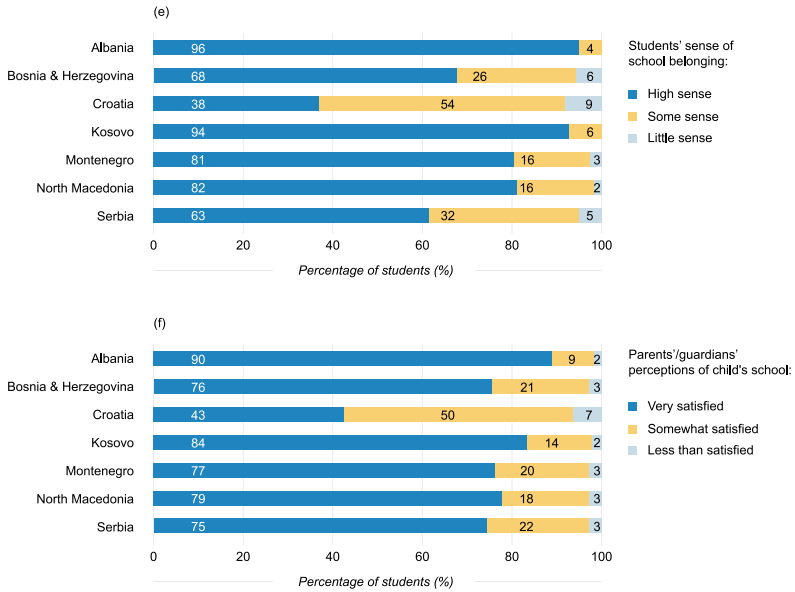|	Students' sense of school belonging:
Albania	96 / 4
Bosnia & Herzegovina	68 / 26 / 6
Croatia	38 / 54 / 9
Kosovo	94 / 6
Montenegro	81 / 16 / 3
North Macedonia	82 / 16 / 2
Serbia	63 / 32 / 5

■ High sense
■ Some sense
□ Little sense

Percentage of students (%)

(f)

	Parents'/guardians' perceptions of child's school:
Albania	90 / 9 / 2
Bosnia & Herzegovina	76 / 21 / 3
Croatia	43 / 50 / 7
Kosovo	84 / 14 / 2
Montenegro	77 / 20 / 3
North Macedonia	79 / 18 / 3
Serbia	75 / 22 / 3

■ Very satisfied
■ Somewhat satisfied
□ Less than satisfied

Percentage of students (%)

Fig. 1 (continued)

liked learning mathematics or science "very much" and reported feeling "very" confident in mathematics or science were smaller than percentages of students who liked learning and were confident in mathematics and science. In Croatia, this pattern was also repeated for students' sense of school belonging and parents' perceptions of their child's school. However, in the other systems across the Dinaric region, this situation was reversed, and the extreme categories were chosen by larger percentages of respondents than the moderate categories. Students in Croatia and Serbia therefore chose the extreme answers to express their attitudes toward mathematics and science notably less frequently than students from other parts of the region; Albanian students and their parents/guardians tended to select the most positive attitudes.

Although these attitude scales may not be directly comparable, the mean values reported by these scales provide an overview of prevailing attitudes within these education systems (Table 2). In comparing national differences across the region with the international mean of 10 points, students' sense of school belonging was strongest in Albania, Montenegro, North Macedonia, and Kosovo, while student confidence was strongest in Croatia and parents' perceptions of their child's school were most positive in Serbia. Across all the participants, attitudes toward science were generally less positive than those toward mathematics. Albanian students reported low levels of confidence in undertaking both mathematics and science. In Montenegro, Bosnia and Herzegovina, and North Macedonia, students reported low confidence in science and low levels of liking learning science. In Serbia, students reported low levels for liking learning mathematics and science. Albania had the highest mean values for all scales and Croatia had the lowest means for all scales. Albania was above the international

Table 2 Mean attitude scores in TIMSS 2019 at grade four for each participating education system from the Dinaric region

Education system	Average score on attitude scale											
	Students like learning mathematics		Students confident in mathematics		Students like learning science		Students confident in science		Students' sense of belonging		Parents' perceptions of their child's school	
Albania	11.8	(0.05)	11.0	(0.07)	11.7	(0.06)	10.9	(0.07)	12.3	(0.03)	11.5	(0.05)
Bosnia & Herzegovina	10.1	(0.06)	10.5	(0.05)	**9.8**	(0.06)	10.2	(0.04)	10.5	(0.06)	10.8	(0.06)
Croatia	**9.1**	(0.07)	10.0	(0.06)	**9.3**	(0.06)	10.0	(0.05)	**9.2**	(0.06)	**9.5**	(0.05)
Kosovo[a]	11.4	(0.04)	11.0	(0.04)	10.9	(0.06)	10.3	(0.05)	12.2	(0.03)	11.1	(0.04)
Montenegro	10.9	(0.04)	11.1	(0.04)	10.5	(0.05)	10.5	(0.04)	11.2	(0.04)	10.9	(0.03)
North Macedonia	11.0	(0.06)	10.9	(0.06)	10.5	(0.07)	10.4	(0.08)	11.4	(0.05)	10.8	(0.05)
Serbia[a]	**9.6**	(0.07)	10.1	(0.07)	**9.5**	(0.07)	**9.9**	(0.06)	10.2	(0.06)	10.8	(0.06)

Notes The international mean score was set at 10.00 for all attitude scales; scores significantly below the TIMSS 2019 international means are shown in bold.

Standard errors appear in parentheses

[a]National defined population covers 90–95% of the national target population

means for all attitudes, while, in Serbia and Croatia, the means for several attitude scales were below the international means. In Croatia, only the student confidence scales showed mean values that exceeded the international means, while, in Serbia, the attitude scales indicated students tended not to enjoy learning mathematics or science, and lacked confidence in science.

4.2 Student Attitudes Toward Mathematics, Science, and Their Achievement

After examining these different patterns in attitudes, we also anticipated that these differences could be related to observed variation in student achievement on the TIMSS 2019 mathematics and science tests. We assessed whether and what relationships existed by calculating Pearson correlation coefficients (r) between student attitudes and achievement scores. In general, we observed stronger correlations between student achievement and student confidence in mathematics and science than between student achievement and students' liking to learn mathematics and science in all participating entities from the Dinaric region (Fig. 2; see also Table S.4 in the supplementary materials available for download at www.iea.nl/publications/RfEVol13).

According to Cohen's standard for evaluation (see Cohen, 1992; Cohen et al., 2003), the correlations between mathematics achievement and confidence in mathematics were moderate, ranging from 0.36 to 0.47. There was a difference of only around 0.1 between the participant with the highest correlation and the one with the lowest correlation, indicating that they were fairly similar. Correlations between mathematics achievement and students' liking to learn mathematics were weaker and the range of values wider. For students in Bosnia and Herzegovina, Serbia, Croatia, and Montenegro, the correlations were generally weak (≤ 0.2), while the correlations with mathematics achievement in North Macedonia and Albania were slightly stronger, but still only relatively weakly linked to liking to learn mathematics (≤ 0.3). Kosovo was the only system where mathematics achievement and liking to learn mathematics were moderately linked (a correlation of 0.35). Overall, mathematics achievement was consistently more strongly related to confidence in mathematics and more weakly related to liking to learn mathematics for all participants from the Dinaric region; the trend line also showed that as the strength of the correlation of achievement with confidence in mathematics increased, the correlation between achievement and liking to learn mathematics tended to decrease (Fig. 2a).

Similarly, correlations between science achievement and student confidence in science were weak for six of the participating entities (ranging from 0.26 in Serbia to 0.33 in Kosovo), while North Macedonia exhibited a moderate correlation (0.42). The correlations between students' science achievement and liking to learn science were also relatively weak, but there was a significant relationship in almost all the Dinaric education systems, except for Serbia. North Macedonia showed the highest
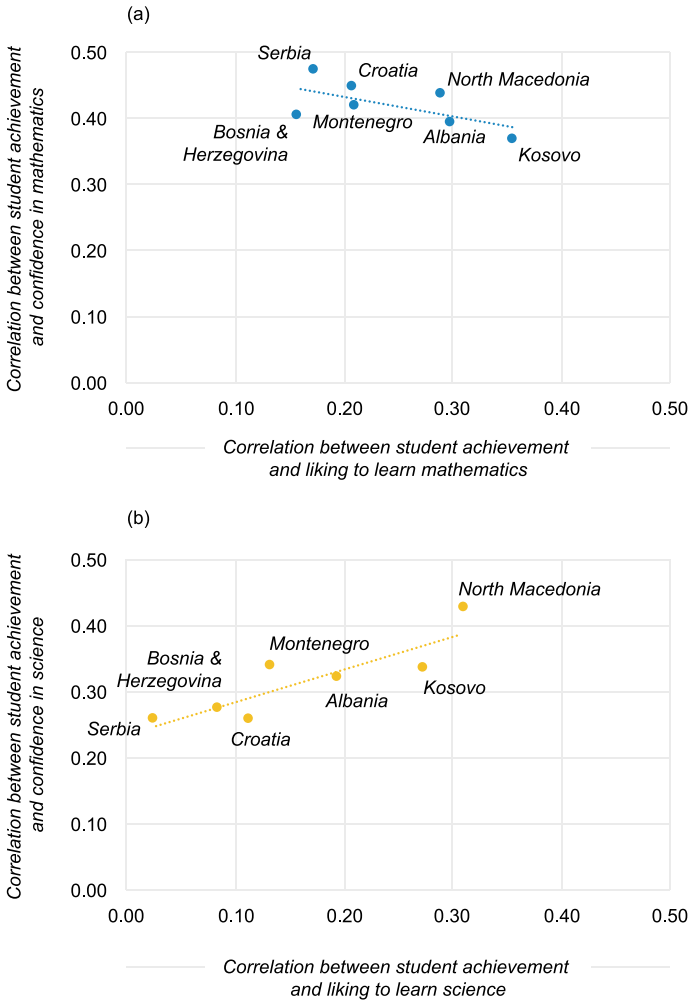
(a)

(b)

Fig. 2 Comparing the correlations between student achievement and students like learning scales against the correlations between student achievement and the students' confidence scales for **a** grade four mathematics and **b** grade four science. *Notes* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

correlation coefficient (≈0.3). Confidence in science was clearly more strongly associated with science achievement than liking to learn science (Fig. 2b). Interestingly, as opposed to our findings for mathematics, stronger correlations between science achievement and confidence in science were associated with stronger correlations between science achievement and liking to learn science across the region, as indicated by the increasing trend between points representing both correlation coefficients for each education system (Fig. 2b).

In general, our results for the Dinaric region are consistent with previous analyses for all systems participating in TIMSS 2015, where average confidence in mathematics was a stronger correlate of average achievement than average scores for liking to learn mathematics (Lee & Chen, 2019). The weaker correlations between achievement and liking to learn the subject compared to the correlations between achievement and confidence similarly reflect results from other countries confirmed by previous TIMSS studies (Mullis et al., 2016b). This may be partially because confidence scales include the student's self-evaluation of their knowledge in the respective subject. The student's assessment of their ability is likely to be based on prior feedback received about their success in a specific subject, and it is thus not unexpected that this would align with their measured achievement.

4.3 School Environment and Achievement

As anticipated, the attitudes of students and parents that were not directly linked to mathematics or science were less strongly related to student achievement (Table 3). Students' sense of school belonging was only positively correlated with mathematics and science achievement in Kosovo; in Serbia the correlation was negative. In Croatia, there was a positive correlation between students' sense of school belonging and their science achievement. According to Cohen's standard (Cohen, 1992; Cohen et al., 2003), correlations of <0.2 would have only a small effect. However, Kraft (2020) proposed that mean achievement differences of 0.05–0.2 should instead be

Table 3 Correlations between attitudes toward school and student achievement

Education system	Correlation between students' sense of school belonging and grade four student achievement in				Correlation between parents' perceptions of their child's school and grade four student achievement in			
	Mathematics		Science		Mathematics		Science	
Albania	0.03	(0.02)	0.04	(0.03)	−0.05	(0.03)	**−0.06**	(0.03)
Bosnia & Herzegovina	0.02	(0.02)	0.02	(0.02)	0.00	(0.02)	0.01	(0.02)
Croatia	0.03	(0.03)	**0.07**	(0.03)	−0.01	(0.03)	0.00	(0.03)
Kosovo[a]	**0.06**	(0.03)	**0.09**	(0.03)	−0.03	(0.02)	−0.02	(0.02)
Montenegro	0.01	(0.03)	−0.03	(0.02)	−0.01	(0.02)	0.01	(0.02)
North Macedonia	0.03	(0.04)	0.05	(0.04)	0.02	(0.02)	0.02	(0.02)
Serbia[a]	**−0.06**	(0.03)	**−0.07**	(0.03)	**0.07**	(0.02)	**0.08**	(0.02)

Notes Statistically significant ($p < 0.05$) correlation coefficients are shown in bold. Standard errors appear in parentheses
[a]National defined population covers 90–95% of the national target population

categorized as medium, since cross-country differences tend to be lower than within-system differences; in this respect, the correlations here may therefore be regarded as having medium effects.

Parents' perceptions of school performance, which are based on opinions about the effort and success of schools in helping students to achieve their full potential, were positively related to both mathematics and science achievement in Serbia and negatively related to science achievement in Albania. Although these relations were again weak, they indicated that, in Albania, students of parents who have more positive perceptions of their child's school, achieved lower scores in science than students of parents who held more negative perceptions of their child's school. Conversely, in Serbia, students with higher mathematics and science achievement in the TIMSS tests tended to have parents who reported more positive perceptions of their child's school than the parents of lower achieving students. Students' sense of belonging and parents' perceptions of school performance were only weakly related to outcomes, and the relationship was significant in only a few Dinaric participants. However, these findings could arise because there is very little variation in these variables; almost all students reported a strong sense of belonging to their school and the vast majority of parents felt that their child's school was doing well (see Fig. 1).

It is possible that parents may be more satisfied with how the school is working if their children present more positive attitudes toward learning and display higher levels of confidence in mastering important subjects. However, interestingly, in six of the seven Dinaric education systems, parents' perceptions of school performance were negatively related with students' liking to learn mathematics and science (Table 4). Moreover, in five of the Dinaric participants, parents' perceptions of school perfor-

Table 4 Correlations between parents' perceptions of school performance and the student attitude scales

Education system	Correlation between parents' perceptions of their child's school and the TIMSS attitude scale							
	Students like learning mathematics		Students confident in mathematics		Students like learning science		Students confident in science	
Albania	**−0.07**	(0.03)	**−0.08**	(0.02)	**−0.07**	(0.03)	**−0.06**	(0.02)
Bosnia & Herzegovina	**−0.09**	(0.02)	−0.03	(0.02)	**−0.06**	(0.02)	−0.03	(0.02)
Croatia	**−0.07**	(0.02)	**−0.07**	(0.02)	**−0.05**	(0.02)	**−0.05**	(0.02)
Kosovo[a]	**−0.05**	(0.02)	**−0.04**	(0.02)	**−0.08**	(0.02)	**−0.06**	(0.02)
Montenegro	**−0.11**	(0.01)	**−0.08**	(0.02)	**−0.09**	(0.02)	**−0.08**	(0.02)
North Macedonia	−0.03	(0.02)	−0.03	(0.02)	−0.03	(0.02)	−0.01	(0.02)
Serbia[a]	**−0.06**	(0.02)	**−0.04**	(0.02)	**−0.04**	(0.02)	−0.02	(0.02)

Notes Statistically significant ($p < 0.05$) correlation coefficients are shown in bold. Standard errors appear in parentheses

[a]National defined population covers 90–95% of the national target population

mance were negatively related with student confidence in mathematics and, in four participants, negatively related to student confidence in science.

These results are similar to a previous study of six parental involvement variables from TIMSS 2015 in 18 European countries (Koršňáková & Stefanik, 2019). Parental perceptions of school performance were the weakest predictors of student mathematics achievement, and generally non-significant, while home resources for learning was the strongest and most significant predictor of mathematics achievement in all the 18 selected European TIMSS participants.

In order to obtain a more detailed picture of parental perspectives, we disaggregated the percentages of students with parents who agreed "a lot" with the various statements about their child's school performance that were included on the TIMSS scale, parents perceptions of their child school (Fig. 3). In most TIMSS participants from the Dinaric region, parents generally agreed a lot with the statement that the school does a good job in helping the child to become better in reading, mathematics, and science, and they also seem to be mostly satisfied about being informed on progress, being included in the child's education, and that schools care about the child's progress. However, fewer parents agreed that the school provided a safe environment and, alarmingly, far fewer parents agreed that their child's school promoted high academic standards. The finding that parents in Croatia were less likely to agree a lot with the statements than parents in other parts of the region aligns with the generally larger percentages of students who were assigned to intermediate responses on the parents' perceptions of their child's school scale (Fig. 1) and with less positive attitudes in general in Croatia (Table 2).

Looking into these relations in more depth revealed other important facts about student attitudes. First, among all TIMSS participants in the Dinaric region, the relations between student's sense of school belonging with liking to learn or feeling confident in both mathematics and science were all significant and positive (Table 4). In other words, students who felt more attached to their school also tended to report greater enjoyment in learning and greater confidence in their capabilities, although we did note relatively large differences in the strength of these relations among the participating systems. In Serbia, Bosnia and Herzegovina, Montenegro, and Croatia, relations between students' sense of school belonging and liking to learn science, as well as liking to learn mathematics, were moderate to strong (correlation coefficient >0.3), while in all seven participants, the relations between students' sense of school belonging and students' confidence in both mathematics and science were weak, but nevertheless significant (Table 5).

Student attitudes appear to be more strongly connected to their achievement than their parents' attitudes toward their school. When defining priorities for improvements in learning practices at school and system level, it is always important to remember that the perceptions of students may differ from those of their parents, although the results here are consistent with the proposition that the quality of the school environment matters.
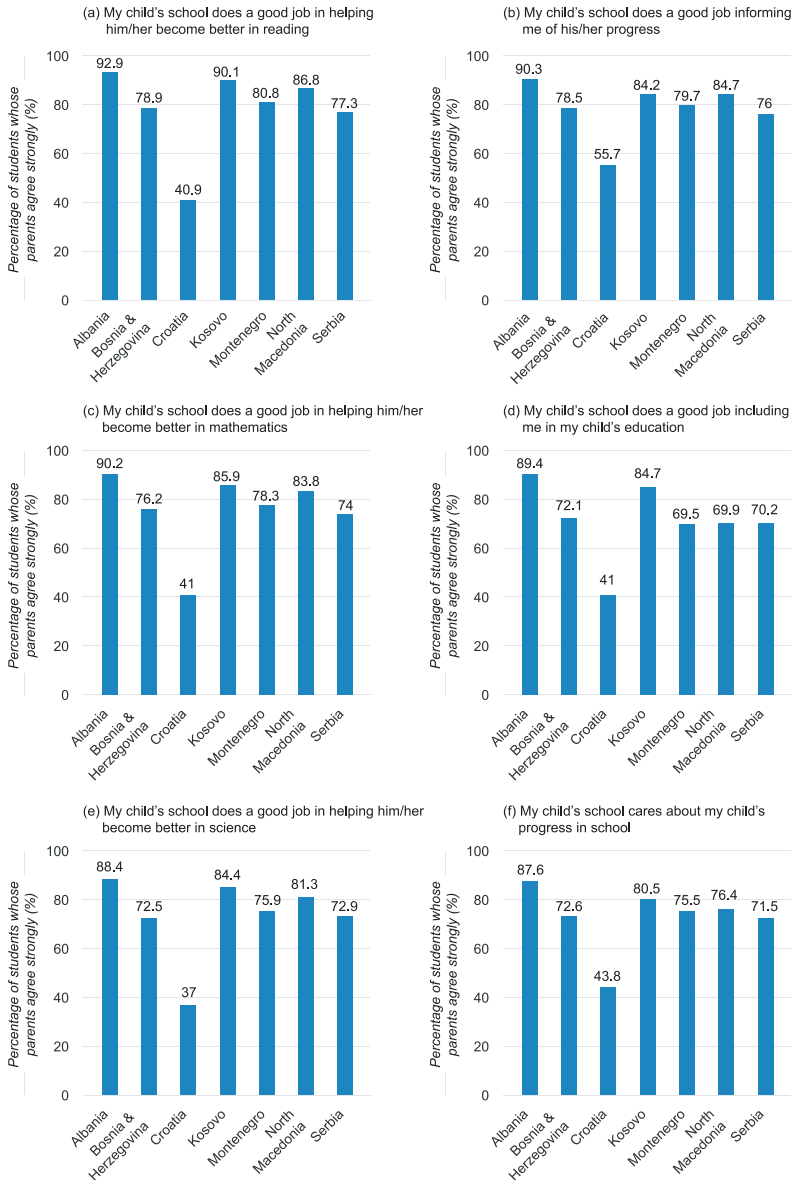
Fig. 3 Percentages of students whose parents agree "a lot" that their child's school: **a** does a good job in helping him/her become better in reading; **b** does a good job informing me of his/her progress; **c** does a good job in helping him/her become better in mathematics; **d** does a good job including me in my child's education; **e** does a good job in helping him/her become better in science; **f** cares about my child's progress in school; **g** provides a safe environment; and **h** promotes high academic standards. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population
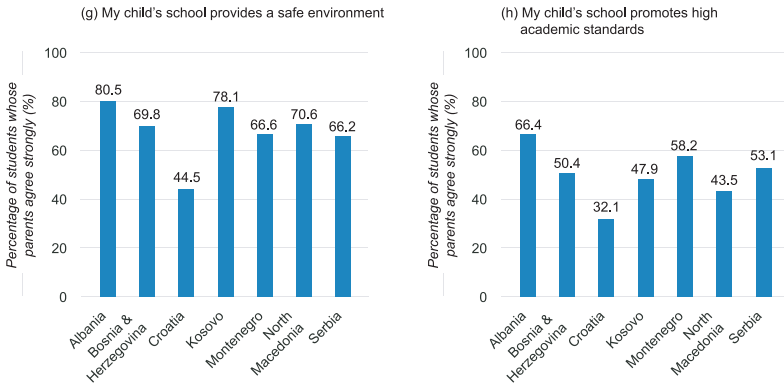
(g) My child's school provides a safe environment

Percentage of students whose parents agree strongly (%)

80.5 69.8 44.5 78.1 66.6 70.6 66.2

Albania / Bosnia & Herzegovina / Croatia / Kosovo / Montenegro / North Macedonia / Serbia

(h) My child's school promotes high academic standards

Percentage of students whose parents agree strongly (%)

66.4 50.4 32.1 47.9 58.2 43.5 53.1

Albania / Bosnia & Herzegovina / Croatia / Kosovo / Montenegro / North Macedonia / Serbia

Fig. 3 (continued)

Table 5 Correlations between students' sense of school belonging and other student attitude scales

Education system	Correlation between students' sense of school belonging and the attitude scale							
	Students like learning mathematics		Students like learning science		Students confident in mathematics		Students confident in science	
Albania	**0.23**	(0.02)	**0.22**	(0.02)	**0.15**	(0.02)	**0.13**	(0.02)
Bosnia & Herzegovina	**0.45**	(0.02)	**0.42**	(0.01)	**0.22**	(0.02)	**0.29**	(0.02)
Croatia	**0.41**	(0.03)	**0.39**	(0.03)	**0.27**	(0.04)	**0.27**	(0.03)
Kosovo[a]	**0.17**	(0.02)	**0.22**	(0.02)	**0.11**	(0.02)	**0.18**	(0.02)
Montenegro	**0.43**	(0.01)	**0.34**	(0.02)	**0.22**	(0.02)	**0.22**	(0.02)
North Macedonia	**0.26**	(0.03)	**0.27**	(0.03)	**0.15**	(0.02)	**0.17**	(0.02)
Serbia[a]	**0.48**	(0.02)	**0.42**	(0.02)	**0.26**	(0.02)	**0.28**	(0.02)

Notes Statistically significant ($p < 0.05$) correlation coefficients are shown in bold. Standard errors appear in parentheses

[a]National defined population covers 90–95% of the national target population

4.4 Relations Between Achievement and Attitudes

We derived between-system comparisons of attitudes and achievement by comparing mean scores on the TIMSS attitude scales with the mean achievement score for each education system. Note that the means of different attitude scales within education systems can also be influenced by differing cultural interpretation of the questions, and thus comparisons are tentative. However, in general, we observed that lower mean attitude scale scores were associated with higher mean achievement scores in both mathematics and science, which suggests that the attitude-achievement paradox was present across the Dinaric region (Fig. 4). Albania was an exception to this pattern,
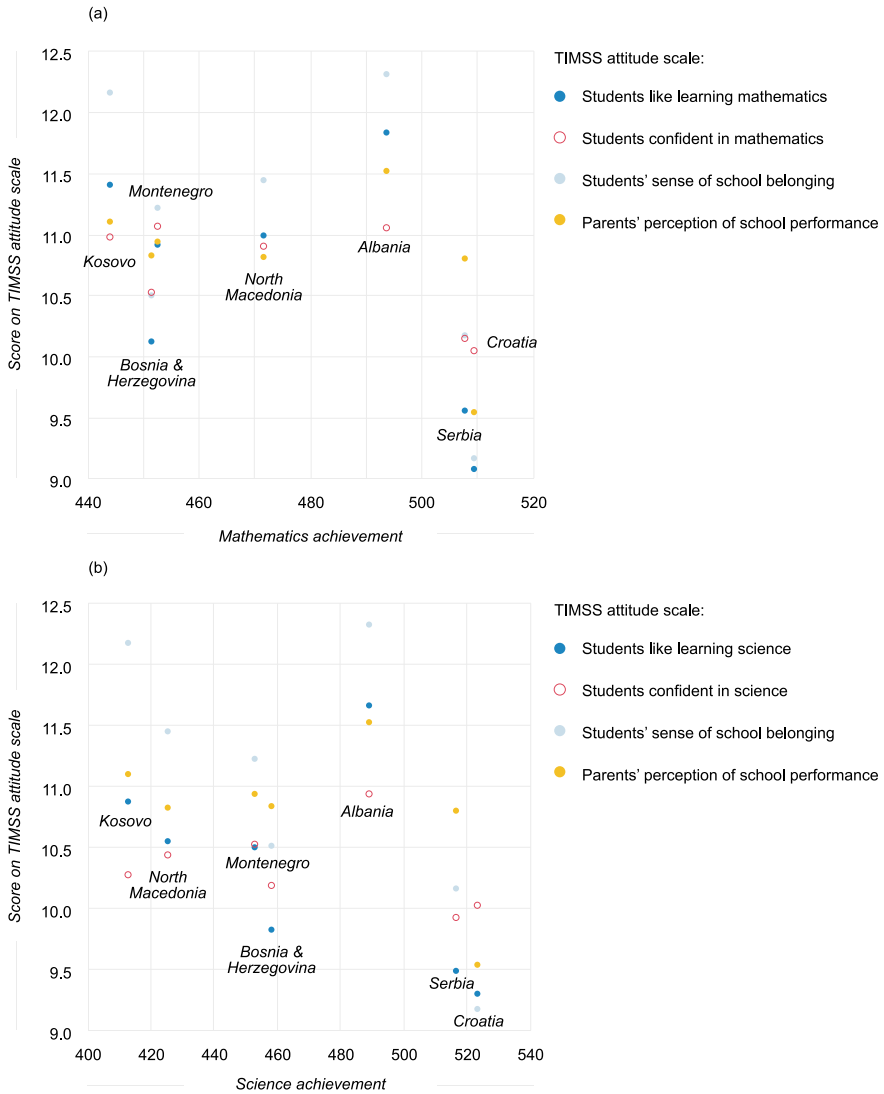
(a)

(b)

Fig. 4 Between-system comparisons of TIMSS 2019 achievement scores and attitudes for **a** grade four mathematics, and **b** grade four science. *Notes* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

recording both relatively high attitude scores and high student achievement; it is perhaps noteworthy that Albania was the only Dinaric participant that was not part of the former Yugoslavia.

To identify which factors may be linked to better learning environments and higher achievement in each education system, a more comprehensive framework is required. We therefore used a set of factors that describe students' background

and learning environments and applied four regression models to further analyze student motivations to learn mathematics and science and student achievement in those subjects. In these regression models, factors related to the learning environment were students' sense of school belonging and their parents' perceptions of school performance. Factors related to student background were student gender and family socioeconomic status, as well as students' confidence in mathematics and science.

We assessed the socioeconomic status of students' families across TIMSS Dinaric participants using the TIMSS 2019 HRL scale. In six of the seven Dinaric education systems, large majorities (≥80% of students) belonged to the intermediate category of students that possessed some resources at home; Albania was the exception, where only 65% of students fell into this intermediate category. The percentages of students having many resources at home ranged from four percent (Kosovo) to 13% (Serbia). The percentage of students having only few resources at home were relatively low for six of the participating systems, ranging from three percent (Croatia) to 15% (North Macedonia); Albania was again the exception, with a more substantial portion of students (30%) having few home resources for learning. Internet access is an important element of the HLR scale, and it is noteworthy that 36% of Albanian students did not have internet access at home; in other parts of the Dinaric region, the percentage of students without internet at home was much smaller.

We then analyzed students' liking to learn mathematics in terms of the five factors that we identified as related to the learning environment and student background. These factors explained a substantial percentage of the variance in liking to learn mathematics in our model (the variance was >40% in four of the seven education systems), from 21% in Kosovo to 53% in Serbia (Table 6). We also estimated the standardized regression coefficients for each factor (Table 6). Regression coefficients can provide greater understanding of the observed variance, indicating: (a) whether the factor makes a significant contribution toward explaining the variance in students' liking to learn mathematics, and (b) the relative strength of the relation between the individual factor and students' liking to learn mathematics, when all other factors are kept constant. We made boys the reference group for the coefficient on gender, thus negative values in our model indicated that girls were less likely to like to learn mathematics than boys, and vice versa.

For all participants from the Dinaric region, we found that confidence in mathematics was the factor that was most strongly related to liking to learn mathematics, followed by students' sense of school belonging (Table 6). The other three factors were significantly related to liking to learn mathematics in only some education systems, but regression coefficients were very small and thus, generally, the relevance of these three factors in the model was almost negligible. Student confidence in mathematics and their sense of school belonging seem to be much more strongly related to positive attitudes toward learning mathematics, and thus seem to be more strongly associated with successful learning.

We found similar results when we used regression modeling to analyze the relations of these five factors with students' liking to learn science (Table 7). Again, these factors explained a substantial percentage of the variance in liking to learn science

Table 6 Standardized regression coefficients for students' liking to learn mathematics

Education system	Number of students (n)	Variance (R^2) explained by model	Standardized regression coefficients: Students confident in mathematics		Students' sense of school belonging		Parents' perceptions of their child's school		Student gender (female)[b]		Students' family SES	
Albania	3924	0.28	**0.49**	(0.02)	**0.15**	(0.02)	0.00	(0.02)	0.01	(0.02)	0.00	(0.02)
Bosnia & Herzegovina	5073	0.46	**0.53**	(0.01)	**0.32**	(0.02)	**−0.03**	(0.01)	−0.02	(0.01)	**−0.06**	(0.01)
Croatia	3655	0.48	**0.57**	(0.02)	**0.28**	(0.02)	−0.01	(0.02)	**−0.07**	(0.02)	**−0.09**	(0.02)
Kosovo[a]	4038	0.21	**0.40**	(0.02)	**0.13**	(0.02)	−0.03	(0.02)	0.01	(0.02)	**0.09**	(0.02)
Montenegro	4039	0.42	**0.50**	(0.01)	**0.32**	(0.01)	−0.02	(0.01)	**−0.04**	(0.02)	**−0.05**	(0.01)
North Macedonia	2553	0.33	**0.52**	(0.02)	**0.17**	(0.03)	0.01	(0.02)	−0.03	(0.02)	−0.02	(0.03)
Serbia[a]	4170	0.53	**0.59**	(0.02)	**0.32**	(0.02)	0.02	(0.01)	−0.03	(0.02)	**−0.10**	(0.01)

Notes SES = socioeconomic status, as measured by the TIMSS 2019 home learning resources scale. R^2 = the proportion of variance in the outcome variable that is explained by the set of predictor variables. Statistically significant ($p < 0.05$) coefficients are shown in bold. Standard errors appear in parentheses

[a]National defined population covers 90–95% of the national target population

[b]Negative values for gender mean that boys tended to achieve higher scores on the student motivation scales than girls

Table 7 Standardized regression coefficients for students' liking to learn science

Education system	Number of students (n)	Variance (R²) explained by model	Standardized regression coefficients: Students confident in science		Students' sense of school belonging		Parents' perceptions of their child's school		Student gender (female)[b]		Students' family SES	
Albania	3915	0.32	**0.53**	(0.02)	**0.14**	(0.02)	−0.01	(0.02)	0.03	(0.02)	−0.01	(0.02)
Bosnia & Herzegovina	5040	0.43	**0.54**	(0.01)	**0.26**	(0.01)	0.00	(0.01)	−0.01	(0.01)	**−0.09**	(0.01)
Croatia	3648	0.47	**0.59**	(0.02)	**0.24**	(0.02)	0.00	(0.01)	**−0.06**	(0.02)	**−0.06**	(0.02)
Kosovo[a]	3985	0.29	**0.47**	(0.02)	**0.12**	(0.02)	**−0.04**	(0.02)	**0.08**	(0.02)	**0.07**	(0.02)
Montenegro	4105	0.33	**0.48**	(0.02)	**0.22**	(0.02)	−0.02	(0.02)	0.01	(0.01)	**−0.05**	(0.02)
North Macedonia	2516	0.41	**0.58**	(0.02)	**0.17**	(0.02)	−0.01	(0.02)	0.01	(0.02)	0.02	(0.02)
Serbia[a]	4128	0.47	**0.58**	(0.02)	**0.26**	(0.02)	0.02	(0.01)	−0.03	(0.02)	**−0.09**	(0.02)

Notes SES = socioeconomic status, as measured by the TIMSS 2019 home learning resources scale. R^2 = the proportion of variance in the outcome variable that is explained by the set of predictor variables. Statistically significant ($p < 0.05$) coefficients are shown in bold. Standard errors appear in parentheses

[a]National defined population covers 90–95% of the national target population

[b]Negative values for gender mean that boys tended to achieve higher scores on the student motivation scales than girls

in our model (the variance was again >40% in four of the seven education systems), and ranged from 29% (Kosovo) to 47% (Serbia) across the Dinaric region.

The model results again indicated that student confidence in science was most strongly associated with students' liking to learn science. Across the Dinaric region, students' sense of school belonging was again also strongly related to liking to learn science, but the standardized regression coefficients indicated that this factor made a smaller contribution toward explaining the variance than confidence. The other factors were significantly related to liking learning science in only a few participants and even when significant, the analyses showed relations were weak. Parents' perceptions of their child's school were related to liking to learn science among students in Kosovo, but the relation was negative, meaning that the more dissatisfied parents are with the performance of the child's school, the more students' like learning science (see Sect. 4.4). Family possession of learning resources was related to students' liking to learn science in five of the seven Dinaric participants. In Kosovo, having more home learning resources was positively related to liking to learn science. In Bosnia and Herzegovina, Croatia, Montenegro, and Serbia, having more home learning resources was negatively related to liking to learn science, a finding that is counter-intuitive and warrants further research. We note that our regression analysis model controlled for factors such as confidence and sense of belonging, but the simple direct correlation coefficient between home learning resources and liking to learn science was negative in Bosnia and Herzegovina (-0.1 ± 0.02), and not significant in Croatia or Montenegro; it only became a positive, but small value (0.1 ± 0.02) in Serbia. One explanation may be that families with high levels of home learning support may put more academic pressure on students, which in turn decreases their motivation toward learning, but it may also be that families with low levels of home learning resources place a high value on education and more strongly emphasize the importance of learning to their children.

We also modeled the relations among the five factors and liking to learn with TIMSS mathematics and science achievement (Table 8). In four school systems, the combination of the six factors explained considerable percentages of the variance in mathematics achievement (22–41% across the Dinaric region; see Table 8). In all the education systems, students' confidence in mathematics was positively related to their mathematics achievement when controlling for all other factors, but varied from being strongly related to mathematics achievement in Croatia, Serbia, and Bosnia and Herzegovina, to more weakly related to mathematics achievement in Kosovo and Albania. The second factor that was strongly related to mathematics achievement was the socioeconomic status of students' families as assessed by their home resources for learning. All the relations were positive, indicating that more home resources for learning and greater confidence can both be positively associated with higher achievement in TIMSS. Liking to learn mathematics was positively related to mathematics achievement in three participants, most strongly in Kosovo. However, in Bosnia and Herzegovina, students with lower mathematics achievement scores reported that they liked learning mathematics more than their high-achieving peers.

Table 8 Standardized regression coefficients for mathematics achievement

Education system	Number of students (n)	Variance (R²) explained by model	Standardized regression coefficients:										
			Students like learning mathematics		Students confident in mathematics		Students' sense of school belonging		Parents' perceptions of their child's school		Student gender (female)[b]		Students' family SES	
Albania	3924	0.25	**0.12**	(0.03)	**0.24**	(0.03)	**−0.04**	(0.02)	−0.03	(0.03)	−0.02	(0.02)	**0.32**	(0.03)
Bosnia and Herzegovina	5073	0.25	**−0.08**	(0.02)	**0.40**	(0.02)	−0.01	(0.02)	−0.03	(0.02)	**−0.06**	(0.02)	**0.28**	(0.02)
Croatia	3655	0.30	−0.06	(0.03)	**0.45**	(0.02)	**−0.06**	(0.02)	−0.02	(0.03)	**−0.06**	(0.02)	**0.29**	(0.03)
Kosovo[a]	4038	0.22	**0.22**	(0.03)	**0.23**	(0.03)	0.00	(0.02)	−0.03	(0.02)	**−0.06**	(0.02)	**0.22**	(0.02)
Montenegro	4039	0.24	0.03	(0.02)	**0.34**	(0.02)	**−0.05**	(0.02)	−0.03	(0.02)	−0.02	(0.02)	**0.27**	(0.02)
North Macedonia	2553	0.32	**0.08**	(0.03)	**0.29**	(0.03)	−0.04	(0.02)	−0.01	(0.02)	0.01	(0.02)	**0.38**	(0.03)
Serbia[a]	4170	0.41	−0.06	(0.03)	**0.44**	(0.03)	**−0.12**	(0.03)	0.01	(0.02)	0.02	(0.02)	**0.39**	(0.02)

Notes SES = socioeconomic status, as measured by the TIMSS 2019 home learning resources scale. R^2 = the proportion of variance in the outcome variable that is explained by the set of predictor variables. Statistically significant ($p < 0.05$) coefficients are shown in bold. Standard errors appear in parentheses

[a]National defined population covers 90–95% of the national target population

[b]Negative values for gender mean that boys tended to achieve higher scores on the student motivation scales than girls

In general, we found differing results across the seven Dinaric participants, leading to a range of different conclusions and interpretations about how students' learning environments and attitudes toward learning may affect student outcomes. For example, in Bosnia and Herzegovina, Croatia, and Kosovo, our modeling indicated that boys achieved higher TIMSS mathematics scores keeping all other factors constant, but, in the other four school systems, there were no gender differences in average mathematics achievement.

In Albania, mathematics achievement tended to be positively related to home learning resources, then to students' confidence, followed by liking to learn mathematics, but the analysis indicated that mathematics achievement was related negatively, albeit weakly, to students' sense of school belonging. In Bosnia and Herzegovina, mathematics achievement was most strongly positively related to students' confidence in mathematics, and then to home learning resources, while the relations with liking to learn mathematics and gender were both weakly negative. In Croatia, Montenegro, and Serbia, student achievement was most strongly positively related to students' confidence and slightly less strongly related to more home learning resources, but there was also a weakly negative relationship with students' sense of school belonging. In Croatia, gender was also related to mathematics achievement, with female students tending to score lower in TIMSS than male students. In Kosovo, three predictors showed similar strong relations with mathematics achievement: liking mathematics, feeling confident, and having more home learning resources. As in Croatia, female students tended to score lower on the mathematics test. In North Macedonia, home learning resources was the strongest positively related predictor of mathematics achievement, followed by a less positive relation with students' confidence; while there was also a positive relation to liking to learn mathematics, this was very weak.

We found that science achievement was generally less strongly related to the factors included in our analyses. In all participating school systems, the strongest predictor of higher science achievement was having more home learning resources (Table 9). This predictor was strongest in Serbia, while Kosovo and Bosnia and Herzegovina showed home resources for learning was a much weaker predictor of achievement. Students' confidence in science was also positively related to higher achievement in all TIMSS participants from the Dinaric region. Girls achieved higher scores in North Macedonia, but modeling showed there were no gender differences in achievement in other parts of the region. In Serbia, liking to learning science and sense of school belonging had negative relations with achievement, indicating students who scored highly on these scales tended to have lower science achievement scores. In Montenegro, the relation between sense of school belonging and science achievement was also weakly negative.

Table 9 Standardized regression coefficients for science achievement

Education system	Number of students (n)	Variance (R²) explained by model	Standardized regression coefficients:					
			Students like learning science	Students confident in science	Students' sense of school belonging	Parents' perceptions of their child's school	Student gender (female)[b]	Students' family SES
Albania	3915	0.19	0.02 (0.03)	**0.19** (0.03)	0.01 (0.02)	−0.03 (0.02)	0.01 (0.02)	**0.33** (0.03)
Bosnia and Herzegovina	5040	0.15	**−0.08** (0.02)	**0.28** (0.02)	−0.01 (0.02)	−0.02 (0.02)	0.01 (0.02)	**0.27** (0.02)
Croatia	3648	0.18	−0.05 (0.03)	**0.23** (0.03)	0.01 (0.03)	−0.02 (0.03)	−0.02 (0.03)	**0.34** (0.03)
Kosovo[a]	3985	0.18	**0.12** (0.03)	**0.22** (0.03)	0.02 (0.03)	0.00 (0.02)	0.00 (0.02)	**0.26** (0.03)
Montenegro	4105	0.21	−0.03 (0.02)	**0.31** (0.02)	**−0.06** (0.02)	−0.03 (0.02)	0.01 (0.02)	**0.30** (0.02)
North Macedonia	2516	0.32	0.06 (0.04)	**0.26** (0.03)	−0.03 (0.03)	−0.02 (0.02)	**0.04** (0.02)	**0.39** (0.03)
Serbia[a]	4128	0.30	**−0.11** (0.03)	**0.24** (0.03)	**−0.07** (0.03)	0.01 (0.02)	0.03 (0.02)	**0.46** (0.03)

Notes SES = socioeconomic status, as measured by the TIMSS 2019 home learning resources scale. R^2 = the proportion of variance in the outcome variable that is explained by the set of predictor variables. Statistically significant ($p < 0.05$) coefficients are shown in bold. Standard errors appear in parentheses

[a]National defined population covers 90–95% of the national target population

[b]Negative values for gender mean that boys tended to achieve higher scores on the student motivation scales than girls

5 Discussion

Our starting hypothesis that student achievement is most strongly linked to student motivation for learning the subject could be only partially supported, as we found that achievement was most strongly linked to student confidence in a subject. Our hypothesis that more family and school support for learning would be related to more positive student attitudes and better achievement could not be supported since, although sense of school belonging can be counted as school support and tended to be linked to positive attitudes toward mathematics and science, home learning resources were mostly negatively associated with students' liking of mathematics and science. Increased family and school support for learning was also generally unrelated to higher student achievement; while home learning resources were positively associated with achievement, there was no consistent strong positive relation with sense of school belonging.

In comparison to other systems in the Dinaric region, Albanian students had very strong positive attitudes toward mathematics and science, but, conversely, they reported the lowest confidence in mathematics and science, and their science achievement was negatively related to parents' perceptions of their school. When assuming all other factors were equal for all students, higher mathematics achievement was predicted for students who more often reported liking to learn mathematics, who were more confident in mathematics, and who had more home learning resources, but, curiously, achievement was also related to a lower sense of school belonging. Higher science achievement was predicted for students who were more confident in science and had more home learning resources.

In Bosnia and Herzegovina, the percentages of students who liked mathematics and science were similar to the percentages of students who felt confident about the subjects, but all these percentages were lower than the percentages of students who had a positive sense of school belonging and had parents who reported positive perceptions of their child's school. Higher mathematics and science achievement were negatively related to liking to learn mathematics or science but positively related to student confidence and access to home learning resources. It was interesting that students with lower mathematics achievement scores reported that they liked learning mathematics more than their high-achieving peers. One explanation may be that less privileged students get more attention from their teachers, and that this investment by their teachers consequently increases their enjoyment in learning mathematics.

In Croatia, the percentage of students who liked to learn mathematics was the lowest among all participating Dinaric school systems, and they tended to report the lowest percentages of positive attitudes in all our analyses. While science achievement was positively related to students' sense of school belonging, mathematics achievement was negatively associated with students' sense of school belonging. Also noteworthy were the generally low levels of satisfaction reported by Croatian parents with their child's school when compared to the other TIMSS participants in the region; this potentially merits further research at a national level.

In Kosovo, of the percentages of students expressing confidence in learning were low (and lower for science than for mathematics) when compared to the percentages of students sharing other attitudes, which were generally highly positive. Mathematics and science achievement were positively related to students' sense of school belonging. Students who were more likely to report liking to learn mathematics or science, who were more confident, and who had more home learning resources tended to score more highly in TIMSS.

In Montenegro, students were less likely to feel confident than to like learning about mathematics, and especially science, which they like to learn very much. Almost all students shared a positive sense of school belonging and almost all parents held positive perceptions of their child's school.

In North Macedonia, the percentages of students who liked to learn mathematics and science were higher than the percentages of students who felt confident in these subjects, and close to the high percentages of students with a positive sense of school belonging and had parents who held positive perceptions of their child's school.

In comparison, Serbia demonstrated large differences in attitudes, with relatively low percentages of students liking to learn or being confident in mathematics or science and high percentages of students with a positive sense of school belonging and with parents who held positive perceptions of their child's school performance. Mathematics and science achievement were negatively related to students' sense of school belonging, but positively related with parents' perceptions of their child's school.

Overall, our results indicate that, in Croatia, North Macedonia, Montenegro, and Serbia, students who were more confident in mathematics or science and who had more home learning resources tended to achieve higher mathematics and science TIMSS scores. Higher achievement also showed a negative association with students' sense of school belonging in Montenegro and Serbia.

In addition, assuming that all other factors are equal for all students, boys tended to score more highly in mathematics than girls in Bosnia and Herzegovina, Croatia, and Kosovo, while girls tended to score more highly in science than boys in North Macedonia.

In general, we found that achievement was not directly linked to students' sense of school belonging, while the associations with parental perceptions of their child's school were unexpected and not easy to explain with our multivariate analyses. However, we can suggest some explanations for the weak relations that we observed. In line with world trends, school systems across the region have focused more on issues of equality and equity in education. Therefore, more emphasis has been given to providing better learning conditions for underprivileged students, which could, in turn, create more positive perceptions of schools among parents and a stronger sense of school belonging among underprivileged and lower achieving students. Our analysis of parental perceptions suggests that policymakers may wish to focus on how schools can better involve parents in their child's education in some parts of the region. In addition, the TIMSS scale for sense of school belonging also contains items related to students' feelings of safety; responses to such items may more closely reflect concepts of not being bullied than environments supporting achievement. Further

study needs to examine the reasons for the relatively weak observed correlations between students feeling that they are not bullied and their sense of school belonging (this correlation was 0.20 in Croatia, Kosovo, and North Macedonia, 0.22 in Serbia and Bosnia and Herzegovina, 0.23 in Montenegro, and 0.25 in Albania).

6 Conclusions

We found that the relations among different attitudes across the Dinaric region were complex, and that there was some evidence for the attitude-achievement paradox, identified previously in other parts of the world (Min et al., 2016). For all Dinaric TIMSS participants, the relations between students' sense of school belonging and both liking to learn and feeling confident in mathematics and science were significant and positive. The percentages of students that had a positive sense of school belonging and students with parents that had positive opinions about their child's school were high across the Dinaric region (>90% for both). This implies strongly that schools across the region are respected and valued institutions, with great power to support change and help stabilize society.

However, the percentages of students with positive attitudes toward learning both subjects and feeling confident in these subjects differed somewhat across the Dinaric region. We observed regional variations in the levels of positive attitudes of students had toward learning and their school climate. We did not anticipate that more positive attitudes of students' towards learning science or mathematics would generally be related to more positive parental perceptions of school performance. In most of the TIMSS participants from the Dinaric region, we found more positive students' attitudes among students with less home resources for learning than among students with more home resources for learning (which is a measure of the family support). These findings further support the important roles that school climate and teachers play in motivating students for learning as part of the learning process in schools.

The relationships between attitudes and achievement are complex. We found that while students may report positive attitudes toward learning both mathematics and science, enjoyment of learning is not the strongest predictor of achievement in the Dinaric region. Student achievement was much more strongly correlated with confidence in mathematics or science than with liking to learn these subjects. As expected, higher achievement was also associated with higher levels of home resources for learning in all school systems. However, the associations between achievement and students' sense of school belonging and/or parents' perceptions of their child's school differed across the region and were only significant in a few cases. These findings are in accordance with previous results from TIMSS 2015, which showed that confidence is a strong correlate of achievement while sense of school belonging is not. As a school's emphasis on academic success is highly related to student achievement (Mullis et al., 2016a), a focus on developing a supportive school climate should be at the heart of principals' and policymakers' efforts to improve teaching and learning for students.

What to do with these findings? Our results suggest that, to foster better achievement, the Dinaric school systems should recognize that students' confidence in mathematics and science seems to be a more important factor than their enjoyment in learning the subjects. Although we assume that many teachers and schools already encourage positive attitudes toward learning mathematics and science among their students, and that fostering an enjoyment of mathematics and science is addressed in student textbooks and promoted in new teaching approaches and by the use of technology, this analysis of the TIMSS 2019 data suggests that more can be done. Teachers also need to identify strategies and teaching approaches that develop students' confidence in their ability to learn and the application of their knowledge and skills. They also need to recognize that, while the factors linked to positive attitudes toward learning (such as gender or parental attitudes) may differ for each school system, a sense of school belonging seems to play a consistently important role in student enjoyment of mathematics and science. While the availability of home resources for learning is a key predictor of student achievement, it is a poor predictor of student attitudes like enjoyment of learning or self-efficacy.

Our analyses provide some important general messages for policymakers across the Dinaric region: strong factors exist in schools and classes that have an influence on students' interest, enjoyment, and knowledge of mathematics and science. Schools and teachers can benefit from a better understanding of the varying contributions of competing factors acting within their education system, and there are clearly advantages to sharing inspiring examples and successes from neighboring school systems when planning stimulating school environments. Education systems may need to work on changing common misconceptions about the associations between attitudes toward education and achievement if they are to turn their efforts into effective improvements for learning. The varying associations that we observed by analyzing the TIMSS 2019 data for the school systems of the Dinaric region, and comparison of their relative strengths or weaknesses can help to determine specific policy measures to help address problems.

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