IEA Research for Education

A Series of In-depth Analyses Based on Data of the International Association for the Evaluation of Educational Achievement (IEA)

Barbara Japelj Pavešić
Paulína Koršňáková
Sabine Meinck *Editors*

Dinaric Perspectives on TIMSS 2019

Teaching and Learning Mathematics and Science in South-Eastern Europe

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Volume 13

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Foreword I

IEA's mission is to enhance knowledge about education systems worldwide and to provide high-quality data that will support education reform and lead to better teaching and learning in schools. In pursuit of this aim, it conducts and reports on major studies of student achievement in literacy, mathematics, science, citizenship, and digital literacy. These studies, most notably TIMSS, PIRLS, ICCS, and ICILS, are well established and have set the benchmark for international comparative studies in education.

The studies have generated vast datasets encompassing student achievement, disaggregated in a variety of ways, along with a wealth of contextual information that contains considerable explanatory power. The numerous reports that have emerged from them are a valuable contribution to the corpus of educational research.

Valuable though these detailed reports are, IEA's goal of supporting education reform needs something more: deep understanding of education systems and the many factors that bear on student learning advances through in-depth analysis of the global datasets. IEA has long championed such analysis and facilitates scholars and policymakers in conducting secondary analysis of our datasets. So, we provide software such as the International Database Analyzer to encourage the analysis of our datasets, support numerous publications including a peer-reviewed journal—*Large-scale Assessment in Education*—dedicated to the science of large-scale assessment and publishing articles that draw on large-scale assessment databases, and organize a biennial international research conference to nurture exchanges between researchers working with IEA data.

The **IEA Research for Education** series represents a further effort by IEA to capitalize on our unique datasets and to provide powerful information for policy-makers and researchers. Each report focuses on a specific topic and is produced by a dedicated team of leading scholars on the theme in question. Teams are selected on the basis of an open call for tenders; there are two such calls a year. Tenders are subject to a thorough review process, as are the reports produced. (Full details are available on the IEA website.)

The Dinaric region—the regional emphasis of the current volume—is named after the Dinaric Alps. Located in South-eastern Europe, this region stretches from

Slovenia through Croatia, Bosnia and Herzegovina, Serbia, Montenegro, Kosovo, Albania, and North Macedonia[1]. This thirteenth volume in the series features invited experts from across the region who offer a multidimensional and culturally sensitive perspective on the Dinaric TIMSS 2019 fourth grade results within the region. In addition, the volume is unique in that chapters that involve empirical analyses were completed in close collaboration with analysts from the IEA. The authors of this volume examine TIMSS participation in the region over time, the approaches of participating countries to implement TIMSS 2019 at the grade four level, and the wider educational contexts of the various systems, including demographic and cultural factors. Relevant within and beyond the Dinaric region, chapters in this volume include analyses of opportunity to learn in mathematics and science (Chapter "Opportunity to Learn Mathematics and Science"); student interests and beliefs (Chapter "Students' Interests, Motivation, and Self-beliefs"); and characteristics of students, teachers, and their principals across the region (Chapters "Characteristics of High- and Low-performing Students" and "Scaffolding the Learning in Rural and Urban Schools: Similarities and Differences"). This book will be a valuable resource for researchers interested in this dynamic and culturally rich region of the world. Further, Dinaric educators will find the analyses and comparisons useful for understanding commonalities and differences across the region.

Future volumes in the series include one dedicated to so-called *process data*—a by-product of a computerized testing platform—and one on the sustainability of global citizenship education.

Series editors
Seamus Hegarty
Leslie Rutkowski

[1] The volume includes analyses from all participating Dinaric education systems. Slovenia did not participate in the 2019 TIMSS cycle.

Foreword II

In February 2018, the European Commission presented the new Western Balkans Strategy, stressing the European future of the region as a geostrategic investment in a stable, strong, and united Europe based on common values. This was again confirmed at the Zagreb Summit in May 2020.

Education, culture, youth, and sport, together with research and innovation, are recognized as essential drivers to boost the economic development, competitiveness, and social cohesion of the region. This year we have learned that unexpected events and crises, as demonstrated by COVID-19, may challenge access to education. Ensuring access to quality education is imperative to give every child a better future; develop their full potential; and, ultimately, contribute to a peaceful, inclusive, and prosperous life for our societies.

IEA's Trends in International Mathematics and Science Study (TIMSS) 2019 mark a milestone in terms of the participation of the Western Balkans region. For the first time, the entire region participated in the same TIMSS round of testing, promoting peer learning. This joint venture supports the ability of the countries in the region to learn from each other by identifying similarities and differences between the neighboring education systems. Further, the publication gathers together useful regional data that can support education authorities to develop appropriate measures to address the most pressing education needs.

The enhanced focus on mathematics and science fits well with the European Commission's renewed priorities on science, technology, engineering, and mathematics (STEM) and with our efforts to increase the number of women studying STEM subjects. These are also reflected in the Digital Education Action Plan 2021–2027 (European Commission 2021) and in the Communication on Achieving the European Education Area by 2025 (European Commission 2020).

Previous experience shows that TIMSS results enhance awareness and drive policy change. I trust this report will serve as a knowledge basis for all regional stakeholders, among them teachers, school leaders, researchers, and decisionmakers, to support and enhance student achievement and engagement in mathematics and science.

Enjoy reading the report.

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Contents

Introduction to Dinaric Perspectives on TIMSS 2019

Paulína Koršňáková, Sabine Meinck, and Barbara Japelj Pavešić

Abstract Ensuring access to quality education is imperative to give every child a better future, develop their full potential and, ultimately, contribute to a peaceful, inclusive, and prosperous society. In 2019, for the first time, the entire Dinaric region participated in IEA's Trends in International Mathematics and Science Study (TIMSS) at grade four, flagging a unique opportunity to gather robust comparative regional data about neighboring education systems. The international collaborative research presented in this book identifies both similarities and differences among these educational systems, sharing useful information about the relative strengths and weaknesses of each, designed to inspire peer learning and improve progress toward quality education for all. Secondary analyses of the TIMSS 2019 data provides some contextual understanding for education authorities across the Dinaric region, enabling them to review their own educational aspirations, connect their practical experience with empirical evidence, and together advance educational collaboration across the region.

Keywords Albania · Bosnia and Herzegovina · Croatia · Kosovo · Montenegro · North Macedonia · Serbia · Grade four education · International large-scale assessments (ILSA) · Trends in International Mathematics and Science Study (TIMSS)

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1 Defining the Dinaric Region

Definitions of Southeastern Europe are various, and may be disputed depending on the perspective, which can be political, economic, historical, cultural, and/or geographical. The same is true for the Balkans (a name derived from the Balkan Mountains), a geographic area in Southeastern Europe with various definitions and meanings, which include both the geopolitical and historical. Both terms commonly refer to a wider area that usually includes Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Kosovo,[1] Montenegro, North Macedonia, and Serbia. Sometimes, Moldova, Romania, Slovenia, and the East Thrace (part of Turkey) are also included.

Fig. 1 The "Western Balkan" region, comprising Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, Serbia, and Kosovo. Croatia (indicated by hatching) joined the European Union in 2013

[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).

Western Balkans is a political neologism that has been used to refer to Albania and the territory of former Yugoslavia, except Slovenia, since the early 1990s (Commission of the European Communities, 2008). The institutions of the European Union (EU) have generally used the term "Western Balkans" (Fig. 1) to refer to the Balkan area that includes non-members of the EU, and developed a policy to support the gradual integration of these Western Balkan economies into the Union. On 1 July 2013, Croatia became the first of this group to join the EU, and Montenegro, Serbia, North Macedonia, and Albania are official candidates for membership. Accession negotiations and chapters have been opened with Montenegro and Serbia, and Bosnia and Herzegovina and Kosovo are potential candidates for future membership (European Parliament, 2019).

The region of the Western Balkans, as used in the European political context, roughly corresponds to the territory of Dinaric Alps (or Dinarides), also known as the Alpet Dinaride or Alpet Dinarike in Albanian and Dinaridi/Динариди in Bosnian, Croatian, and Serbian. They are named after Mount Dinara (1831 m), which lies in the center of the mountain range located at the border of the Dalmatian part of Croatia with Bosnia and Herzegovina, and stretches through Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Montenegro, and Kosovo to Albania in the southeast. The Dinaric Alps extend south to the Sharr Mountains, which connect Kosovo and the northwest of North Macedonia to northeastern Albania (Fig. 2).

Comprising an area of approximately 100,000 km^2, the Dinaric Alps stretch along more than 6000 km of coastline, including the entire area facing the Adriatic Sea, and naturally connect Croatia, Bosnia and Herzegovina, Montenegro, Serbia, Kosovo, Albania, and North Macedonia. This region will be the focus of this publication. The geographical units share many common cultural elements, and the characteristics of natural environment are similar, but they differ in size and population. Kosovo and Montenegro are geographically the smallest, being 10,887 km^2 and 13,810 km^2, respectively, while Serbia is geographically the largest at 88,360 km^2.

Population sizes range from *c.* 600,000 inhabitants in Montenegro to a population of *c.* seven million in Serbia, as of 2018. Kosovo and Albania have the highest population densities, with *c.* 168 people per km^2 and 105 people per km^2, respectively. In general, at least half of the populations in the region live in urban areas, ranging from up to 67% in Montenegro to only 48% in Bosnia and Herzegovina.[2] In most of the economies of the region, the percentage of the population living in urban areas increased slightly during 2018, except in Bosnia and Herzegovina, Croatia, and Serbia. The life expectancy at birth in the region lies between 72.2 years (Kosovo) and 78.07 years (Croatia). The gross national income (GNI) per person (in terms of purchasing power parity) for 2018 varied between US$ 11,540, in Kosovo, and US$ 27,180, in Croatia (World Bank, 2020).

According to the United Nations Development Programme's (UNDP, 2019) human development index (HDI; a composite of indicators for a long and healthy life, knowledge, and a decent standard of living), the seven participants involved in

[2] There is no information available about the urban population in Kosovo.

Fig. 2 The Dinaric Alps

this study[3] were ranked as lying between 46th (Croatia) and 82nd (North Macedonia) among 189 countries in 2018, and all had shown continuous improvement in their scores since they were included in this UNDP index.

2 Trends in International Mathematics and Science Study at Grade Four

EA's Trends in International Mathematics and Science Study (TIMSS) measures student achievement in the subjects of mathematics and science every four years by administering tests to a sample of students at the specified grade (for this research, we focused on grade four). By using advanced sampling methodology, TIMSS ensures a representative sample of the student population in each participating education system. Background information is collected from sampled students, their school principals, teachers, and parents, and includes factors that affect learning, including

[3] Kosovo is not included in the HDI ranking.

school resources, student attitudes, instructional practices, and support at home. The TIMSS results and further analyses of the background information may therefore provide discoveries that can be used to inform future education policy and practices around the world. The TIMSS design enables the measurement of trends in educational achievement, across evolving contexts and reformed educational provision over years and across countries. Advanced statistical modeling of the measurement of achievement ensures that results can be compared with previous cycles, although the set of participating countries and test materials administered changes from one cycle to the next (Martin et al., 2020).

TIMSS is grade-based and curriculum-rooted, and, in this region, the research interest on grade four coincides with a cohort of approximately 10-year-old students at the primary school level. TIMSS considers the context, examining processes as well as outcomes of education, in order to understand the linkages between the intended curriculum (what policy requires), the implemented curriculum (what is taught in schools), and the achieved curriculum (what students learn). The concept of "opportunity to learn" is the underlying focus of the study model, expressed by the framework that serves as the basis for the instrument development and data collection (Mullis & Martin, 2017).

National research coordinators (NRCs) ensure that study instruments and procedures are appropriate for their students and suit the educational context of their system. Assessment questions are pre-tested (this is referred to as "pilot" and "field" testing), and any issues identified during these early trials are addressed before the main assessment is administered. IEA makes every effort to safeguard the quality and comparability of data through careful planning and documentation, supporting cooperation among participating education systems, standardization of procedures, and rigorous quality control (Martin et al., 2020). The resulting data are organized and stored in an international database, ensuring full comparability across countries and with data from previous years. Datasets, complemented by detailed technical documentation and user guides (Fishbein et al., 2021) are available as free open-access resources for research on the websites of IEA (2021a), and the TIMSS & PIRLS International Study Center at Boston College (TIMSS & PIRLS International Study Center, 2021).

Two decades of TIMSS results (1995–2015) reveal important trends. For example, more countries have registered increases rather than decreases in average student achievement scores for grade four mathematics and science. Students have also demonstrated increasing levels of knowledge, and gender gaps in student achievement are decreasing. These overall improvements in educational achievement are accompanied by additional gains, such as improved school environments (e.g., safer schools), better educated teachers, more support for teachers' professional development, and better curriculum coverage (Mullis et al., 2016).

The TIMSS open access datasets are recognized by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as a solid evidence base for researchers, educators, and policymakers interested in monitoring progress toward the sustainable development goals (SDGs) (UNESCO Institute for Statistics, 2018). The lowest of the four TIMSS international benchmarks, which serve as specific points on the scale of measured achievement, represents a level of basic knowledge and competencies equivalent to the "SDG minimum proficiency level." On average, across all TIMSS 2019 countries, 92% of students met this level of basic knowledge in TIMSS 2019 grade four mathematics, showing that they could add and subtract whole numbers, had some understanding of multiplication by one-digit numbers, could solve simple word problems, and had some knowledge of simple fractions, geometric shapes, and measurements; the percentage of grade four students achieving this level of competency in mathematics varied across the Dinaric region from 73 to 95% (Mullis et al., 2020). Meanwhile, 92% of grade four students across all TIMSS 2019 countries met the TIMSS 2019 minimum proficiency level in science by demonstrating that they had some basic knowledge of scientific concepts and foundational scientific facts. The percentage of grade four students achieving this level of scientific understanding varied from 59 to 98% across the participating Dinaric region systems (Mullis et al., 2020).

3 Engagement with TIMSS

The Dinaric region first became involved in IEA international assessments over 60 years ago; the former Yugoslavia was one of the countries that participated in IEA's Pilot Twelve-Country Study project in 1959–1961 (IEA, 2021b). This project assessed five subject areas: mathematics, reading comprehension, geography, science, and non-verbal ability (Foshay et al., 1962). The six successor states of Yugoslavia, namely Bosnia and Herzegovina, Croatia, Montenegro, North Macedonia, Serbia, and Slovenia, have also participated in various TIMSS cycles. For example, Bosnia and Herzegovina participated at grade eight in TIMSS 2007, Croatia at grade four in TIMSS 2011 and 2015, North Macedonia at grade eight in TIMSS 1999, 2003, and 2011, Serbia at grade eight in TIMSS 2003 and 2007 and at grade four in 2011 and 2015, and Slovenia at grades four and eight in all cycles from 1995 to 2015. However, TIMSS 2019 marks a unique milestone for participation in the region, with seven participants administering the study at grade four.

The TIMSS results have been used in different ways by education systems across the region, and so have had varying impact. For example, TIMSS was administered at grade eight in Bosnia and Herzegovina in 2007, and this was followed by a national secondary analysis of the data two years later. Results from this analysis were made publicly accessible to local stakeholders. While education authorities did not use these results to shape educational policies, a few enthusiastic teachers and other professionals did make use of the outcomes (Centre for Policy and Governance, 2013; Popić & Džumhur, 2020; Suzić & Ibraković, 2009). However, TIMSS results have also contributed toward major policy changes in the region. In Croatia, an expert group, supported by various stakeholders in the field, used results from international large-scale studies (together with other data) as foundation for the most recent curriculum reform, which was launched with the school year 2019/2020. TIMSS has thus had direct impact on national policies and educational reforms, with permanent influence on teaching practices for primary education in Croatia. Specifically, secondary analysis of TIMSS 2015 results resulted in changes in the curriculum for the subjects mathematics, physics, chemistry, biology, and nature and science. For example, for physics, the TIMSS 2015 analysis revealed that Croatian students had only limited familiarity with some of the test content, as it was either entirely absent from the national curriculum or was taught at a higher grade. As a direct consequence of these findings, the revised 2019/2020 physics curriculum introduced new content areas, moved content to earlier grades, or upgraded content areas to higher levels, such as understanding or connecting concepts. The Croatian Education and Teacher Training Agency also used the results to develop a series of teacher training courses about TIMSS. TIMSS results were thus used to prompt discussion about the learning and teaching challenges evolving from the paradigm change from traditional ways of reproducing theoretical knowledge towards new approaches for developing student competencies (Elezović & Muraja, 2020).

In North Macedonia, participation in TIMSS contributed to a higher awareness of the generally low level of national student achievement and the need for external measurement. The results were used to develop new curricula for mathematics, chemistry, physics, and biology, and prompted the introduction of a new science subject named natural sciences, which is now taught nationally from grade one to grade six (Lameva, 2020).

TIMSS has also influenced educational policies in Serbia since 2003. Serbian educational authorities recognize TIMSS study results as an indicator of the effectiveness of the whole education system and use them as basis for decision-making to improve the quality of education. TIMSS results also contributed to the development of educational standards for mathematics and science in primary education; this can be considered one of the most important outcomes of the study. Furthermore, the experience of participating in TIMSS was used as a basis for preparation of procedures for the end of school examinations and for national testing. The Serbian education authorities have also used data collected by TIMSS on school infrastructure to make decisions about future school investments, as well as using selected data and materials as supporting materials in teacher education programs (Đerić et al., 2020; Kadijević et al., 2004; Kadijevich, 2019).

3.1 An Aside: Slovenia's Participation in TIMSS

While Slovenia did not participate in TIMSS 2019 for financial reasons, it had previously participated from 1995 until 2015. In Slovenia, TIMSS was regarded as a reliable standard tool for measurement of mathematics and science education. The unbiased perspective of the reports from international comparisons was recognized as constructive, avoiding some of the direct criticisms directed at national projects focused on nationally known problems. TIMSS results were used to initiate changes in many areas of the educational system. For example, results were used to introduce new content (i.e., data displays) into the curricula and alter the order of teaching science content in early grades, and sharing international comparisons of time spent on learning and homework helped to change public opinion on what was an appropriate student workload. TIMSS data also became an important information source for national projects, providing information on, for example, regional differences, or gender and age gaps in achievement. Teachers were encouraged to use publicly available items from TIMSS in their teaching practice, and use these to design similarly challenging items or connect different content. TIMSS cognitive areas totally changed the understanding of mathematics and science cognitive levels. Teachers learned that attitudes have an important role in teaching and became attentive to background factors linked to achievement, teaching, and learning (Japelj Pavešič, 2013). Mathematics and science achievement increased over time in Slovenia, and national conferences providing extended feedback to teachers about student success resulted in improvements in teaching practice.

4 Aspirations and Expectations for This Book

The examples in Sect. 3 demonstrate how TIMSS results have been used to inform educational authorities and stakeholders in the field of education, support decision-making, and guide educational reforms in the region. Education systems can benefit from the high-quality data retrieved from standardized large-scale assessments. Such data enable secondary analyses that may shed light on specific education-system-level questions or issues, which together with educational stakeholder engagement and reflection, results in better understanding and evidence-driven action. The secondary analyses based on the TIMSS 2019 cycle data from neighboring education systems provide educational authorities across the Dinaric region with additional tools to review their own education systems' strengths and weaknesses. With this much deeper contextual understanding, they can connect practical experiences in the region with empirical evidence from TIMSS 2019. This book provides an initial interpretation of the regional educational landscape in 2019, and the analyses we present are designed to prompt researchers to investigate other aspects of their education systems.

5 Notes About the Statistical Analyses Methods Used in This Book

To compare findings across the Dinaric region, we analyzed data using basic and advanced methods to estimate percentages, means, correlations, and develop regression models. We conducted all statistical computations using established standard procedures for data from large-scale assessments. For all our calculations, we used the

IEA's IDB (International Database) Analyzer (IEA, 2021a), a statistical tool specifically developed for the correct analysis of large-scale assessment data that works in conjunction with the well-known SPSS statistical package (IBM, 2021). This tool accounts for the complex unit and item sampling design by applying sampling weights to the analyses, and uses plausible values when working with achievement variables. We used the jackknife repeated replication method (as described in Martin et al., 2020) to determine standard errors and statistics related to significance tests of group differences or other statistical parameters (e.g., correlation and regression coefficients). The IDB Analyzer tool was used to calculate Pearson correlation coefficients for selected variables of interest (Freedman et al., 2007; see also IEA, 2021c for instructional videos on the use of the IDB Analyzer, including one covering Pearson correlation coefficients). Throughout, we used *t*-test statistics to determine statistical group differences, assuming two-tailed tests with a significance level of $\alpha = 0.05$.

In TIMSS, items assessing a common underlying construct are combined to form a scale. The individual scales used in the chapters of this book are available in the TIMSS international database (TIMSS & PIRLS International Study Center, 2021) and their construction is described in detail in the TIMSS technical report (Yin & Fishbein, 2020). These TIMSS scales are constructed using item response theory scaling methods, with a scale center point of 10 (to represent the mean score of the combined distribution of all TIMSS 2019 grade four participants). In each case, the units of the scale are chosen so that the standard deviation of the distribution is equivalent to two scale score points. All cases with valid responses to at least two items on a scale were included in the calibration and scoring processes. Each scale was divided into three regions (representing high, middle, and low score values) designed to provide a content-referenced interpretation for the scale values. The boundaries between scale score regions differ across attitude scales; the cut points were based on judgments made by the TIMSS & PIRLS International Study Center staff and are presented together with the scales' means for each TIMSS participating education system in the TIMSS 2019 international reports (Mullis et al., 2020; Yin & Fishbein, 2020).

Although we provide references in each chapter, we encourage readers interested in data availability and quality issues, or further general information about TIMSS 2019, to explore the following publications and resources:

(1) The *TIMSS 2019 Assessment Frameworks* describe the general foundations of mathematics and science assessment, as well as the additional factors associated with student learning in mathematics and science that are investigated using the TIMSS questionnaires completed by students, their parents, teachers, and school principals. It also provides an overview of the assessment design, including general parameters for item development (Mullis & Martin, 2017).

(2) The *TIMSS 2019 Encyclopedia* is a comprehensive compendium of how mathematics and science are taught in the education systems participating in the study. Each TIMSS 2019 participant prepared a chapter summarizing the key

aspects of mathematics and science education within their education system and answered the TIMSS 2019 curriculum questionnaire (Kelly et al., 2020).

(3) The *TIMSS 2019 International Results in Mathematics and Science* summarizes a wide array of results, including achievements and trends (Mullis et al., 2020).

(4) *Methods and Procedures. TIMSS 2019 Technical Report* provides additional details related to the development of the TIMSS assessments and questionnaires, the documentation of the numerous quality assurance steps and procedures implemented by all those involved in the TIMSS 2019 assessments, and also describes the methods used for sampling, translation verification, data collection, database construction, and the construction of the achievement and context questionnaire scales (Martin et al., 2020).

(5) The *TIMSS 2019 User Guide for the International Database* supports and facilitates the use of the data collected in TIMSS 2019. As mentioned in Sect. 2, a public-use version of the database is available for download from IEA and the TIMSS & PIRLS International Study Centre at the Boston College (Fishbein et al., 2021).

6 Overview of the Chapter Contents

Dinaric Perspectives on TIMSS 2019 uses secondary analyses of the TIMSS data to develop a multidimensional, context-rich perspective on TIMSS results at grade four for seven participants from the Dinaric region. Data from Albania, Bosnia and Herzegovina, Croatia, Kosovo, Montenegro, North Macedonia, and Serbia provide a basis for the comparison of the different contexts for learning and methods for teaching science and mathematics to grade four students.

Chapter "Context and Implementation of TIMSS 2019 at Grade Four in the Dinaric Region" examines the implementation of TIMSS 2019 across the region, exploring the different education systems and study-specific context information, highlighting both regional similarities and differences. This includes the structure of the formal schooling systems, starting with early childhood education and care, to the end of the years of compulsory education, outlining the language of instruction, the mathematics and science curricula, and quality assurance components across the region. The chapter also addresses certain TIMSS administration procedures, such as sampling or test administration, ensuring the context of our findings is clearly understood.

Chapter "Opportunity to Learn Mathematics and Science" examines opportunity to learn mathematics and science, or the "observable structure" of teaching for learning outcomes, which includes the intended, implemented, and attained curricula. Specifically, this chapter investigates the relationship between the content taught and student achievement across education systems.

Students' interests, motivation, and self-beliefs and their impact on student achievement are the focus of chapter "Students' Interests, Motivation, and Self-beliefs". Student achievement has been linked to student attitudes toward learning about mathematics and science, student motivation, and confidence, as well as parental attitudes toward mathematics and science.

Chapter "Early Literacy and Numeracy Competencies: Predictors of Mathematics Achievement in the Dinaric Region" looks at early literacy and numeracy competencies in the Dinaric region. Factors such as socioeconomic status, the number of years spent in early childhood education facilities, and home resources have all been associated with early literacy and numeracy competencies, which are, in turn, related to student performance in schools. The chapter analyzes regional differences in these competencies and how they are related to student achievement.

Chapter "The Role of Learning Resources, School Environment, and Climate in Transforming Schools from Buildings to Learning Communities" examines the role of learning resources and school environment in transforming schools from buildings to learning communities. Identifying the characteristics of school resources and environment that create successful school environments may ameliorate the lack of resources on a school or individual level. The analyses also cover the relationship between school emphasis on academic success and student achievement and the relationship between students' sense of belonging and achievement results.

Chapter "Teachers, Teaching and Student Achievement" explores the relationship between the quality of teachers (measured in terms of education and professional development), instructional practice in participating classes, and grade four student outcomes on the TIMSS test. In the Dinaric region, grade four students have teachers with similar educational backgrounds (in terms of experience, level of education, and level of professional development). Robust regional analyses supply an evidence base for future investigation into the effectiveness of the strategies for improvement.

Chapter "Characteristics of Principals and Schools in the Dinaric Region" examines school effects on the academic achievement of students. The research looks at whether the level of education, years of experience of the principal, the location of the school, and/or school composition have significant effects on student achievement, as well as perceptions of school emphasis on academic success.

After defining high- and low-performing students, according to the proficiency levels set by the TIMSS international benchmarks in mathematics and science for both groups, chapter "Characteristics of High- and Low-performing Students" describes and compares selected characteristics of these groups of students across the region.

Finally, chapter "Scaffolding the Learning in Rural and Urban Schools: Similarities and Differences" identifies differences and similarities between rural and urban schools, particularly from the perspective of different types of support for student learning. A better understanding of the urban–rural achievement gap in science and mathematics, taking into account family and school factors, may improve support for learning at school.

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Context and Implementation of TIMSS 2019 at Grade Four in the Dinaric Region

Paulína Koršňáková and Sandra Dohr

Abstract Governments and policymakers around the world view large-scale assessments, such as IEA's Trends in International Mathematics and Science Study (TIMSS), as increasingly important in supporting continuous improvement in the quality of education and education systems. However, a good knowledge of the contexts and environments that exist when these studies are implemented is essential to fully understand study results, draw conclusions, and make policy recommendations. Collecting background information about the components of the participating education systems thus supports better appreciation and interpretation of the TIMSS 2019 assessment results for the Dinaric region. Relevant topics include descriptions of the early childhood education and care (ECEC) sector, compulsory education provision, languages of instruction across the region, and brief summaries of the existing mathematics and science curricula. The role of assessments for quality assurance in the region, and an introduction to the TIMSS 2019 survey design and its local implementation, provide additional context. Together, this supporting documentation gives crucial insight into how education functions throughout the region and serves as solid basis for interpreting the analyses in this book.

Keywords Assessment · Compulsory education · Digitalization · Dinaric region · Early childhood education · Mathematics instruction · Primary school · Quality assurance · Science instruction · Trends in International Mathematics and Science Study (TIMSS) · Western Balkans

1 Introduction

Participation in international large-scale assessments enables education systems to compare and learn from each other; the results are used as a means to improve educational quality. However, to interpret the outcomes, it is important to consider the various, and likely unique combination of antecedent contextual and explanatory

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factors that also play a role in the assessment results. Education systems serve social and cultural goals (Komatsu & Rappleye, 2017) and reflect the overall economic situation that interconnects governmental decisions related to specific educational goals with politics and resources (see, e.g., Hanushek & Woessmann, 2019). Looking into educational policies and practices can provide essential context for understanding student performance results from large-scale assessments, such as IEA's Trends in International Mathematics and Science Study (TIMSS), and can eventually contribute to improving results over time. Establishing the context for teaching and learning is therefore the basis for analyzing data and making comparisons between education systems.

Seven participants from the Dinaric region took part in TIMSS 2019, namely Albania, Bosnia and Herzegovina, Croatia, Kosovo,[1] Montenegro, North Macedonia, and Serbia. We provide a comparative overview of the structures of the participating education systems and a brief introduction to some of the topics that are covered in depth in this book. We first explore the paths of schooling that children in the region typically go through during their school career, including opportunities for early childhood learning. We then provide a brief synopsis of the mathematics and science curricula at the system level. A particular focus of this chapter is how quality assurance functions in each of the respective education systems and what role student assessments play in that context. We conclude by examining the most important features of TIMSS 2019 and the implementation of the study at grade four across the region.

2 Schooling Paths in the Region

2.1 Early Childhood Education and Care

Generally, the term early childhood education and care (ECEC) refers to the "provision for children before the start of compulsory primary education" (European Commission/EACEA [Education, Audiovisual and Culture Executive Agency]/Eurydice, 2019c, p. 12) and includes services that ensure the child's safety and care as well as services that support the child's educational development. The ECEC sector can be further categorized, and the transition from a childcare-type setting (e.g., nurseries) to an education-type setting (e.g., kindergartens), or the age of transition (under and over three years), are commonly used to divide the sector (European Commission/EACEA/Eurydice, 2019c).

ECEC provision is generally available in form of nurseries, kindergartens, and preschool preparatory programs in the Dinaric region, and attendance at this level is not mandatory, except in parts of Bosnia and Herzegovina, Croatia, and Serbia. Bosnia

[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).

and Herzegovina has structured their provision into three different levels, which include nurseries for children between six months and three years, kindergartens for children from three to six years, and pre-school preparatory programs, which start a year before the first grade of primary school. The last level is compulsory for the majority of the population (Popić & Džumhur, 2020). Serbia provides pre-school education in form of nurseries for children between six months and three years, and kindergartens for children aged three to seven. Since the school year 2006, one year of preparatory pre-school education before the beginning of primary school has become mandatory (Đerić et al., 2020). In Croatia, attending the last year of ECEC in part-time format was made compulsory in 2014. This implies that children in Croatia, Serbia, and parts of Bosnia and Herzegovina are legally entitled to have a guaranteed place for the last year of ECEC (European Commission/EACEA/Eurydice, 2019c).

Participation rates for the ECEC sector are available for the region from different sources (e.g., both Eurostat, the European Commission's statistics hub, and UNICEF, the United Nations Children's Fund, publish such statistics). However, depending on the methodology of national statistical institutes, the definition of an ECEC institution, or the classification of age groups, numbers can vary considerably between education systems and thus, comparisons may be difficult. For instance, participation rates could include only children in early childhood educational development programs (coded as International Standard Classification of Education [ISCED] 010; see UNESCO [United Nations Educational, Scientific and Cultural Organization] Institute of Statistics, 2012 for an explanation of the ISCED classifications) and exclude children in childcare provisions that fall outside of the ISCED classification or vice versa (European Commission/EACEA/Eurydice, 2019c). Another factor that needs to be taken into account is the structure of the sector and whether the offer is mainly public or private. This can have an effect on official participation rates (UNICEF, 2017).

According to Eurostat data, participation rates for children under the age of three in ECEC provisions are only available for some education systems in the region; for 2017, these included Croatia (15.9%), North Macedonia (10.3%), and Serbia (14.5%). In 2017, participation rates of children between the age of four and the starting age of compulsory primary education were 82.8% in Croatia, 70.4% in Montenegro, 68.6% in Serbia, and 39.5% in North Macedonia (European Commission/EACEA/Eurydice, 2019c). Even though enrollment rates in the ECEC sector are rather low throughout the region, it is notable that considerable efforts have been made in recent years to increase the participation of children in ECEC provision one year prior to the beginning of primary education, notably in Kosovo (Aliu, 2019; UNICEF, 2017) and Bosnia and Herzegovina (UNICEF, 2020).

2.2 Compulsory Education

Children in the Dinaric region generally enter primary school in the calendar year of their sixth or seventh birthday, depending on the various regionally established

Table 1 Students' starting and leaving age for compulsory education/training and duration

Education system	Full-time compulsory education/training		
	Starting age (years)	Leaving age (years)	Duration (years)
Albania	6	15	9
Bosnia & Herzegovina	6	15	9
Croatia[a]	7	15	8
Kosovo[b]	6	14	9
Montenegro	6	15	9
North Macedonia	5 yrs and 7 months	17, or 19 yrs and 6 months	11–13
Serbia	5 yrs and 6 months	14 yrs and 6 months	9

Source European Commission/EACEA/Eurydice (2019a)
Notes
[a]The year of compulsory pre-primary education in Croatia is only part-time education, and was therefore not considered in this table
[b]Data for Kosovo were obtained from the Division for Quality Assurance, Standards, Assessment and Licensing/Ministry of Education, Science, and Technology (DQASAL/MEST, 2020)

cut-off dates. In Croatia, only the children who reach their sixth birthday before 1 April can start school in September of that same calendar year, while, in Serbia, the equivalent cut-off date is 1 March. In addition to official policies, some education systems allow a degree of parental discretion and choice, or include a medical and psychological examination procedure in the enrollment process (Kelly et al., 2020). Considering compulsory education as "a period of full-time education/training that is compulsory for all students" (European Commission/EACEA/Eurydice, 2019a, p. 5), the duration of compulsory education in the region ranges from eight years in Croatia to 11–13 years in North Macedonia (see Table 1). The duration of compulsory education in North Macedonia depends on the chosen secondary school track, which can be general or vocational, and takes two to four years to complete (Lameva, 2020).

Primary and lower secondary education is organized as a single-structure model across the region, with no transition between primary and lower secondary education (see Fig. 1) and includes general and compulsory education for all students. In addition to some differences with regards to the entry age mentioned above, the duration of the primary level differs. Grade four may have a different position within the single structure. While grade four is the final grade of the first educational cycle in Croatia and Serbia, it is grade five in Albania, Bosnia and Herzegovina, and Kosovo. In Montenegro, and North Macedonia the primary and lower secondary education is organized in three-year cycles, grade four being the lowest grade of the second cycle (European Commission/EACEA/Eurydice, 2018).

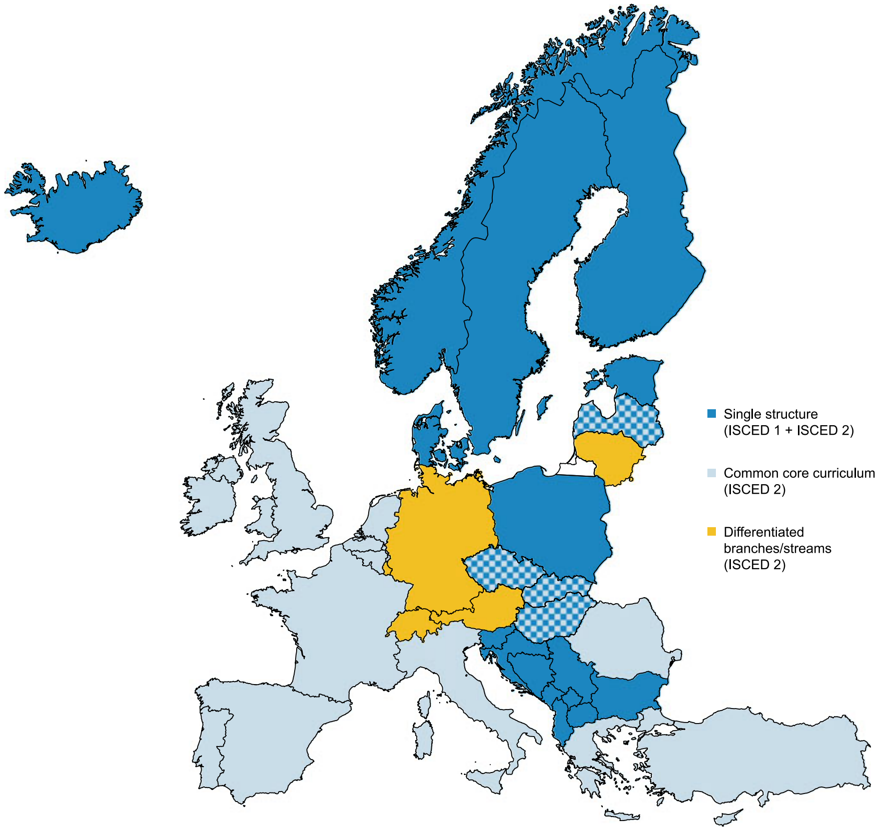

Fig. 1 Main models of primary and lower secondary education (ISCED 1–2) in Europe 2018/2019
Source Based on information provided by European Commission/EACEA/Eurydice (2018)

2.3 Language of Instruction

Across the region, several different languages are used for teaching in schools. The TIMSS 2019 assessment was administered in the main languages of instruction in the region (see Sect. 5, Table 2).

In Croatia, Croatian is the only language of instruction in the great majority of the schools, however, in certain regions, minority languages are recognized as a second official language. Minorities are guaranteed education in their native language using three different approaches; namely, schools where all classes are taught in the minority language, schools where both Croatian and the minority language are taught, and schools where at least some additional language classes in the minority language are available. The recognized minority languages in Croatia are Albanian, Czech, Hungarian, Italian, German, Macedonian, Polish, Serbian, Russian, Rusyn, Slovak, Slovene, and Ukrainian (Elezović & Muraja, 2020).

Table 2 TIMSS 2019 administration and sampling information

Education system	Average age at the day of testing	Testing window in 2019	Number of participating students	Number of participating schools	Number of participating students with participating parents	Number of participating teachers	Overall participation rate of students (%)		Administered languages
							Before replacement	After replacement	
Albania	10.0	27 March	4426	167	4350	214	97.4	97.4	Albanian
Bosnia & Herzegovina	10.1	25 May–13 June	5628	178	5499	332	94.6	94.6	Bosnian, Croatian, Serbian
Croatia	10.5	18 March–18 April	3785	153	3731	260	83.5	85.2	Croatian, Serbian[b], Italian[b]
Kosovo[a]	9.9	15 April–5 May	4496	145	4435	219	97.3	97.3	Albanian
Montenegro	9.8	11 March–1 April	5076	140	4980	358	98.3	98.3	Montenegrin
North Macedonia	9.8	15 April–15 May	3270	150	2968	234	92.1	94.6	Macedonian, Albanian
Serbia[a]	10.6	31 March–14 April	4380	165	4297	213	93.4	96.9	Serbian

Notes All participants administered TIMSS 2019 at grade four, and all participants met the participation requirements
[a]National defined population covers 90–95% of national target population
[b]Only used for the school and home questionnaire

Serbia uses the Serbian language as their main language of instruction, but ethnic minorities may receive instruction in their mother tongue. So far, instruction in primary schools has been organized in Albanian, Bosnian, Bulgarian, Croatian, Hungarian, Romanian, Rusyn, and Slovak (Đerić et al., 2020).

In Bosnia and Herzegovina, education is delivered in the official languages Bosnian, Croatian, and Serbian, depending on the curricula. In addition, some private schools offer instruction in English, French, Turkish, and German (Popić & Džumhur, 2020).

In North Macedonia, the official language of instruction is Macedonian, however, national minority groups are entitled to receive compulsory education in their mother tongue. Instruction in primary schools is available in Macedonian, Albanian, Bosnian, Serbian, and Turkish, whereas secondary schools only provide instruction in Macedonian, Albanian, and Turkish (Lameva, 2020).

The official language of instruction in Montenegro is Montenegrin. However, teaching is also performed in other languages in official use, which include Serbian, Bosnian, Croatian, and Albanian (Radović, 2020).

Kosovo has two official languages that are used for instruction in schools, namely Albanian and Serbian. In addition, national minorities have a right to education in their native language, such as Bosnian and Turkish (DQASAL/MEST, 2020).

The majority of students in Albania are taught in Albanian. Recognized national minorities may receive schooling in their native language, which is currently available for the Greek and North Macedonian ethnic minorities (Council of Europe, 2017).

3 Mathematics and Science Curricula in the Region

In general terms, a curriculum can be defined as "the major organizing concept in considering how educational opportunities are provided to students and the factors that influence how students use these opportunities" (Mullis & Martin, 2017, p. 4). More precisely, the curriculum can be presented at three levels: (1) the intended; (2) implemented; and (3) attained curriculum. These levels, arranged in a top-down order, represent: (1) educational policies and national and social contexts; (2) actual teaching in the classroom, which includes home and school context; and (3) learning outcomes. To make improvements in student attainment, authorities in the education systems need to ensure that any intended changes are being implemented in schools and classrooms. Usually, it is a time-consuming effort to change routine and habit, which includes learning infrastructure and teaching practices. Quality assurance activities in the form of external evaluation, particularly if all stakeholders are involved, can aid with the implementation of the intended plans and improvements.

3.1 Teaching and Instruction

A national curriculum that covers mathematics and science instruction at grade four is commonly used across the region, except in Bosnia and Herzegovina, where mathematics and science curricula vary among its constituents (however, in 2018, a new common core curriculum based on learning outcomes was established as a common foundation from which to create the individual curricula; Bosnia and Herzegovina Council of Ministers, 2018). For the remainder of the region, the mathematics curriculum that was in place during the TIMSS 2019 administration was introduced in 2000 in Kosovo, in 2006 in Croatia, in 2007 in Serbia, in 2014 in Albania, in 2015 in North Macedonia, and in 2017 in Montenegro. Across the region, the science curriculum was generally introduced at the same time as the mathematics curriculum, except in Serbia, where the science curriculum was introduced in 2006, a year earlier than the mathematics curriculum (Kelly et al., 2020). During 2014–2016, North Macedonia adopted an adapted version of the Cambridge International Assessment curriculum (see Cambridge Assessment, 2021) for mathematics and science, which provides a comprehensive set of progressive learning objectives and a structure for teaching across grades one to nine (Lameva, 2020). In Croatia, Kosovo, and Serbia, the mathematics and science curricula have undergone continuous reform since the establishment of the curricula that were in place during the TIMSS 2019 administration. During the 2018/2019 academic year, a new curricular reform was introduced on an experimental basis to a limited number of schools in Croatia, and this implementation was subsequently extended to all schools in the following school year. The gradual introduction of the new curriculum, starting at grade one, means that reform of the grade four curriculum is scheduled for completion by school year 2022/2023 (Elezović & Muraja, 2020). In Kosovo, a new competency-based curriculum was initiated in the school year 2017/2018 at the school entry grades and its further implementation is still ongoing (DQASAL/MEST, 2020).

For all TIMSS participants in the region, both mathematics and science are taught by the classroom teacher (see chapter "Teachers, Teaching and Student Achievement" for more information on teachers' instructional practice and measures of teacher quality). Across the Dinaric region, 17–22% of the total instruction time in grade four is devoted to teaching and learning mathematics, and nine to 17% of the time is allocated to teaching and learning science (see chapter "Opportunity to Learn Mathematics and Science" for more information on opportunities to learn). To evaluate the implementation of their mathematics and science curricula, all education systems make use of school inspector visits and school self-evaluation. Albania, Croatia, Kosovo, and Montenegro use national or regional examinations to evaluate the (achieved) mathematics curriculum, and Kosovo also undertakes a research program for this purpose. Albania, Bosnia and Herzegovina, Croatia, Kosovo, and Montenegro use national or regional examinations to evaluate the science curriculum (Kelly et al., 2020).

3.2 Digital Competence and Use of Information and Communications Technology

From the perspective of national mathematics curricula in the region, Albania, Kosovo, Montenegro, and North Macedonia include statements or policies about students' use of digital devices in grade four mathematics instruction. For instance, in Montenegro, information and communications technology (ICT) use is frequently recommended for undertaking calculations and researching new ideas. Calculators are used in grade four mathematics instruction to check the correctness of calculations. Acquiring ICT skills, such as finding, processing, and saving information, is also a general goal of the state's education program, although none of the region's education systems include specific statements about students' use of digital devices during mathematics tests or exams in their curricula. However, the recently implemented curriculum in Croatia (which was initiated for grade one in the school year 2018/2019) emphasizes using digital technologies in teaching and learning from grade one onwards. For science instruction in grade four, the national curricula in Albania, Kosovo, Montenegro, and North Macedonia contain statements about the use of digital devices, such as computers, tablets, or calculators. For example, in Montenegro, students are encouraged to become familiar with using digital devices in all subjects. Teachers may decide to use computers in the classroom to demonstrate experiments or to get students to practice their skills, although this is not mandatory (Kelly et al., 2020).

There are some special initiatives related to ICT in the region. In Croatia, the development of digital competencies is seen as a cross-curricular endeavor and, as part of the reforms that started on an experimental basis in the school year 2018/2019, school equipment is being upgraded and ICT slowly introduced into teaching practices. Before this reform, computers were rarely used outside of informatics lessons in primary education, and the infrastructure and conditions for ICT use in teaching varied considerably between schools and counties. ICT use is considered central to improving and modernizing teaching and learning in Croatia (Elezović & Muraja, 2020). Across the wider region, there are several other ICT initiatives, including the twenty-first century schools program managed by the British Council; this provides support to around 4500 primary schools in the region, to strengthen digital education and digital literacy (British Council, 2020).

According to a European Council recommendation (European Union, 2018), digital competence can be defined as "the confident, critical and responsible use of, and engagement with, digital technologies for learning, for work, and for participation in society." This definition, accompanied by a comprehensive framework known as DigComp 2.1 (Carretero et al., 2017), has become a popular reference tool for many European countries in incorporating digital competence in their national curricula, and has also been adopted in the Dinaric region. Bosnia and Herzegovina refers to the European definition of digital competence for school education in its curricula and related strategy documents, whereas Albania and Serbia refer to the European definition in addition to their own national definition. In contrast, Croatia has its individual national definition of digital competence, and Montenegro and North Macedonia do not have a common definition. In principle, digital competence in primary and secondary education can be implemented as a cross-curricular theme, as a separate subject, or integrated into other subjects. In the school year of 2018/2019, the national curriculum for primary education (ISCED 1) in Serbia included digital competence as a cross-curricular component, while in Montenegro and North Macedonia it was included as a compulsory separate subject (European Commission/EACEA/Eurydice, 2019b).

4 The Role of Assessments for Quality Assurance

4.1 Decision-Making Authorities and Distribution of Responsibilities

Throughout the Dinaric region, the decision-making authority and responsibilities related to different factors within the education system are generally structured in a similar way, reflecting the similar circumstances across the region when the end of communism around 1990 resulted in the process of transition from centralized planning to a market-based economy. The general trend of recent years has been to delegate more responsibility from central governmental levels downwards through the hierarchies within the systems. For example, North Macedonia has transferred greater responsibility for educational matters to municipalities and, since 2005, the municipalities have been responsible for funding and running pre-school institutions, primary schools, and secondary schools. They were also empowered to open new establishments, distribute central funding, maintain and audit schools, and appoint principals, teachers, and school board members. These reforms have led to relatively high levels of school autonomy in terms of resource management and student assessment policies. Principals have increased responsibility when it comes to human resource activities related to teachers, and teachers have more control over the development of classroom assessments. The North Macedonian government considered this step as an important move toward improving the quality of education, equality of opportunities, and the overall efficiency of the system (Kitchen et al., 2019; Lameva, 2020).

Albania has gone through a similar series of educational reforms, deemed necessary to improve educational outcomes such as student performance. In 2003, regional education directorates and offices were set up to support the Ministry of Education, Sport, and Youth with implementing the national education policies in schools. Further decentralization of school services in 2019 made regional directorates responsible for school evaluation. Reforms led to increased school autonomy, which should enable schools to make effective use of resources and reflect on their policies and practices. As one example, after approval from the local educational institutions, schools are now entitled to draft individual curricula based on the ministry-approved curriculum framework (Maghnouj et al., 2020).

In Kosovo, municipalities are in charge of the construction and maintenance of educational facilities and for ensuring a healthy environment for staff and students. They are also responsible for enrolling students and hiring teachers and other school staff (DQASAL/MEST, 2020).

In Serbia, the Ministry of Education, Science, and Technological Development is responsible for educational research, planning, development, supervision of pre-school, elementary, secondary, and higher education, and the organization, evaluation, and supervision of employees in the education sector. Public educational institutions are financed mainly from national and local budgets. It has been estimated that, during the last few years, almost 90% of the total funds have been provided from the national budget, with the remainder derived from local budgets. Recently, municipalities have become more involved in the funding of education; however, the government still provides the essential materials and technical resources that are a necessary minimum for school operations (Đerić et al., 2020). The process of democratization, decentralization, and depoliticization of education in Serbia started in 2000 at all levels of education, targeted at educational policy and practice and quality and equity in education (Spasenović et al., 2007).

4.2 Quality Assurance Structure in Education Systems

Quality assurance is an integral part of education systems, impacting educational outcomes. Exactly how quality assurance is implemented and where it is located within the education system depends on the structure of a system. It can form part of the role of the ministry of education or be organized as a completely independent external institution. Across the Dinaric region, multiple relevant institutions deal with quality assurance in a pre-university context. These include internal quality assurance processes, which can be defined as a continuous process of rethinking and reevaluating current practice, guided by various procedures, including statistics, indicators, and other information collected from and serving different stakeholders. Conversely, external quality assurance processes may include national and international assessments and evaluations by school inspectorates.

The education systems in the Dinaric region usually subdivide quality assurance into the following sections: early childhood education and school education, higher education, and adult education and training. Quality assurance in the school sector is structured in different ways and focuses on varying aspects throughout the region.

In Albania, the bodies responsible for quality assurance in the school sector are the National Agency for Education, Training, and Qualifications and the State Education

Inspectorate. Internal quality assurance mechanisms in Albania include school self-evaluation, which is conducted via the Albanian school performance charter (Albanian Ministry of Education and Sports, 2014), a document that incorporates information on achievement, support for the school in performing their duties, and standard indicators, and functions as a self-evaluation instrument for schools. National student assessments have been an established external quality assurance instrument since 2016, conducted at the end of grades five, nine, and 12, and managed by the Centre for Educational Services (European Commission/EACEA/Eurydice, 2020).

Quality assurance in Bosnia and Herzegovina is integrated into all institutions related to education, and the Agency for Pre-primary, Primary, and Secondary Education (APOSO) holds the authority to establish learning standards, evaluation of achievements, and development of the common core curriculum (Bosnia and Herzegovina Council of Ministers, 2018). At school level, internal evaluation is part of the governance structure and external evaluation is carried out by expert advisors, who may review school operations or the work of teachers (European Commission/EACEA/Eurydice, 2020). The first external evaluation at state level concerning grade four was carried out as a national assessment in 2002 by a predecessor of APOSO. National assessments in Bosnia and Herzegovina do not occur regularly due to a lack of financial resources (Popić & Džumhur, 2020).

Quality assurance in Croatia is managed by several governmental agencies with a focus on the specific levels of education. The Teacher Training and Education Agency is mainly responsible for quality assurance of the pre-primary, primary, and secondary education sector (European Commission/EACEA/Eurydice, 2020). External national examinations are usually conducted by the National Center for External Evaluation of Education (NCEEE); since its establishment in 2006, national exams have been conducted at rather irregular intervals and are seen as diagnostic tools. In 2011, IEA studies were introduced in the form of a combined TIMSS and PIRLS (Progress in International Reading Literacy Study; see IEA, 2021) assessment at grade four. Since then, these IEA studies have become an independent international tool for deepening the understanding of student achievement and student attitudes in primary education (Elezović & Muraja, 2020).

In Kosovo, the Ministry of Education Science, and Technology (MEST) is primarily responsible for ensuring the quality of pre-university education. Quality assurance activities are carried out by various subdivisions and subordinate agencies of the ministry, such as the Education Inspectorate or the Division for Quality Assurance, Standards, Assessment, and Licensing (DQASAL). The latter was established in 2001 to develop education policies and to conduct national and international assessments. Among other tasks, they also evaluate the quality of service of educational institutions or advise executives of education institutions. TIMSS 2019 represents the first international assessment in Kosovo dedicated to grade four students[2] (DQASAL/MEST, 2020).

The quality assurance system in Montenegro stipulates that all educational institutions carry out annual quality assurance and improvement activities in the form of self-evaluation. In addition, the Bureau for Education Services is responsible for external quality assurance in the sector of pre-school, primary, and secondary education. All quality assurance activities in Montenegro are based on the *Rulebook on the content, form, and manner of quality assessment of educational work at institutions* (Government of Montenegro, 2020). This covers areas such as students' achievement, quality of teaching and learning, the governance and management of the institution, or cooperation with parents (European Commission/EACEA/Eurydice, 2020).

Quality assurance in the pre-school, primary, and secondary education sector in North Macedonia is carried out by the State Education Inspection (SEI), the Bureau for Development of Education (BDE), and the State Examination Center (SEC). The last body is responsible for the external evaluation of students' achievement and teaching (European Commission/EACEA/Eurydice, 2020). The first national assessment of mathematics in North Macedonia was organized at the end of grade four in 2000 and followed by an assessment for natural sciences in 2006, which aimed to provide the relevant education institutions with valid data about student attainment that could be used to create educational policy and provide feedback for schools and teachers. Over the period from 2014 to 2016, electronic external testing was carried out for students in grade four. A new law on primary education demanding national assessment is currently being developed, with the first tests planned for 2021 (Lameva, 2020).

The Serbian Ministry of Education, Science, and Technological Development supervises external quality assurance activities that are conducted by the National Education Council, the Institute for the Improvement of Education, and the Institute for Education Quality and Evaluation. These institutions are responsible for determining educational standards, national testing, suggesting improvements, or adapting educational policies. The main aim of the internal quality assurance lies in strengthening school self-governance and autonomy and in ensuring the professional development of teachers by identifying ways for improvement of their practices and management (European Commission/EACEA/Eurydice, 2020). The first national testing of grade four students was undertaken in 2006 by the Institute for Educational Quality and Evaluation. In 2015, Serbia introduced annual tests in mathematics for students in grades four and six.

[2] It is important to mention the existing parallel education system, which has separated Albanian Kosovars from Serbian Kosovars since the 1990s (OECD [Organisation for Economic Cooperation and Development], 2006; Gabršček & Dimc 2000). Data collected in TIMSS 2019 exclusively covers the Albanian Kosovars.

4.3 TIMSS 2019 Implementing Institutions

International large-scale assessments have become an integral part of external quality assurance across the Dinaric region in recent years, as internationally standardized testing provides high-quality data and potentially beneficial comparable insights into the strengths and weaknesses of education systems. Although TIMSS had been previously implemented in many parts of the region, 2019 was the first time that all education systems in the region chose to use the assessment to monitor the mathematics and science achievement of their grade four students. The national institutions involved in implementing TIMSS 2019 across the region have been vital for the success of the study in the participating education systems.

The Educational Services Center (QSHA) in Albania was established in 2017 as an evolution from multiple older institutions. Currently, QSHA is a special institution for organizing, monitoring, and supervising educational reforms and quality assurance in the field of evaluation of achievement and exams. It exercises the technical, professional, supportive, and recommendatory function of the assessment and organization policies of state exams (e.g., the school-leaving examination[3]). The institution is also involved in all international large-scale assessments in which Albania participates (European Commission/EACEA/Eurydice, 2020).

In Bosnia and Herzegovina, APOSO was established to serve as an independent administrative organization promoting quality of education at pre-primary, primary, and secondary levels. The agency was also appointed to conduct the TIMSS administration in Bosnia and Herzegovina (Popić & Džumhur, 2020). The agency has its seat in Mostar and two regional units located in Sarajevo and Banja Luka. Planning and implementing international comparative studies form part of the work of the regional unit in Sarajevo, together with other tasks related to learning standards, student achievements, and evaluating the results in primary and secondary education. APOSO is further involved in developmental and research programs and projects, designing and maintaining relevant databases, performing psychometric measurements, statistical analysis, publishing activities, and performing translation tasks (APOSO, 2020).

The NCEEE in Croatia originated with the mission to provide valid and objective monitoring and external evaluation of the national education system, in collaboration with its stakeholders, to define and improve the quality of education. The NCEEE, located in Zagreb, is responsible for comprehensive external evaluation of the pre-tertiary education system in Croatia. In addition to the objective and transparent external evaluation of learning outcomes and the development, implementation of the system of external evaluation of education, and conduct of international research in education, the NCEEE licenses, certifies and educates key stakeholders in education on the quality of education at all levels of the system, and research and development in educational measurement, and continually promotes and develops the quality of the education system to foster positive change (NCEEE, 2020).

[3] School-leaving examinations are commonly referred to as “Matura” across the region. However, preference was given to the term “school-leaving examination” throughout the chapter.

In Kosovo, DQASAL was first established in 2001 as part of the Ministry of Education, Science and Technology of the Republic of Kosovo, and is responsible for the development of educational policies and national and international student assessments. The competencies of the division include the organization and implementation of international assessments, the dissemination of study results, and the implementation of the national school-leaving examination. The institution further consults and cooperates with municipal education institutions to support them with self-assessment and development based on test results, and organizes teacher seminars about assessing student achievement (DQASAL/MEST, 2020).

The government of Montenegro established the Examination Center in Podgorica in 2005. The Examination Center conducts the external evaluation of achieved standards of knowledge and competences of students, organizes counseling for teachers to provide professional assistance for a better implementation of external knowledge assessment, prepares and organizes regional and national competitions for primary and secondary school students, organizes and conducts state examinations (e.g., the school-leaving examination), investigates and develops external assessments, and assesses the international comparability of the quality of the education system, including implementing relevant international assessments (Examination Center, 2005).

The North Macedonian State Examinations Center (SEC) was established in 2009 with headquarters in Skopje as an independent successor of the Assessment Unit. Its role is to evaluate the quality of education through external assessments. SEC's competencies include the organization, implementation, and support of external assessments, and evaluating student achievement in primary and secondary education in North Macedonia. SEC also prepares and implements national external assessments, such as the school-leaving examination at the end of secondary school. The responsibilities of the center additionally include preparing and monitoring examination materials for high school and secondary vocational education. As an institution, SEC oversees the training and licensing of principals of primary and secondary schools and also issues certificates (licenses) to teachers and professional associates from primary and secondary education. SEC is responsible for the preparation and implementation of international assessments (State Examinations Center, 2020).

The Institute for Educational Research (IER) is an independent research institute in Serbia, founded in 1959. Granted the status of a scientific institution in 1961, the institute is currently a leading research institution in the field of education and contributes to the development and improvement of the quality of education in Serbia. Its main objectives are researching excellence and innovation, and promoting science and the awareness of the role of educational research. It integrates basic, applied, and developmental multidisciplinary research to contribute to scientific, educational, and social development in Serbia. IER was responsible for implementing TIMSS from 2003 to 2019, focusing on grade four since 2011 (IER, 2012).

5 TIMSS Survey Design and Its Implementation in the Region

The TIMSS 2019 assessment was organized around a content dimension and a cognitive dimension, both of which consisted of several sub-domains. The assessment framework describes the content domains (e.g., measurement and geometry in mathematics or life science in science) and topics within these domains include specific abilities that grade four students should be able to demonstrate. The cognitive domains of knowing, applying, and reasoning describe the thinking skills students are expected to use to solve the mathematics and science problems. Each item in the assessment was assigned to a specific content and cognitive domain (Centurino & Jones, 2017; Lindquist et al., 2017) and, similarly, the aspects of the learning context covered by TIMSS 2019 were addressed in the context questionnaires framework (Hooper et al., 2017).

In recognition of the increasing use of information technology for learning and assessment in recent years, the TIMSS pen-and-paper assessment transitioned to a digital data collection mode in 2019 ("eTIMSS"; see Mullis & Martin, 2017), however the pen-and-paper option was retained as an option.

Among the Dinaric region TIMSS 2019 participants, only Croatia opted for eTIMSS. The eTIMSS design was more extensive because it also included four blocks of problem-solving and inquiry (PSI) tasks and items. However, for this research we only considered the item blocks in eTIMSS 2019 that had a matching counterpart in the pen-and-paper format, although they were adapted to make appropriate use of digital components (e.g., slightly modified so students could make use of additional "drag and drop," or "sorting" features).

The individual grade four student response burden for the TIMSS 2019 assessment was the same as it has been since TIMSS 2007, allowing 72 min for the assessment and 30 min for the student questionnaire, with a short break before undertaking the second part of the assigned student achievement booklet and again before completing the student questionnaire. TIMSS' ambitious reporting goals require many more questions in the assessment than could be answered by a single student in the amount of testing time available. TIMSS thus uses a matrix sampling approach that involves packaging the entire assessment pool of mathematics and science items at each grade level into a set of 14 student achievement booklets, with each student completing just one booklet. Item response theory scaling methods are then used to assemble a comprehensive picture of the achievement of the entire student population of a country from the combined responses of individual students to the assessment booklets that they are assigned (Martin et al., 2017).

Participants of TIMSS 2019 administering the assessment at grade four could choose to use booklets with some less difficult blocks in mathematics than the regular TIMSS grade four assessment. Out of the seven TIMSS 2019 participants in the Dinaric region, all but Croatia and Serbia opted for the less difficult mathematics assessment. The less difficult mathematics assessment was designed for students that are still developing fundamental mathematics skills. The results of these tests are reported on the same achievement scale as other TIMSS participants, but the less difficult items extend the TIMSS mathematics achievement scale to provide better measurement at the lower end of the scale. Experiences with TIMSS Numeracy in 2015 and PIRLS Literacy in 2016 (the less difficult version of IEA's PIRLS reading assessment) indicate that lower-performing students are more strongly motivated by less difficult items, and better demonstrate what they know and can do, resulting in fewer omitted items and higher completion rates. Consequently, the results from the less difficult TIMSS and regular TIMSS are comparable, regardless of the version of the assessment the students have taken (Mullis & Martin, 2017).

5.1 Sampling and Some Key Characteristics of the Target Grade

The international TIMSS sample design calls for a minimum of 150 schools with one or more intact classes in grade four, resulting in a student sample of approximately 4000 students per participating entity. The target grade for this publication is grade four and the population is defined internationally as "the grade that represents four years of schooling, counting from the first year of ISCED Level 1" (Martin et al., 2017, p. 81). ISCED Level 1 corresponds to primary education or the first stage of basic education. In addition to the grade, TIMSS attempts to avoid assessing very young students and sets the minimum average age at the time of testing of 9.5 years. If this condition is not met, participants need to assess the next higher grade. For the participants in this publication, TIMSS 2019 was administered at grade four. The average student's age on the day of testing in the region ranged from 9.8 in Montenegro and North Macedonia to 10.6 in Serbia. Data from 3270 to 5628 students per participating education system were collected between 11 March and 15 May 2019 across the region. The student assessment was administered in the main languages of instruction within the education system. North Macedonia administered the test in one minority language, namely Albanian, and Croatia prepared the home and school questionnaire in Serbian and Italian as well as Croatian (see Table 2).

TIMSS employs a two-stage random sampling design. A sample of schools is drawn first, then one or more intact classes of students are selected from each of the sampled schools. Intact classes of students are sampled rather than individuals from across the grade level or of a certain age because TIMSS pays particular attention to students' curricular and instructional experiences in the classrooms. Sampling complete classes also has the operational advantage of less disruption to the school day compared to individual student sampling (Joncas & Foy, 2012). Each TIMSS participant needed to define the national target population and apply the TIMSS sampling methods to achieve a nationally representative sample of schools and students. The development and implementation of the national sampling plan is a collaborative exercise involving the country's national research coordinator (NRC) and the TIMSS 2019 sampling experts. This procedure ensures that the school sampling frame (the school population list from which the school sample is drawn) provided by the NRC is complete, checking that categories of excluded students are clearly defined, justified, and kept to a minimum. The objective is to draw a nationally representative sample of students, while making sure both international and national requirements regarding sampling precision are met. National requirements are often addressed by applying a specific stratification approach (Meinck, 2020).

School location within the participating education systems and whether this location was urban or rural were the major explicit stratification variables used across the region. Albania also stratified their schools by school type (whether public or private), Kosovo by school shifts, and North Macedonia and Bosnia and Herzegovina by language of instruction. TIMSS aims to cover the whole grade four student population in all countries, but allows the exclusion of specific populations for practical reasons. At the within-school level, across the Dinaric region, classes or students with functional or intellectual disabilities were excluded, as were non-native language speakers, however, there were some differences at the school level. Most of the exclusions could be attributed to a small number of grade four students in schools (less than three), and the exclusion of schools that only taught students with special needs or provided instruction in a minority language, or those studying a different curriculum (e.g., international schools). In Albania, Montenegro, and Serbia, all students who were not taught in the majority language of instruction were specified as language-based exclusions. In TIMSS 2019, Kosovo and Serbia exceeded the five percent maximum exclusion rate that is usually set for studies designed for cross-national comparisons. In both cases, this happened because of their linguistically diverse populations; TIMSS 2019 could not always be administered in all recognized languages of instruction. In Kosovo, schools with the Bosnian or Serbian language as the primary language of instruction accounted for 8.56% of the overall exclusion rate, and the schools serving the minority populations in Serbia accounted for 8.21%. The analyses in this study only used the data from assessments delivered in the prevailing Albanian language in Kosovo and the Serbian language in Serbia. It is important to underline that the TIMSS 2019 test was administered in the language of instruction. The vast majority of the sampled students responded to the test in a language that they were using at home (Table 3). However, the data collected by TIMSS also indicates that classrooms are not linguistically homogenous.

After sampling had been completed and all data collected, the TIMSS sampling experts documented population coverage, and school and student participation rates, and constructed appropriate sampling weights for data analysis. The target for TIMSS is a sampling participation of 100% for all sampled schools, classrooms, and students, and the achievement data are reported according to this target. TIMSS participants were assigned to one of three categories on the basis of their sampling participation: category 1 (considered to have met all TIMSS 2019 sampling requirements and to have acceptable participation rates), category 2 (meeting the participation requirements only after including replacement schools), and category 3 (failed to meet the participation requirements even with the use of replacement schools) (LaRoche & Foy, 2016). Across the region, all participants fell in category 1, indicating that the quality and validity of the results can be trusted.

Table 3 How often do students speak the language of the test at home?

Education system	Percentage of students (%)			
	Always	Almost always	Sometimes	Never
Albania	86.58	6.30	6.21	0.91
Bosnia & Herzegovina	84.38	8.34	6.50	0.79
Croatia	68.19	20.04	10.48	1.29
Kosovo	87.16	5.97	6.44	0.43
Montenegro	71.27	11.74	10.81	6.17
North Macedonia	79.10	7.91	10.00	2.99
Serbia	84.77	9.55	5.12	0.56

Source Mullis et al., (2020)

5.2 *Quality Assurance for the TIMSS 2019 Test Administration Across the Dinaric Region*

Strict quality assurance procedures ensure large-scale assessments produce high quality, internationally comparable data. In TIMSS 2019, quality assurance was an integral part of the study and was implemented at both the international and national levels. This encompassed all main activities from the assessment framework, including assessment and questionnaire development, sampling, instrument preparation, data collection, scaling, and data analysis. The TIMSS quality assurance components that were implemented during the data collection period were the international and national quality control programs, and the TIMSS *Survey activities questionnaire* (SAQ), completed by all NRCs.

The SAQ is used by NRCs to document their experiences of the TIMSS 2019 main data collection processes. The questions cover all activities from school sampling, preparing the national study instruments including their translations, reviews, printing, checking and distribution, selecting and training the school coordinators and test administrators, maintaining the security of the assessment materials and the confidentiality of the responses, observing testing sessions, scoring the obtained responses, and performing data entry and checks. All these activities are additionally described in the TIMSS 2019 *Survey operations procedures units*, which are documents designed to provide guidance to NRCs. The NRCs reported that these guidance documents were considered clear and useful, although some participating entities encountered various challenges during the preparation of the assessment instruments (e.g., difficulties in using the Adobe InDesign® package to prepare the national versions of the international instruments).

Three interlinked aspects were related to data availability and quality: (1) school coordinator and test administration appointment and training; (2) the implementation of the national quality control program within the participating schools; and (3) independent observations undertaken as part of the international quality control program, which was overseen by the TIMSS & PIRLS International Study Center.

All school coordinators from the Dinaric region were appointed by the participating schools, and all undertook formal training. In most cases, these school coordinators trained the test administrators in the participating schools. However, in Bosnia and Herzegovina, most of the test administrators were trained by staff from the national study center. In Kosovo and North Macedonia, the test administrators were external to the participating schools. They brought the assessment materials for the testing session to the school, conducted the session, and collected all materials after the session was finished. Based on the completed TIMSS test administration forms, the most frequent problem for students was encountering unknown words and/or tasks that they had not yet covered in school (e.g., fractions in Croatia).

As part of the national quality control programs, the data collection was observed in the participating schools; these observations took place in all participating entities in TIMSS 2019 from the Dinaric region, except Kosovo and Montenegro, who had insufficient budget for this activity. Testing sessions in the recommended 10% of participating schools were observed in Albania, Croatia, and Serbia, 12% of the sampled schools were visited in Bosnia and Herzegovina, and 100% of schools were visited in North Macedonia. The national quality control monitors (NQCMs) did not document any major problems or special circumstances that occurred repeatedly during the administration of the TIMSS assessment.

In addition to the information from national quality control and the SAQ, international quality control monitoring was also part of TIMSS 2019. International quality control depended on reported observations from selected experts appointed as international quality control monitors (IQCMs). These individuals were employed independent of the TIMSS 2019 national centers and personally trained for monitoring activities by the TIMSS & PIRLS International Study Center (see Johansone & Flicop, 2020 for more detailed information on these aspects).

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Opportunity to Learn Mathematics and Science

Agim Alia, Barbara Japelj Pavešić, and Mojca Rožman

Abstract IEA's Trends in International Mathematics and Science Study (TIMSS) uses the curriculum as the major organizing concept in considering how educational opportunities are provided to students. "Opportunity to learn" is generally defined by the instructional time spent on a specific subject area and instructional content. TIMSS data can be used to analyze key aspects surrounding students' opportunities to learn mathematics and science, in combination with background factors that influence how students use these opportunities. The results concerning opportunity to learn can be compared at different levels, related to the prescribed curriculum, the implemented curriculum, and attained educational goals. Across the Dinaric region, the TIMSS 2019 data showed that there were some discrepancies between intended, implemented, and attained curricula. Officially prescribed contents in national curricula differed from the teacher reports of content taught in school. The analyses also revealed that there were no significant common relations between the percentage of students that were taught the topics and mean national achievement in TIMSS 2019 across the Dinaric region and that, contrary to expectations, school content coverage could not solely explain observed student achievement. Other important elements may have a mediating effect, such as the quality of instruction or time and opportunities available for learning outside school.

Keywords Grade four · Instructional time · Instructional content · Mathematics achievement · Opportunity to learn · Science achievement · Trends in International Mathematics and Science Study (TIMSS)

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1 Introduction

Opportunity to learn (OTL) can be considered the “observable structure” of teaching (Schmidt & Maier, 2009; Schmidt & McKnight, 1995) and thus makes a valuable contribution toward learning outcomes. OTL connects nationally prescribed contents and methods of teaching and learning (the intended curriculum) with learning contents, class environment, and school climate (the implemented curriculum), and students’ outcomes (the attained curriculum).

Alignment between educational goals, intended and implemented curricula, and educational outcomes is deemed an essential characteristic of effective education. The expectation is that better alignment between these leads to more effective education and hence better student performance. The concept of OTL is commonly used to compare content covered, as part of the implemented curriculum, with student achievement. As such, OTL can be viewed as a facet of the broader concept of alignment (Scheerens, 2017).

Accordingly, OTL can be characterized as the alignment between teaching processes and student achievement, or as “the alignment of standards and output measures, mediated by teaching processes” (Scheerens, 2017, p. 41), it can also refer to a wide range of inputs and processes within a school context that support intended student outcomes. In doing so, instructional time and content have also consistently been characterized as core elements of OTL, along with a number of instructional quality indicators. Carroll (1963) was first to define OTL as “the amount of time allowed for learning, for example by a school schedule or program” (see Carroll, 1989, p. 26). The central concept is the notion that students cannot learn content that has not been presented in class. Carroll (1989) included OTL as one of five variables in a formula that he used to express a student’s degree of learning. Some of these variables can be measured to a certain extent by time, in terms of the amount of time a student needs to be given to learn, understand, and master a task, and the amount of time allowed for this learning in the curriculum. This has led researchers to examine how time dedicated to instruction (the instructional time) may be related to student achievement. According to Kurz (2011, see also Elliott & Bartlett, 2016), Stevens (1996) distilled the first comprehensive conceptual framework of OTL, bringing together four elements: content coverage, content exposure (time on task), content emphasis (the emphasis on the cognitive processes required), and quality of instructional delivery (the methods and quality of the instructional practices used to deliver the content).

Content exposure refers to the estimated total amount of time actually devoted to covering the specific content (Leinhardt & Seewald, 1981). Terms like instructional time, amount of time devoted to teaching certain subject areas, and amount of teaching periods (or hours per week or year) are traditional measures of this particular dimension of OTL (Stedman, 1994; Wang, 1998). Brophy (2000) found that more time allocated to teaching specific content in classrooms positively contributed to student achievement. To provide students with the necessary opportunities to learn the intended curriculum, teachers must allocate instructional time toward addressing specifically prescribed teaching goals to achieve the requisite student outcomes (Elliott & Bartlett, 2016). Such measures may be categorized by teacher-oriented indicators, such as allocated time (the time scheduled for instruction), or by more explicitly student-oriented indicators, such as instructional time (proportion of allocated time used for instruction), engaged time (proportion of instructional time during which students are engaged in learning), and academic learning time (proportion of engaged time during which students are experiencing a high success rate of learning). Researchers have found time-based OTL indices to be moderately related to student achievement after controlling for student ability and socioeconomic status (Elliott & Bartlett, 2016, p. 5).

Teachers must also ensure that they cover the content outlined by the formal curricula, as these are the topics that students are likely to be assessed on. In 1964, IEA undertook the First International Mathematics Study (FIMS) in twelve countries, to investigate the outcomes of various school systems for mathematics, which was, at the time, undergoing reforms in many educational systems (Husén, 1967). This results from this early IEA study led to increased research interest in content-based conceptualizations of OTL, designed to evaluate the content overlap between enacted and assessed curricula (Elliott & Bartlett, 2016). Anderson (1986, p. 3682) noted that the "opportunity to learn from the Husén perspective is best understood as the match between what is taught and what is tested." Perhaps the most important measure of content coverage in current policy efforts is the alignment of teachers' instruction with state standards and/or assessments (Scheerens, 2017).

Substantial empirical evidence has documented the importance of OTL variables in explaining students' test scores and found that students were more likely to respond to an item correctly if they had the opportunity to learn the tested concepts and skills, especially if students had this opportunity during the year the assessment was delivered. Wang (1998) examined the impact of Stevens' (1996) four dimensions of OTL on outcomes and found that OTL was a significant predictor of student achievement in both written tests and other scores students received in schools. Variations in the effects of OTL could be attributed to differences in test format. In their study of English language learner achievement, Aguirre-Muñoz and Boscardin (2008) stated that content exposure was the most significant predictor of students' written test scores, whereas the quality of instructional delivery was the most significant predictor of practical test scores.

IEA's Trends in International Mathematics and Science Study (TIMSS) is one of the few international studies that are curriculum based, and it thus routinely collects information about OTL at different levels. As stated in the TIMSS framework, "TIMSS uses the curriculum, broadly defined, as the major organizing concept in considering how educational opportunities are provided to students and the factors that influence how students use these opportunities" (Mullis, 2017, p. 4).

Along with total instructional hours per year, TIMSS collects information, on a national level, on whether the curriculum or any other official document prescribes the percentage of total instructional time to be devoted to mathematics and science instruction at the grade four.

1.1 Framework and Research Questions

For our research, we considered a restricted concept of OTL. We used a conceptual framework that combined elements from educational effectiveness, a curriculum model, and the notion of OTL to analyze curriculum effects. In our model the intended curriculum is defined as the curriculum that an education system intends to implement, as stated in their official policy documents. At the school, classroom, and teacher level are the actors that actually implement that curriculum. Finally, the students (hopefully) attain the content taught. At each of these levels, we can observe specific curriculum factors that together define the whole curriculum (Bokhove et al., 2019).

We use the term opportunity to learn specifically with reference to the mathematics and science topics covered in classroom instruction. This reflects both the narrow curricular sense in which the concept was originally developed by Carroll (1963) and in the studies implemented by IEA. We chose to focus on the definition of OTL as time of exposure and quality of content for two reasons: (1) the provision of content is the fundamental rationale of schooling and the education system, and (2) this is an aspect of schooling that both reflects education policy and is amenable to education policy reform (see Scheerens, 2017, p. 41).

Seven participants from the Dinaric region took part in TIMSS 2019, namely Albania, Bosnia and Herzegovina, Croatia, Kosovo,[1] Montenegro, North Macedonia, and Serbia. Our analysis of the TIMSS 2019 data was designed to address two key research questions:

(1) *What can TIMSS 2019 tell us about students' opportunities to learn mathematics and science across the Dinaric region?*
(2) *Can students' opportunities to learn be related to their mathematics and science achievement?*

We explored key aspects of OTL included in the TIMSS international framework at grade four. In TIMSS, content exposure is defined as the instructional time prescribed and devoted to mathematics and science curricula at the grade four, and content coverage is defined as the number and content of mathematics and science topics intended to be taught and effectively taught in classes (Mullis & Martin, 2017). We explored both content exposure and content coverage at the level of intended curriculum and at the level of implemented curriculum. Our analyses conceptualized OTL as the overlap between intended content coverage and implemented content coverage; OTL is thus a measure of the relation between implemented content and intended content. Content coverage addresses the degree to which content was covered throughout the continuation of the school, in order to see if students have adequate opportunity to learn topics assessed by the test. Content exposure refers to the total amount of time spent on covering the specific subjects. Finally, we assessed

[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).

the relationship between OTL and the attained curriculum, namely the mathematics and science achievement of TIMSS grade four students across the Dinaric region.

2 Methods and Data

As part of TIMSS, 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). All the data used in our analyses were collected by the TIMSS 2019 grade four assessment. We carefully selected relevant data collected by the TIMSS 2019 background questionnaires to inform our analyses using variables at all three curriculum levels (Table 1).

When examining the data available from TIMSS 2019 for grade four students, we limited our observations to two basic elements of the concept of opportunity to learn: time exposure (namely the time allocated to instruction in a topic in school) and content exposure (the amount of content presented to students by teachers). To observe the effect of OTL on final educational outcomes, we related the national averages for these elements to the national mean achievement of students in each topic, which was measured independently by TIMSS 2019 in all participating education systems.

Mathematics and science curricula were assessed using broad content domains: for mathematics, these were number, measurement and geometry, and data, and, for science, these were life science, physical science, and earth science. Each content was divided into specific topics, numbering 17 in total for mathematics (seven for number, seven for measurement and geometry, and three for data; Lindquist et al., 2017) and 26 in total for science (seven for life science, twelve for physical science, and seven for earth science; Centurino & Jones, 2017). These topics served as a basis for international development of items for students to solve in the TIMSS assessment (Mullis & Martin, 2017). Therefore they represent the content assessed by TIMSS.

In TIMSS, information on mathematics and science contents covered in national curricula up to grade four were collected at a system level by a curriculum questionnaire completed by the national research coordinator (NRC) in each participating entity from the Dinaric region. Such information reflects the content of the intended curricula. We assessed the implemented curricula using international data on principals' and teachers' responses to the TIMSS context questionnaires[2] (TIMSS & PIRLS International Study Center, 2018). The attained curriculum was evaluated using students' mathematics and science achievement scores in the TIMSS 2019

[2] In TIMSS teachers teaching mathematics and science to the sampled class are selected to respond to the teacher questionnaire. As they do not represent the teacher population in each system, teacher data is analyzed as an attribute of students.

Table 1 List of variables used in our analyses

Variables		Description	Values/response options	References
Content exposure variables	Prescribed instructional time for mathematics/science	The percentage of total instructional time prescribed for mathematics/science instruction at grade four of primary/elementary school at the system level (as reported by the national research coordinators)	Percentage	Fishbein et al. (2021), Supplement 1, pp. 146 and 159
	Total instructional time	Based on principals' reports of school days per year multiplied by the principals' reports of instructional hours per day	Hours per year	Mullis et al. (2020), exhibit 12.1
	Actual instructional time for mathematics/science	Based on teachers' reports of weekly mathematics/science instructional hours provided to the sampled class of students divided by their principals' reports of school days per week multiplied by their principals' reports of school days per year	Hours per year	Mullis et al. (2020), exhibits 12.1 and 13.1
Content coverage variables	Intended coverage of mathematics topics	National research coordinators estimated what proportion of grade four students should have been taught each of the 17 TIMSS grade four mathematics topics by the end of grade four, according to the national mathematics curriculum[1]	(1) All or almost all the students (2) Only the more able students (3) Not included in the curriculum through grade four	Fishbein et al. (2021), Supplement 1, pp. 151–154
	Intended coverage of science topics	National research coordinators estimated what proportion of grade four students should have been taught each of the 26 TIMSS grade four science topics by the end of grade four, according to the national science curriculum[2]	(1) All or almost all the students (2) Only the more able students (3) Not included in the curriculum through grade four	Fishbein et al. (2021), Supplement 1, pp. 163–168

(continued)

Table 1 (continued)

Variables		Description	Values/response options	References
	TIMSS topics	For each content topic listed in TIMSS assessment frameworks, teachers reported whether it was "mostly taught before this year," "mostly taught this year," or "not yet taught or just introduced". The topics variables (8 in total, covering the main and subdomains) reported the percentages of topics within a domain/subdomain that students were taught according to their teachers "mostly before this year" or "mostly this year," averaged across relevant TIMSS grade four mathematics and science topics[1, 2, 3]	Percentage of students taught TIMSS topics	Fishbein et al. (2021), Supplement 3, pp. 12–17 Mullis et al. (2020), exhibits 12.4 and 13.4
Control variables	Home resources for learning scale[a]	Based on students' and parents' reports regarding the availability of five resources: • 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 on scale mean student had more home resources for learning	Yin & Fishbein (2020), p. 16.39
	Classroom teaching limited by students not ready for instruction scale[a]	Consists of teachers' estimates on how much is their teaching in the sampled class limited by eight student attributes Response options: not at all, some, a lot	Higher values on the scale were assigned to teachers who reported being less limited in teaching	Fishbein et al. (2021), Supplement 1, pp. 95–97

Notes The references provide the external document that contains information on exact item wording and, in the case of latent scales, some additional useful information (such as the Cronbach's alpha reliability coefficient, principal components analysis of the included items, and the relationship between the scale and student achievement)

[a]These 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 information on scale construction, please see Yin and Fishbein (2020)

[1]The 17 TIMSS grade four mathematics topics are described in more detail in Lindquist et al., (2017, pp. 15–18) and comprise seven number topics, seven measurement and geometry topics and three data topics. [2]The 26 TIMSS grade four science topics are described in detail in Centurino and Jones (2017, pp. 32–38) and comprise seven life science topics, 12 physical science topics, and seven earth science topics. [3]We here use the terminology from Fishbein et al. (2021), however, we believe the true meaning of the variables is rather the "percentage of TIMSS topics taught to students"

assessment.[3] In addition, to analyze the achieved curriculum in more detail, we subdivided student achievement according to the specific mathematics (number, measurement and geometry, and data) and science (life science, physical science and earth science) content domains. The teacher questionnaire (see TIMSS & PIRLS International Study Center, 2018) also asked teachers to report which topics they had already taught to students participating in TIMSS prior to the assessment. These reports of the implemented curriculum can be compared with demonstrated knowledge measured by mathematics and science items in TIMSS tests.

During the development stages of every TIMSS assessment, a great deal of work is dedicated to ensuring comparability of achievement; here, the assessment content plays an important role. The test content is agreed by all participating education systems working in collaboration and aims to cover topics that are considered relevant by participating nations and that are also covered by the prescribed curricula in the majority of the participating systems. TIMSS provides additional information on the discrepancies between the assessment materials and national curricula, by undertaking a test-curriculum matching analysis of content topics (for further details and results, see Mullis et al., 2020, Appendix C). We used this data to also assess effect of content coverage on regional test scores.

Learning opportunities are not only provided to students in school but also outside formal settings, and especially at home. More books at home and higher education levels of parents have been clearly linked with more opportunities for children to learn at home (Chiu & Xihua, 2008; Eccles, 2005), but TIMSS provides an even more comprehensive scale that can be regarded as a measure of OTL at home, namely the TIMSS home resources for learning scale (HRL scale; Yin & Fishbein, 2020, p. 16.39). This scale covers the information on number of adult and children books and internet access at student home as well as parental education and occupations. Higher values on the HRL scale indicate greater access to home resources for learning, which, in turn, implies more OTL.

To investigate the relationship between OTL and achievement in more depth, as well as the percentages of students taught the topics, we also considered another aspect of OTL which can be linked to the classroom time provided to teaching content. In assessing the importance of higher content exposure, we also needed to consider how achievement may be affected when classroom teaching and hence content exposure is limited by the effects of lower home support and more problematic class

[3] Student achievement was measured by a large number of science and mathematics TIMSS assessment items that together covered all topics from the framework. For TIMSS, the reporting goals mean that many more questions are required for the assessment than can be answered by any one student in the amount of testing time available. Accordingly, TIMSS uses a matrix sampling approach that involves packaging the entire assessment pool of mathematics and science items at each grade level into a set of 14 student achievement booklets, with each student completing just one booklet and therefore only answering part of the whole set of TIMSS items (Martin et al., 2017). Item response theory (IRT) and plausible values methodology were used to compare student scores on the TIMSS international scale metric, which was set to have a mean of 500 and a standard deviation of 100 points in the first cycle of TIMSS (Martin et al., 2020).

climate. Among their responses to the TIMSS teacher questionnaire, teachers estimated how much they felt limited in teaching because of different student attributes. This was used to create a TIMSS scale, classroom teaching limited by students not ready for instruction (the LSN scale; Fishbein et al., 2021, Supplement 1, pp. 95–97). We included this scale in our analyses because additional instructional time is expected to be needed for students getting ready for instruction and consequently less time is available for teaching content; therefore lower values on this scale can be used as a negative measure of OTL.

To describe and assess the differences in students' opportunities to learn about mathematics and science across the Dinaric region, we compared reports from each of the participating education systems derived from TIMSS data on the relevant factors. We undertook additional analyses to discover the relationships between the factors associated with OTL and student achievement, combining data from different sources reported on different scales. We calculated average time devoted to learning and percentages of the learning time devoted to mathematics and science, both according to national prescribed curricula and as reported at the school level by principals. We then used teacher reports on the actual content taught in the sampled schools and calculated mean percentages of students exposed to specific content for each education system. To examine the relationship between students' opportunity to learn and their mathematics and science achievement, we calculated Pearson's correlation coefficients between selected variables and student achievement. Finally, we used regression models to discover the relations between achievement and content exposure, taking two other factors into account: learning outside school and potential limitations to exposure to content taught in school. For the first factor, we used values on the TIMSS HRL scale to assess students' external learning opportunities. The second variable we used was the TIMSS LSN scale. Student achievement was dependent variable in our regression models and we used *t*-test statistics to determine group differences (for a more information about the data sources and methodological tools, which account for the complex survey design, please see Sect. 5.

3 Results

3.1 Content Exposure

For all participating Dinaric education systems, we collected available data on agreed national curriculum targets or any other official document that prescribed the percentage of total instructional time that should be devoted to mathematics and science instruction at grade four. As this information was extracted from official documents, it can be considered a reasonable indicator of the intended or prescribed curriculum at the system level. In some of the Dinaric systems, schools were teaching an integrated curriculum (where school subjects are deliberately combined), so hours spent solely on mathematics or science instruction could not always be accurately

Table 2 Percentage of instructional time allocated at the system level to mathematics and science curricula at grade four

Education system	Percentage of total teaching time at grade four prescribed at the system level for teaching:	
	Mathematics	Science
Albania	17	9
Bosnia & Herzegovina	20	10
Croatia	22	17
Kosovo	21	8
Montenegro	19	10
North Macedonia	22	9
Serbia	21	8–13

reported. However, percentages of total instructional time prescribed nationally for mathematics and science instruction at grade four indicate that mathematics instruction was generally allocated about 20% of total instructional time in the participating systems and there was relatively low variation in the amount of time allocated, the lowest percentage being in Albania (17%) and the highest in Croatia (22%) (see Table 2). Science instruction was generally allocated approximately nine percent of total instructional time in most of the participating systems, although there variation was greater; notably, Croatia allocated 17% of grade four instructional time to science. Mathematics was thus generally allocated more learning time than science, and there was also more consistency among the Dinaric systems in the time allocated to this topic.

At the level of curriculum implementation, we compared information collected from teachers and principals regarding the instructional time spent in individual sampled classes (Fig. 1), as the total instructional time across all subjects per year versus the instructional time devoted specifically to mathematics and science in the Dinaric education systems. Teachers reported the number of hours of instruction per week and principals reported the number of school weeks and days per year. The number of hours for mathematics and science per school year show that Croatia and Bosnia and Herzegovina provide the highest total number of hours of school instruction per year, and Albania and Montenegro provide the lowest number of hours of instruction per year. As a comparison, Croatian students received 206 hours more instruction per year than their peers in Montenegro. Across the Dinaric region, the distribution of time devoted to mathematics and science instruction varied considerably. Croatia devoted the highest number of hours per year to science instruction (82 h), while Kosovo spent the highest number of hours per year on mathematics instruction (150 h); Albania devoted the lowest number of hours per year to both mathematics and science instruction (113 h and 54 h, respectively).

We compared information on prescribed hours reported at the system level by the national research coordinators with the information provided by principals and teachers about the implemented instructional hours and noted there were differences across the Dinaric region between the prescribed and implemented instructional

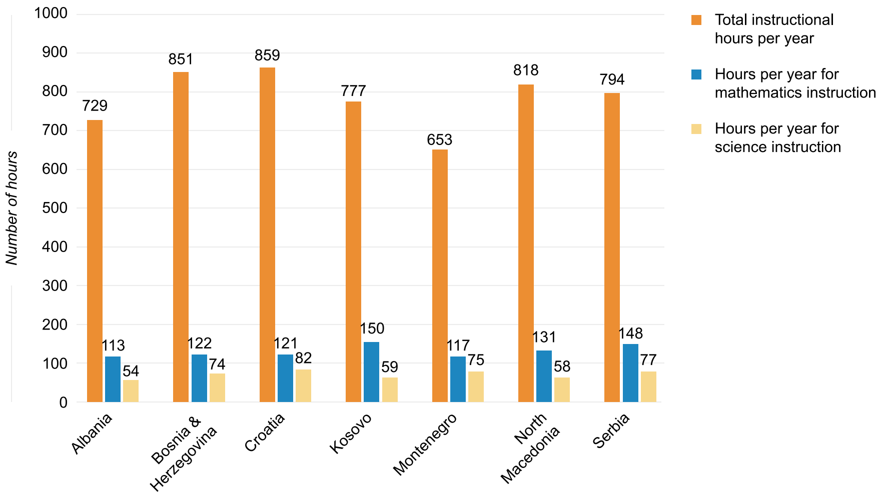

Fig. 1 Total instructional time received by students as reported by principals, and instructional time devoted to mathematics and science, as reported by teachers.
Notes In Kosovo and Serbia, the national defined population covers 90–95% of the national target population. In Kosovo, data for mathematics instruction were available for ≥70% but <85% of the students

time allocated to mathematics and science. On average, across the Dinaric participants, the prescribed instructional time was about 20% of the total instructional time for mathematics and about 10% of the total for science (see Table 2). In reality, the percentage of implemented instructional time (as calculated from the numbers reported by principals and teachers; see Fig. 1) was slightly lower than the prescribed instructional time in all participating systems. For mathematics, the time spent on instruction ranged from 14% of total instructional time in Croatia and Bosnia and Herzegovina to 19% in Kosovo. For science, this time ranged from seven percent in North Macedonia to 11% in Montenegro.

3.2 *Content Coverage for Mathematics and Science Topics*

Our first observation from analyzing the curricular data is that the intended curricula in the Dinaric region were defined at the system level and hence consistent for all students in each system. According to data collected by the TIMSS 2019 curriculum questionnaire (Fig. 2), there were large differences in the intended mathematics topics taught across Dinaric systems. Three of them, Albania, Bosnia and Herzegovina, and Croatia, indicated that seven out of the 17 TIMSS mathematics topics were not included in their grade four curricula. Kosovo reported that four topics were not included in their grade four curriculum. There was also considerable variation in the selection of topics that were taught. Bosnia and Herzegovina and Croatia flagged four

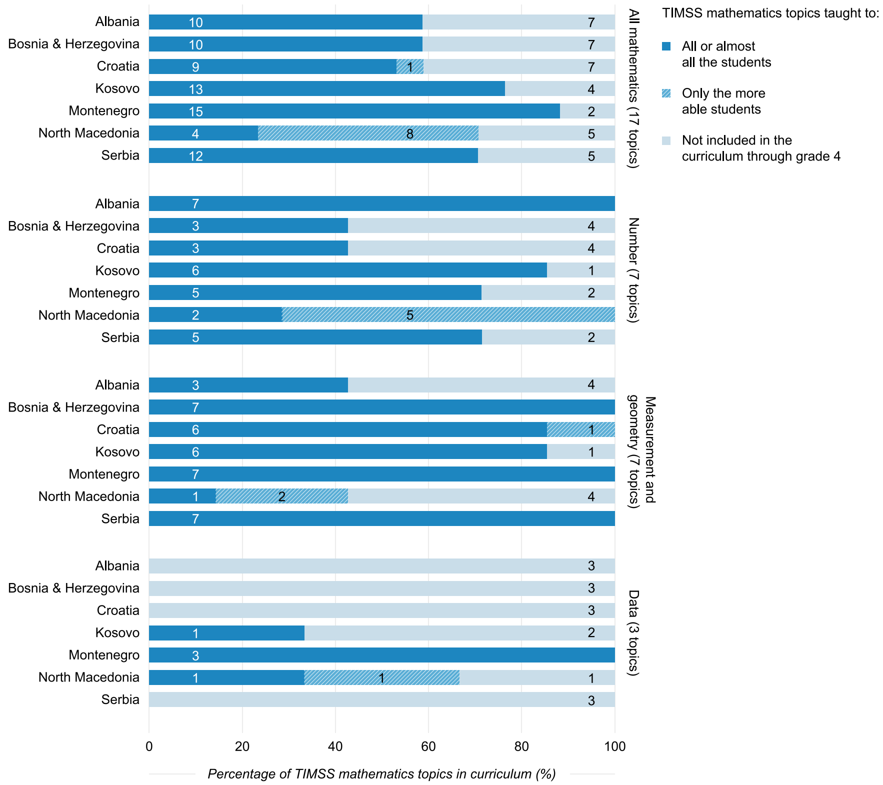

Fig. 2 Intended curriculum coverage of TIMSS mathematics topics, as reported by national research coordinators.
Note Numbers in the bars indicate the number of TIMSS topics in each category

out of seven number content topics were not included in their curricula. Regarding measurement and geometry content, Albania and North Macedonia marked four out of seven topics as not included in their curricula. It is worth noting that only Montenegro included all three data topics in their curriculum; the other Dinaric systems did not cover these topics at grade four, or only to minor extent, indicating there was generally low coverage of this content domain across the region. In North Macedonia, it was noteworthy that a number of topics were intentionally only taught to more able students; other Dinaric systems generally expected all topics included in the curriculum would be taught to all students (Fig. 2).

According to the NRC reports, there were also large differences in science curricula topics across the Dinaric region (see Fig. 3). Only Kosovo and Montenegro reported covering all TIMSS science topics; in North Macedonia there were three topics that were only taught to the more able students. Bosnia and Herzegovina and Croatia omitted the largest number of TIMSS topics from their curricula (12 and 10, respectively). Bosnia and Herzegovina, Croatia, and North Macedonia did not

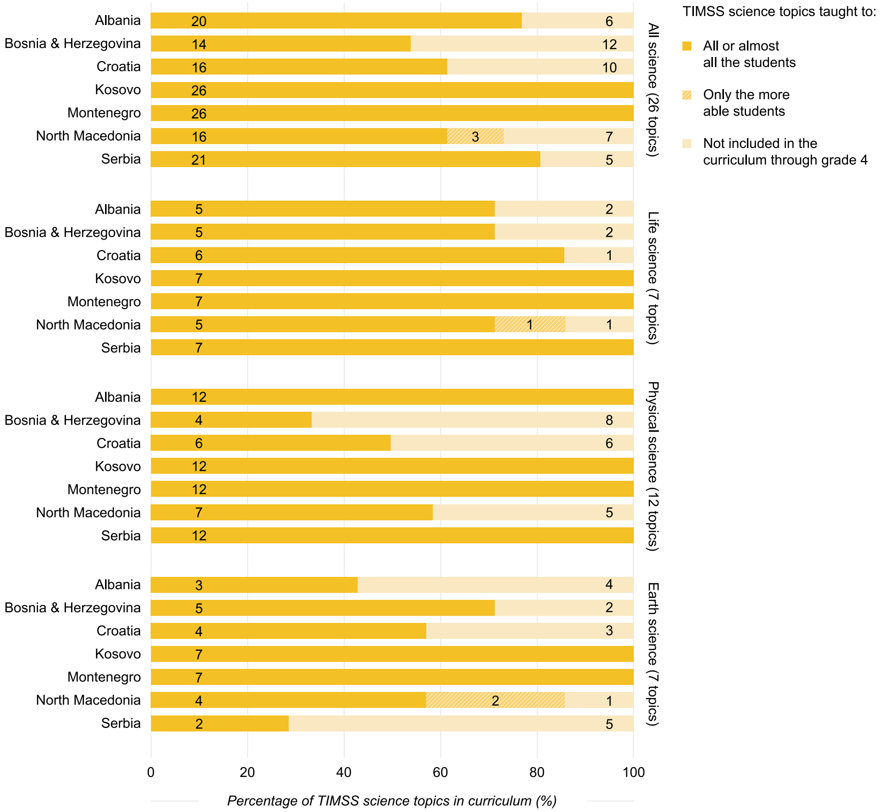

Fig. 3 Intended curriculum coverage of TIMSS science topics, as reported by national research coordinators.
Note Numbers in the bars indicate the number of TIMSS topics in each category

cover a large number of the topics belonging to the physical science domain, but the other four Dinaric participants reported their curricula covered all twelve topics. Montenegro was the only Dinaric participant to cover all TIMSS earth science topics in their curriculum (Fig. 3).

Teachers reported the mathematics content in the TIMSS 2019 assessment that they taught their students (Fig. 4). Their reports revealed that there were quite substantial disparities in the implemented mathematics curricula across the Dinaric region. For example, Kosovo, Croatia, and Serbia focused more on measurement and geometry content, while North Macedonia, Bosnia and Herzegovina, and Albania focused more on number content topics. It is noteworthy that teacher reports of implemented curricula (Fig. 4) only partially aligned with the intended curricula (Fig. 2). Overall, the coverage of the mathematics topics assessed by TIMSS varied across the region, with particularly low coverage in Bosnia and Herzegovina, and high coverage in North Macedonia (Fig. 4).

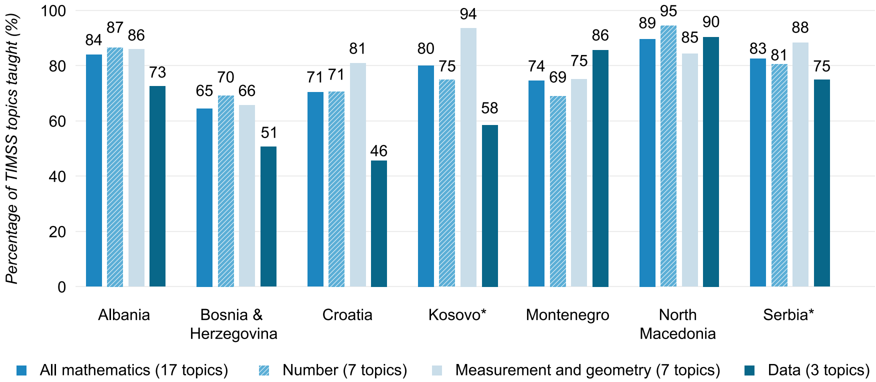

Fig. 4 Average percentages of topics covered by the TIMSS 2019 mathematics assessment that students were taught.
Notes The 17 TIMSS grade four mathematics topics are described in more detail in Lindquist et al., (2017, pp. 15–18). In Kosovo and Serbia, the national defined population covers 90–95% of the national target population (for actual percentages and standard errors, see Table S.1 in the supplementary materials available for download at https://www.iea.nl/publications/RfEVol13)

Teachers also reported the science content in the TIMSS 2019 assessment that they taught their students (Fig. 5). On average, teachers in Bosnia and Herzegovina, Croatia, and Montenegro reported particularly low coverage of the TIMSS science topics by grade four, and there was some regional variation in the range of topics that were taught. Montenegro, Albania, Bosnia and Herzegovina, and Kosovo had a

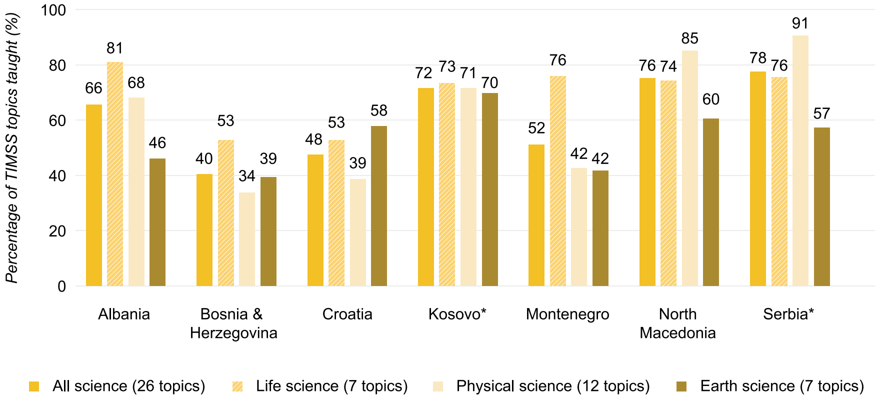

Fig. 5 Average percentages of topics covered by the TIMSS 2019 science assessment that students were taught.
Notes The 26 TIMSS grade four science topics are described in detail in Centurino and Jones (2017, pp. 32–38). In Kosovo and Serbia, the national defined population covers 90–95% of the national target population (For actual percentages and standard errors, see Table S.2 in the supplementary materials available for download at https://www.iea.nl/publications/RfEVol13)

greater focus on the life science topics, while Serbia and North Macedonia focused more on teaching physical science topics. Serbian teachers seemed to have particularly concentrated on teaching physical science content, while Croatia focused on teaching earth science content. In Bosnia and Herzegovina, Montenegro, and Albania, teacher reports indicated low coverage of earth science topics (39%, 42%, and 46%, respectively).

3.3 Relating OTL with Mathematics and Science Achievement

3.3.1 Relationships Between OTL and Achievement Within Education Systems

The TIMSS data provides an opportunity to compare teachers' descriptions of content taught with the achievement of their students, and thus investigate whether there is a relationship between the amount of content taught and student achievement. While the design of international large-scale assessments (ILSAs) does not enable researchers to draw conclusions about the direct impact of learning factors on achievement, it is possible to use bidirectional correlations as indications. However, when we analyzed the correlations between teacher reports on content coverage and student achievement, we found only spurious statistical evidence of such a relationship across Dinaric participants (Tables 3 and 4).

Table 3 Correlations between teachers' reports on average content coverage of TIMSS mathematic topics and TIMSS mathematics achievement (overall and disaggregated by content domains)

Education system	All TIMSS mathematics topics		TIMSS number topics		TIMSS measurement and geometry topics		TIMSS data topics	
Albania	−0.06	(0.04)	−0.07	(0.04)	−0.02	(0.04)	−0.03	(0.04)
Bosnia & Herzegovina	0.07	(0.04)	**0.08**	(0.03)	0.03	(0.03)	0.05	(0.03)
Croatia	−0.03	(0.03)	−0.02	(0.04)	−0.04	(0.03)	0.00	(0.04)
Kosovo[a]	0.02	(0.04)	−0.01	(0.04)	0.00	(0.04)	0.06	(0.04)
Montenegro	0.02	(0.03)	0.04	(0.03)	0.02	(0.03)	0.00	(0.03)
North Macedonia	0.01	(0.05)	0.02	(0.06)	−0.02	(0.05)	0.03	(0.05)
Serbia[a]	−0.01	(0.03)	−0.05	(0.03)	−0.01	(0.03)	0.00	(0.03)

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

Table 4 Correlations between teachers' reporting on average content coverage of TIMSS science topics and TIMSS science achievement (overall and disaggregated by content domains)

Education system	All TIMSS science topics		TIMSS life science topics		TIMSS physical science topics		TIMSS earth science topics	
Albania	−0.05	(0.05)	**−0.11**	(0.05)	0.04	(0.05)	−0.03	(0.05)
Bosnia & Herzegovina	0.00	(0.04)	−0.01	(0.04)	0.04	(0.03)	−0.02	(0.04)
Croatia	0.02	(0.03)	0.01	(0.03)	0.01	(0.03)	0.01	(0.03)
Kosovo[a]	−0.03	(0.04)	−0.05	(0.04)	−0.01	(0.04)	−0.01	(0.04)
Montenegro	**0.06**	(0.03)	0.02	(0.03)	0.06	(0.03)	**0.07**	(0.03)
North Macedonia	−0.01	(0.05)	−0.06	(0.05)	0.04	(0.06)	0.01	(0.06)
Serbia[a]	0.01	(0.06)	−0.01	(0.05)	0.05	(0.04)	−0.03	(0.05)

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

We found that correlation coefficients were very low and, in general, not significant. There was a very weak positive relationship (indicating that higher achievement was related to more exposure to the topic) in the mathematics content area of number in Bosnia and Herzegovina, and exposure to science content generally, as well as earth science content in particular, was positively related to higher student achievement in Montenegro. Counterintuitively, in Albania, the more students were exposed to life science topics, the lower their scores in this content domain, but this negative coefficient was of very low magnitude. Such results are unexpected, but there are potential explanations. Teachers may not have been sufficiently confident to confirm the basic content as taught, and may have instead chosen the option "not yet taught or just introduced". Another explanation may that that the topic as described in the TIMSS teacher questionnaire also encompassed topics that were not yet included in the curriculum, leading the teacher to again report the topic as not yet taught (a specific example might be that the conductivity of heat or electricity within the topic of classifying materials based on physical properties was not yet taught, although other aspects, such as weight/mass, volume, and state of matter were covered by the curriculum). However, additional system-level research is required to establish whether such theories are valid.

3.3.2 Alignment Between OTL and TIMSS Test Materials at the System Level

We referred to the test-curriculum matching analysis result for the Dinaric participants (see Mullis et al., 2020, Appendix C) to evaluate whether the content of the TIMSS test items was covered in the regional curricula. Achievement scores for each education system are recalculated based on the inclusion of only those TIMSS achievement items that were reported as included in the intended curricula up to grade four. This information provides additional context regarding a student's OTL, as it indicates whether the achievement of a participant would change if only "matched" items were considered, and provides a wider perspective on the average national achievement, which might be very different if students only responded to curriculum matched items. The analysis also reconfirmed the number of items covered by the regional curricula. We found large differences in coverage across the Dinaric region; as an example, almost all TIMSS science items were covered by the North Macedonian science curriculum, but only half of the science test content was covered by the Croatian curriculum (Tables 5 and 6). According our test-curriculum matching analyses, across most of the Dinaric participants, in general their mean achievement would be the same, even if the TIMSS test had been based on items tailored to their specific curricula. There were a few exceptions to this: for example, Montenegro and Bosnia and Herzegovina would have performed better if their students had been assessed on a selection of items tailored to the Montenegrin curriculum, and students in Croatia and Serbia would also have achieved better scores if they had been assessed on items covered by the Croatian curriculum.

3.3.3 The Net Effect of OTL on Student Achievement

To better understand the varying importance of these different aspects of OTL across the Dinaric region, we used the TIMSS topics coverage variables as predictors of mathematics and science achievement in regression models, controlling for values on the TIMSS HRL and LSN scales (Tables 7 and 8). The LSN scale and TIMSS topics coverage variables were reported at the class level by their teachers, but treated here as student-level features. The results confirm that there were large differences across the region in the relation between content exposure and achievement, even after controlling for limitations related to home support and classroom climate, but, in general, content exposure was not significantly related to achievement (Tables 7 and 8). After controlling for the factors attributable to lower home support and limitations for teaching due to students not ready for instruction, there was no significant positive relationship between the percentages of students that were taught the mathematics or science topics and student achievement in any of the education systems that we studied. However, in Bosnia and Herzegovina, Montenegro, and North Macedonia, we found that lower scores on the LSN scale were weakly associated with higher TIMSS mathematics and science achievement. Across the Dinaric region, the strongest significant predictor of higher student achievement in mathematics and science was having access to more home resources for learning. This association was strongest in Serbia and North Macedonia, but relatively weak in Kosovo, indicating that achievement in Kosovo depends less on factors that lie outside formal school settings than it does in other parts of the region.

Table 5 Test-curriculum matching analysis with the content of the TIMSS 2019 test materials for mathematics curricula across the Dinaric region

TIMSS mathematics							
Education system	Croatia	Serbia					
Croatia	+	+					
Serbia	+	●					
Number of TIMSS test items covered (possible TIMSS points)	127 (136)	132 (141)					
TIMSS less difficult mathematics							
Education system			Albania	Bosnia & Herzegovina	Kosovo	Montenegro	North Macedonia
Albania			●	●	●	●	●
Bosnia & Herzegovina			●	+	●	●	●
Kosovo			●	●	●	●	●
Montenegro			●	+	●	●	●
North Macedonia			●	●	●	●	●
Number of TIMSS test items covered (possible TIMSS points)			173 (186)	123 (130)	160 (172)	140 (151)	177 (190)

Notes The TIMSS mathematics assessment contained a total of 171 items (students could score a maximum of 183 possible assigned points) and the TIMSS less difficult mathematics assessment contained a total of 177 items (students could score a maximum of 190 possible assigned points). Read down the column under a participant's name to compare difference in achievement scores based on the items identified as covered by that participant. Scores on the diagonal are differences in achievement scores, based on the test items identified

+Mean score would be higher on the item list covered by the compared participant (for example, both Montenegro and Bosnia & Herzegovina achieved better scores in mathematics when assessed using a selection of test items tailored to the Montenegrin curriculum)

● Mean score would not differ on the item list covered by compared participant

Table 6 Test-curriculum matching analysis with the content of the TIMSS 2019 test materials for science curricula across the Dinaric region

Education system	Albania	Bosnia & Herzegovina	Croatia	Kosovo	Montenegro	North Macedonia	Serbia
Albania	●	●	●	●	●	●	●
Bosnia & Herzegovina	●	●	●	●	●	●	●
Croatia	●	●	●	●	●	●	●
Kosovo	●	●	●	●	●	●	●
Montenegro	●	+	●	●	+	●	●
North Macedonia	●	●	●	●	●	●	●
Serbia	●	●	●	●	●	●	●
Number of TIMSS test items covered (possible TIMSS points)	146 (151)	100 (104)	79 (81)	168 (173)	124 (128)	168 (173)	125 (130)

Notes The TIMSS science assessment contained a total of 169 items (students could score a maximum of 174 possible assigned points). Read down the column under a participant's name to compare difference in achievement scores based on the items identified as covered by that participant. Scores on the diagonal are differences in achievement scores, based on the test items identified

+Mean score would be higher on the item list covered by the compared participant (for example, both Montenegro and Bosnia & Herzegovina achieved better scores in mathematics when assessed using a selection of test items tailored to the Montenegrin curriculum)

● Mean score would not differ on the item list covered by compared participant

4 Discussion

Our aim was to describe the opportunities to learn provided to grade four students across the Dinaric region, and establish whether this could be linked to their demonstrated mathematics and science achievement in TIMSS 2019.

To assess the effect of time exposure, we compared prescribed and implemented opportunities to learn. Across the Dinaric region, many of the participants reported that the nationally prescribed percentage of teaching allocated to mathematics and science was similar and they also reported comparable disparities in the actual implementation of the timetable. Like many other participants in TIMSS, official documents for the Dinaric region suggested that more time is devoted to teaching mathematics than science. We also found that participants in the region reported that similar percentages of total instruction time were prescribed for mathematics lessons, while there was more regional variation in the time spent teaching science. In Croatia, the nationally prescribed time for science instruction was at least 50% higher than in the

Table 7 Amount of variance in students' mathematics achievement explained by the regression model, standardized regression coefficients for TIMSS mathematic topics coverage, classroom teaching limited by students not ready for instruction, and home resources for learning

Education system	Number of students (n)	Variance (R^2) explained by model	Standardized regression coefficients:					
			TIMSS mathematics topics coverage		Teaching limited by students not ready for instruction		Home resources for learning	
Albania	4074	0.16	−0.05	(0.03)	0.05	(0.04)	**0.38**	(0.03)
Bosnia & Herzegovina	5244	0.13	0.05	(0.03)	**0.06**	(0.03)	**0.35**	(0.02)
Croatia	3631	0.13	−0.02	(0.03)	0.01	(0.03)	**0.36**	(0.02)
Kosovo[a]	4203	0.09	0.02	(0.04)	0.04	(0.03)	**0.29**	(0.02)
Montenegro	4292	0.13	0.01	(0.02)	**0.07**	(0.02)	**0.36**	(0.01)
North Macedonia	2806	0.23	0.04	(0.03)	**0.13**	(0.04)	**0.46**	(0.02)
Serbia[a]	4206	0.27	−0.01	(0.03)	0.00	(0.03)	**0.51**	(0.02)

Notes R^2 = the proportion of variance in the outcome variable that is explained by the set of predictor variables. Statistically significant ($p < 0.05$) regression coefficients are shown in bold. Standard errors appear in parentheses

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

Table 8 Amount of variance in students' science achievement explained by the regression model, standardized regression coefficients for TIMSS science topics coverage, classroom teaching limited by students not ready for instruction, and home resources for learning

Education system	Number of students (n)	Variance (R^2) explained by model	Standardized regression coefficients:					
			TIMSS science topics coverage		Teaching limited by students not ready for instruction		Home resources for learning	
Albania	4074	0.15	0.00	(0.04)	0.03	(0.05)	**0.38**	(0.03)
Bosnia & Herzegovina	5267	0.10	0.05	(0.03)	**0.06**	(0.03)	**0.32**	(0.02)
Croatia	3631	0.14	0.00	(0.03)	0.01	(0.02)	**0.37**	(0.03)
Kosovo[a]	4270	0.09	−0.02	(0.04)	0.05	(0.03)	**0.29**	(0.03)
Montenegro	4110	0.14	**0.06**	(0.03)	**0.06**	(0.02)	**0.37**	(0.02)
North Macedonia	2814	0.26	0.05	(0.04)	**0.12**	(0.04)	**0.49**	(0.03)
Serbia[a]	4138	0.26	−0.01	(0.04)	0.01	(0.03)	**0.51**	(0.03)

Notes R^2 = the proportion of variance in the outcome variable that is explained by the set of predictor variables. Statistically significant ($p < 0.05$) regression coefficients are shown in bold. Standard errors appear in parentheses

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

other participating systems. However, across the Dinaric region, the implemented curricula, as reported by teachers and principals, were found to deviate from the prescribed teaching time.

The results from TIMSS 2019 are similar to other sources. According to a Eurydice report (European Commission, 2018) that assessed all grades of primary education across European countries, the bulk of school teaching time was devoted to writing and reading, then to mathematics, followed by science. In 2018, in almost all European countries at each primary school grade, the number of hours of teaching officially recommended for science was significantly less than the number of hours recommended for mathematics. According to the report, the percentages of teaching hours recommended for mathematics in the Dinaric region at that time ranged from 17.9% in Albania to 22.2% in Croatia, and the percentages of teaching hours recommended for science ranged from 5.7% in Montenegro to 13% in Bosnia and Herzegovina.

We analyzed NRC reports on nationally prescribed content coverage and compared intended curriculum coverage with the list of content topics that were assessed by the TIMSS 2019 mathematics and science tests and with teacher reports of which TIMSS assessment topics were taught to classes.

We found that there was lower overall coverage of the TIMSS mathematics content than the TIMSS science content. Across the region, in general, we found that more than half of the mathematics and science topics were intended to be taught to all students. For mathematics, measurement and geometry topics had the best coverage, followed by the TIMSS number topics. The three data topics were not covered at all by four of the Dinaric participants, while one topic of the three topics was covered in another two participants. North Macedonia was the only education system that prescribed different content to be taught to more able students. In all other participating systems, the same curriculum was delivered to all students. Teacher reports on the delivery of topics in in the classroom suggest many topics were covered. On average, teachers reported that almost two-thirds of students were taught all TIMSS mathematic topics in five of the Dinaric systems, while teachers from Bosnia and Herzegovina and Croatia reported fewer students received instruction related to the TIMSS content topics. Across the region, the TIMSS content related to the data domain was least likely to be covered.

Regional curricula were better at covering TIMSS science topics than TIMSS mathematics topics, but teachers' reports of classroom delivery of content were more inconsistent. In Kosovo and Montenegro, NRCs reported that all of the 26 science topics used in the TIMSS assessment were covered in the curricula, and, generally, all participants reported good coverage of the science content topics. However, unlike mathematics, there were very obvious mismatches between the reports of the intended and the implemented curricula. While NRCs reported most science topics were covered, teachers from Bosnia and Herzegovina, Croatia and Montenegro reported that the percentages of students taught different science content topics in the classroom ranged from only 30 percent to 60% and, for the earth science content area, the coverage reported by teachers was less than 60% in another three participants. When we disaggregated the responses to establish which domains were taught, we found great variation in the attention given to physical science and life science across the region. In general, the earth science and physical science topics were less likely to be taught than the life science topics. Physical science topics were taught to most students in North Macedonia (85% of students) and Serbia (90% of students), while the life science topics were taught to most students in Albania (80% of students) and Montenegro (75% of students).

We also analyzed relations between opportunities to learn and learning outcomes. While there is ongoing debate about whether increasing instruction time in school increases student achievement (Andersen et al., 2016; Jez & Wassmer, 2013; Yeşil Dağlı, 2019), evidence has suggested that the quality of instruction and the time available for learning may have a positive effect on student achievement and even compensate for weaknesses in other areas, such as ability or willingness to learn (Gettinger, 1985). However, we found that, in the Dinaric region, the TIMSS 2019 data provided no evidence that spending more hours on mathematics or science led to higher achievement. This confirms data from earlier cycles of TIMSS, which showed that mean national achievement was not positively associated with average hours of instruction (see Martin et al., 2016, exhibit 9.1 and Mullis et al., 2016, exhibit 9.1). Our study also showed that, in Dinaric region, there was no unequivocal correlation between instructional time and achievement.

International research shows that other important elements can have a mediating effect, such as the quality of instruction or time and opportunities available for learning outside school (Jacob & Ryan, 2018; Özek, 2018). The positive relationship between increased instruction time and student achievement is more apparent when the increase is accompanied by other support measures and directed at disadvantaged students, for instance, those who come from less privileged families or home environments (European Commission, 2018). We therefore investigated the relationship of OTL with achievement taking into account two mediating variables: the accessibility of home resources for learning, as reported by parents in the TIMSS home questionnaire, and teacher reports of classroom teaching being limited by students who were not ready for instruction, which we used, respectively, as proxy measures of opportunities given to students outside school and quality of instruction. We found no strong general relationship between content coverage or topics taught and achievement. Although some Dinaric systems covered a large proportion of topics in their curricula or allocated more time to instruction, these differences did not translate into differences in student achievement. The presence of a weak relationship between content coverage and achievement showed that, along with teachers' reports of which topics were taught, some students had not yet mastered topics reported as taught, and likewise did not know how to solve items that required knowledge of content not yet taught in school. The results showed that higher home support was an important predictor of higher science and mathematics achievement for students in all seven education systems, and an especially strong factor in Serbia and North Macedonia. Quality of teaching, as assessed by the teacher reports of feeling limited by students not ready for instruction, was found to be significantly related to lower achievement in Bosnia and Herzegovina, Montenegro, and North Macedonia. This suggests that the science and mathematics capital that students bring with them to school is potentially important. As student achievement seems to be strongly linked with opportunities available to them outside school, teachers and schools need to be especially aware of the importance of their role in providing quality OTL to students who have low levels of home support.

5 Conclusions

Our research demonstrated there was some variation in OTL across the Dinaric region. We noted discrepancies between intended, implemented, and attained curricula in terms of instructional time and content coverage in mathematics and science at grade four. Across the Dinaric region, there was no significant common relationship between the percentage of students that were taught the topics and mean national achievement in TIMSS 2019, but the reports of officially prescribed curricular contents did not align with teachers' reports of the content taught in schools. School content coverage was not related to achievement. We found achievement showed a strong positive association with home learning resources and a weak association with content exposure in school. Establishing the teaching characteristics that could provide the best OTL requires further in-depth research, as learning can be facilitated in many ways and may also depend on teacher characteristics. Our central message to teachers is that more attention should be given to learning more about students' existing knowledge, whether that was acquired in the classroom or outside school. Quality OTL in school is especially important for those students who lack the requisite home resources to support their learning.

This study demonstrates that the concept of OTL is extensive and plays an important role in student achievement. OTL also embraces the opportunities students have to learn outside schools. Teachers and policymakers therefore need to consider the mathematics and science capital that students are exposed to both inside and outside formal school settings, and provide additional school support for those students who lack the requisite resources and assistance in the home. Although new national policies may be necessary to achieve overall improvement, our analyses of the TIMSS 2019 data suggest that better teaching and learning of mathematics and science in the Dinaric region may be achieved by more rigorous focus on narrowing the disparities between the intended and implemented curricula. Understanding the reasons behind the observed differences is an important first step. Teachers may wish to carefully review the content of the prescribed curricula and compare this with what is presently taught in the classroom.

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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

[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

(continued)

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

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

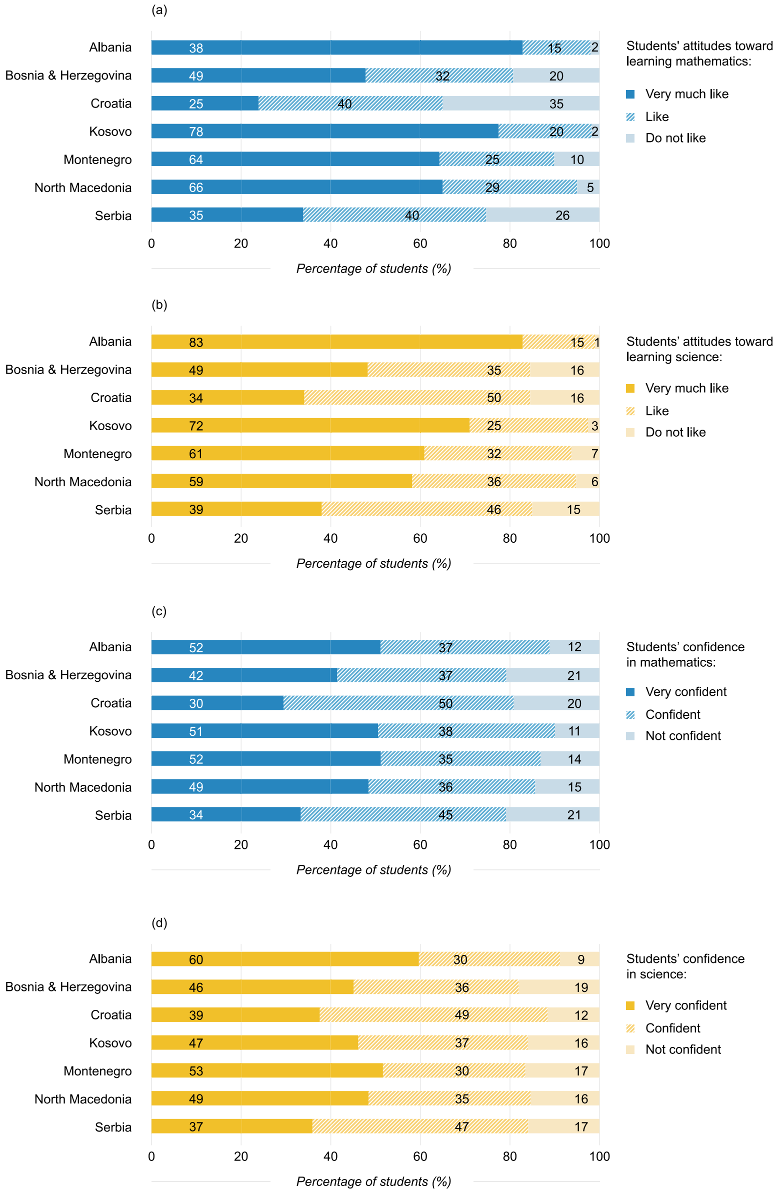

Fig. 1 Percentages of students in each category of six TIMSS 2019 attitude scales: **a** students like learning mathematics, **b** students like learning science, **c** students confident in mathematics, **d** students confident in science, **e** students' sense of school belonging, and **f** parents' 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/publications/RfEVol13)

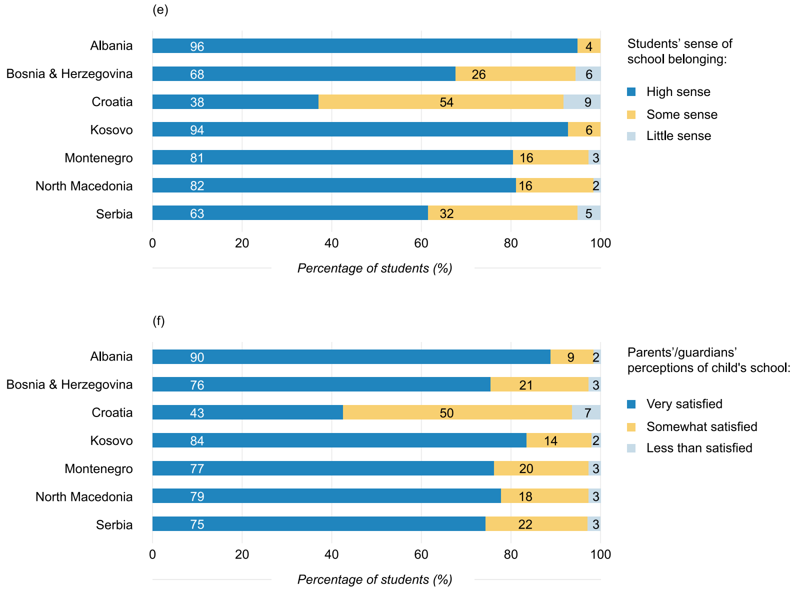

Fig. 1 (continued)

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 ($\leq$0.2), while the correlations with mathematics achievement in North Macedonia and Albania were slightly stronger, but still only relatively weakly linked to liking to learn mathematics ($\leq$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

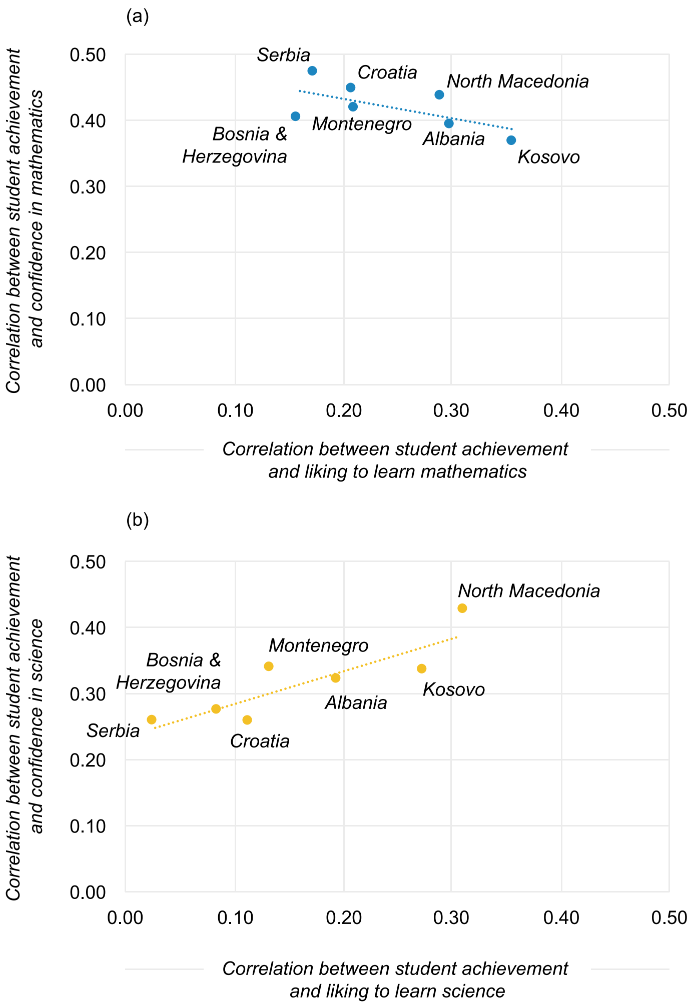

Fig. 2 Comparing the correlations between student achievement and students like learning scales against the correlations between student achievement and the students' confidence scales for **a** grade four mathematics and **b** grade four science. *Notes* In Kosovo and Serbia, the national defined population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

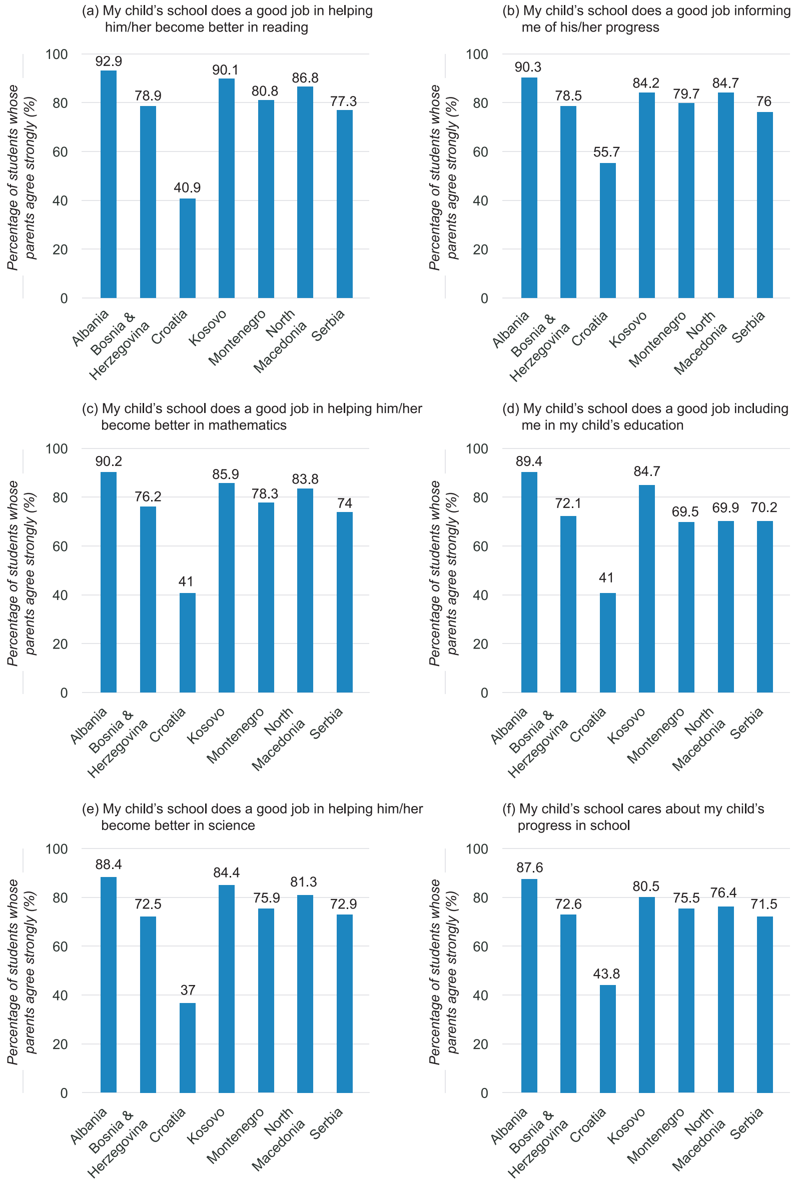

Fig. 3 Percentages of students whose parents agree "a lot" that their child's school: **a** does a good job in helping him/her become better in reading; **b** does a good job informing me of his/her progress; **c** does a good job in helping him/her become better in mathematics; **d** does a good job 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

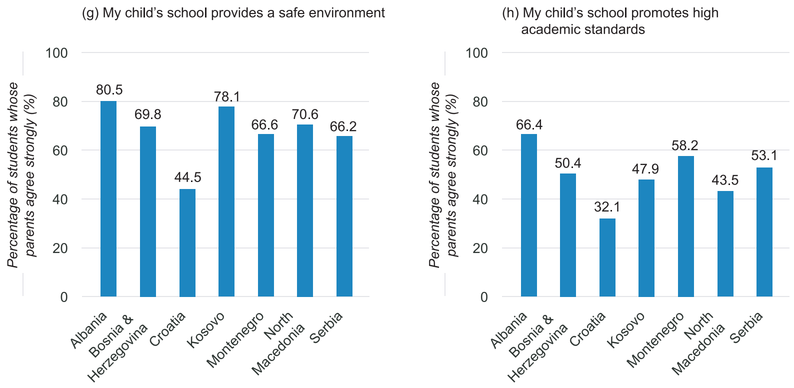

Fig. 3 (continued)

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,

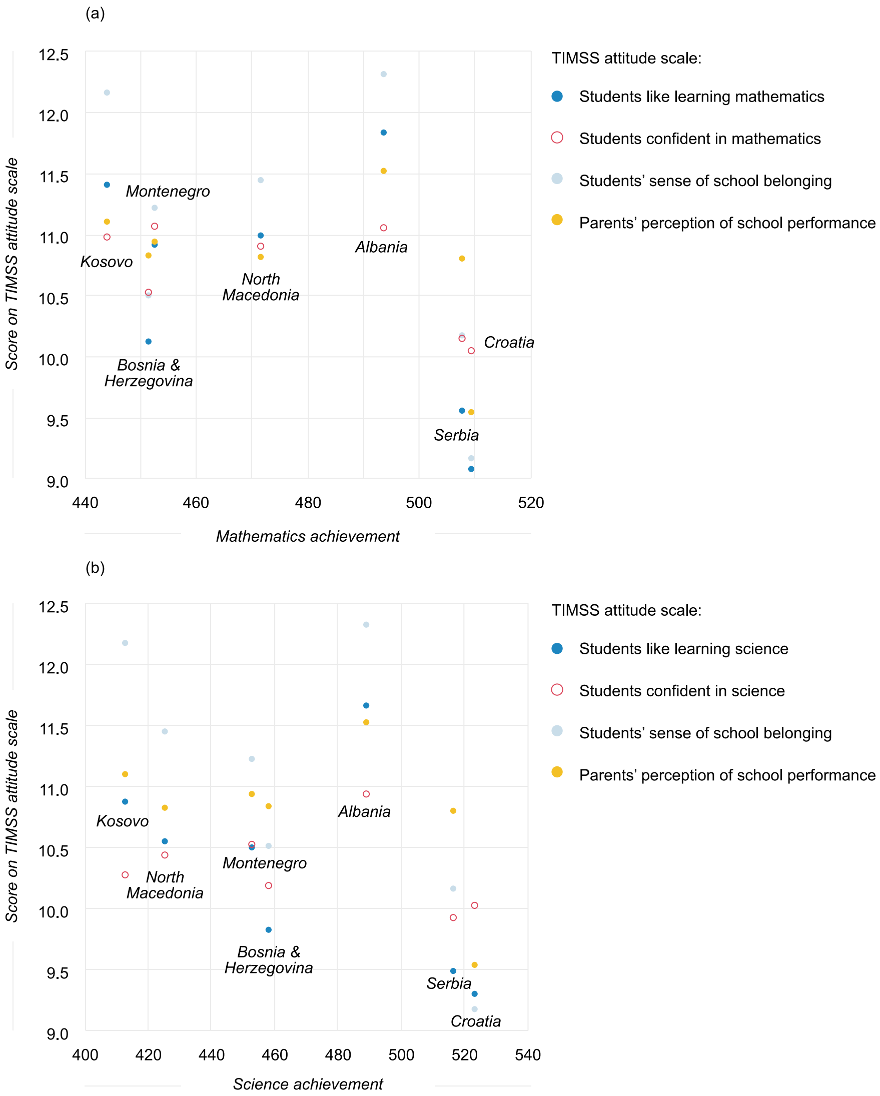

Fig. 4 Between-system comparisons of TIMSS 2019 achievement scores and attitudes for **a** grade four mathematics, and **b** grade four science. *Notes* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

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 ($\geq$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 (R^2) 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 (R^2) 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**	(0.02)	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 (R^2) 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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Early Literacy and Numeracy Competencies: Predictors of Mathematics Achievement in the Dinaric Region

Ženeta Džumhur, Nada Ševa, and Mojca Rožman

Abstract Studies have indicated that early literacy (EL) and early numeracy (EN) competencies are strong predictors of later mathematical performance in school. Data from IEA's Trends in International Mathematics and Science Study (TIMSS) 2019, together with comprehensive exploration of regional similarities and differences between education systems, confirm that students' preschool EL and EN competencies are important predictors of mathematics achievement among grade four students from the Dinaric region. This applies for all content domains specified in the TIMSS 2019 mathematics framework: numbers, measurement and geometry, and data. Although TIMSS 2019 parental reports for the different EL and EN tasks varied considerably across the region, children in the Dinaric region who could recognize letters, write numbers, or count independently before starting school tended to achieve higher scores on the mathematics tasks in TIMSS 2019. This confirms that EL and EN skills have a strong relationship with later school outcomes in mathematics. Recognition of these findings could provide the basis for changes in the preschool curriculum and further development of programs for parents/guardians on numeracy development.

Keywords Early literacy · Early numeracy · Grade four education · International large-scale assessments (ILSA) · Mathematics achievement · Parental reports · Trends in International Mathematics and Science Study (TIMSS)

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1 Introduction

Early literacy and numeracy competencies relate to the set of knowledge and skills developed during the preschool period. Early literacy (EL) includes the knowledge and abilities linked to language (vocabulary, background knowledge, semantics, and communication skills), print awareness (alphabet, and concepts about print), and phonological awareness (rhyme, alliteration, segmentation, and blending) (Rohde, 2015). Early numeracy (EN) is a term that encompasses several skills, such as verbal counting, knowing number symbols, recognizing quantities, discerning number patterns, comparing numerical magnitudes, and manipulating quantities (i.e., adding and subtracting objects from a set) (Raghubar & Barnes, 2017). EL and EN competencies, as a part of a school readiness construct, have been demonstrated to be strong predictors of mathematical achievement in school (Duncan et al., 2007; Melhuish et al., 2008; Nguyena et al., 2016).

It is important to emphasize that both EL and EN are set in the context of cultural, demographic, and community characteristics. Thus, they can be viewed as an interactive process of skills and context rather than a linear series of individual components (Rohde, 2015). Numerous studies have confirmed this theoretical stance, indicating that children's exposure to literacy and numeracy experiences in the preschool period may be positively correlated with their early literacy and numeracy competencies (Gustafsson et al., 2013; LeFevre et al., 2009; Skwarchuk et al., 2014). It is suggested that several factors account for this effect: socioeconomic status (SES) of families, number of years spent in kindergarten, home resources related to language and mathematical competencies, parental preschool literacy and numeracy practices, and parental attitudes toward mathematical development and schooling in general (Zippert & Rittle-Johnson, 2020). Cultural differences can play an important role in the quality of home numeracy experiences (Aunio et al., 2004; Lefevre et al., 2002). They are usually associated with sociological differences, such as perceived value of education and knowledge in general, educational policies, and parents/guardians' perceptions related to whether children should be learning through school-like activities in early childhood, as well as linguistic differences in the way numeral systems are represented (Cankaya & LeFevre, 2016). In addition, parental attitudes and beliefs about their own, as well as their children's mathematical competencies, can influence the nature of the early learning experiences they provide (Hart et al., 2016; Zippert & Ramani, 2017).

In the context of large-scale assessment studies like IEA's Trends in International Mathematics and Science Study (TIMSS) and Progress in International Reading Literacy Study (PIRLS), recent cycles have indicated that early learning activities can help to lay the foundation for positive schooling outcomes in the future (Meinck et al., 2018). Results from TIMSS 2011 for European Union (EU) countries showed that EL and EN competencies were related to subsequent success in mathematics (Soto-Calvo & Sánchez-Barrioluengo, 2016). Nevertheless, the strength of the prediction varied across the countries, as well as the size of the effect of early numeracy compared to early literacy competencies.

2 Purpose of the Study and Research Questions

Seven participants from the Dinaric region took part in TIMSS 2019, namely Albania, Bosnia and Herzegovina, Croatia, Kosovo,[1] Montenegro, North Macedonia, and Serbia. Given the importance of social and cultural diversities, our aim was to extend research into the value of developing early competencies using TIMSS 2019 data for participants from the Dinaric region. A previous study into early numeracy experiences in Serbia from TIMSS 2015 showed that the variables related to providing a supportive home environment for learning (home resources for learning, early literacy and numeracy activities, preprimary education, early literacy and numeracy tasks; (see Mullis et al. 2016) explained more than a quarter of the variance in student achievement at grade four (Radišić & Ševa, 2017). They found that availability of home resources for learning proved to be the strongest predictor of achievement, followed by a variable based on parents'/guardians' assessment of their child's mathematical competencies before starting school, and kindergarten attendance. We based our research design on that used for a study of EU countries undertaken by Soto-Calvo and Sánchez-Barrioluengo (2016). Using this design enabled us to follow the trends in the relation between EN/EL competencies and mathematics achievement in Dinaric region in a comparable manner.

Our work was guided by three key research questions:

(1) *Do students from Dinaric region exhibit regional differences in early numeracy and literacy competencies?*
(2) *To what extent is student performance in mathematics at grade four related to early literacy and numeracy competencies, and, in particular, related to the tasks from number content domain?*
(3) *Are there any gender differences in levels of early literacy and numeracy competencies, and are those differences reflected in student mathematics achievement at grade four?*

3 Variables

The predictor variables used in this study are the composite variables early literacy tasks (ELT) and early numeracy tasks (ENT). These variables represent parental estimation of their children's competencies before entering the first grade of primary school regarding their early literacy and early mathematical competencies, collected retrospectively when the students were in grade four through the TIMSS 2019 Early Learning Survey (also referred to as the home questionnaire; TIMSS & PIRLS International Study Center, 2018). We also used parental reports of single literacy and numeracy tasks to explore specific characteristics of students' preschool competencies in more detail (Table 1).

[1] All references to Kosovo in this document should be understood to be in the context of United Security Council resolution 1244 (1999).

Table 1 List of variables used in analyses

Variable	Description	Values/Response options	Reference
Early literacy tasks scale[a]	Parents' responses on how well their child could do the following when he/she began the first grade of primary/elementary school: • Recognize most of the letters of the alphabet • Read some words • Read sentences • Read a story • Write letters of the alphabet • Write his/her name Response options: very well, moderately well, not very well, not at all	The higher the score the higher the student's competency in performing early literacy tasks, as assessed by their parents/guardians Index: Very well, Moderately well, Not well	Martin et al. (2020, p. 16.32)
Early numeracy tasks scale[a]	Parents' responses if their child could do the following when he/she began the first grade of primary/elementary school • Count by himself/herself • Recognize written numbers • Write numbers Response options: up to 100 or higher, up to 20, up to 10, not at all • Do simple addition • Do simple subtraction Response options: Yes, no	The higher the score the higher the student's competency in performing early numeracy tasks, as assessed by their parents/guardians Index: Very well, Moderately well, Not well	Martin et al. (2020, p. 16.32)

(continued)

The dependent variable was student achievement in mathematics and its content subdomains (number, measurement and geometry, and data) in TIMSS 2019. The following variables were used as control variables in regression models: attendance in preschool programs (recoded into "no attendance," "less than three years," and "three years or more"), student gender, and the TIMSS home resources for learning scale (Table 1).

Table 1 (continued)

Variable	Description	Values/Response options	Reference
Home resources for learning scale[a]	Based on students' and parents' reports regarding the availability of five resources: • 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 Index: Many resources, Some resources, Few resources	Martin et al. (2020, p. 16.39)
Student gender	Information on students' gender provided by students	Boy Girl	Fishbein et al. (2021, Supplement 1, p. 11)
Attendance in preschool programs	How long was your child visiting early childhood or pre-primary educational program	Did not attend Less than 1 year 1 year 2 years 3 years 4 years or more	Fishbein et al. (2021, Supplement 1, p. 45)

Note [a]These 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

We analyzed data using basic and advanced methods to estimate percentages, means, correlations, and develop regression models. We conducted all statistical computations using established standard procedures for data from large-scale assessments (see Sect. 5 for more details on the analysis methods and tools that we used).

4 Results

4.1 *Similarities and Differences in Students' Early Numeracy and Literacy Competencies Across the Dinaric Region*

We derived average scale scores for the composite variables ELT and ENT from the TIMSS 2019 data for the education systems from the Dinaric region (Table 2). According to Mullis et al. (2020), these average scale scores indicate that children in the Dinaric region could do, on average, most early literacy and numeracy tasks moderately well.

Early Literacy Competencies Across the Dinaric Region

In order to further explore the variation in early competencies, we investigated the percentages of students in the Dinaric region who, according to their parents/guardians, were able to perform specific early literacy tasks "very well" or "moderately well" (Fig. 1). The vast majority of parents/guardians reported that their child could write their name (>90% across the region), and more than 80% of students could recognize and write letters before attending school (with the exception of Montenegro). Far fewer children could perform more advanced activities, like reading words, sentences, or even stories, or writing words. It is understandable that fewer students mastered skills like reading stories before starting formal schooling, since pre-reading skills for children aged four to five are associated with recognizing syllables as well as the first and last letters in a word (Čudina-Obradović, 2002). In addition, children of this age group are usually emerging from the scribble stage of development when their writing begins to look like real letters and words, combined with shapes that are visually similar to displaced and valid letters (Baucal, 2012; Hope, 2008).

Table 2 Average scale scores for composite variables early literacy tasks (ELT) and early numeracy tasks (ENT)

Education system	Average score on the ELT scale		Average score on the ENT scale	
Albania	10.7	(0.07)	10.6	(0.07)
Bosnia & Herzegovina	10.2	(0.03)	9.7	(0.04)
Croatia	10.6	(0.04)	10.4	(0.05)
Kosovo[a]	10.7	(0.04)	10.5	(0.05)
Montenegro	9.8	(0.03)	9.6	(0.03)
North Macedonia	10.0	(0.05)	10.2	(0.06)
Serbia[a]	10.0	(0.04)	10.0	(0.05)

Notes Standard errors appear in parentheses
[a]National defined population covers 90–95% of the national target population

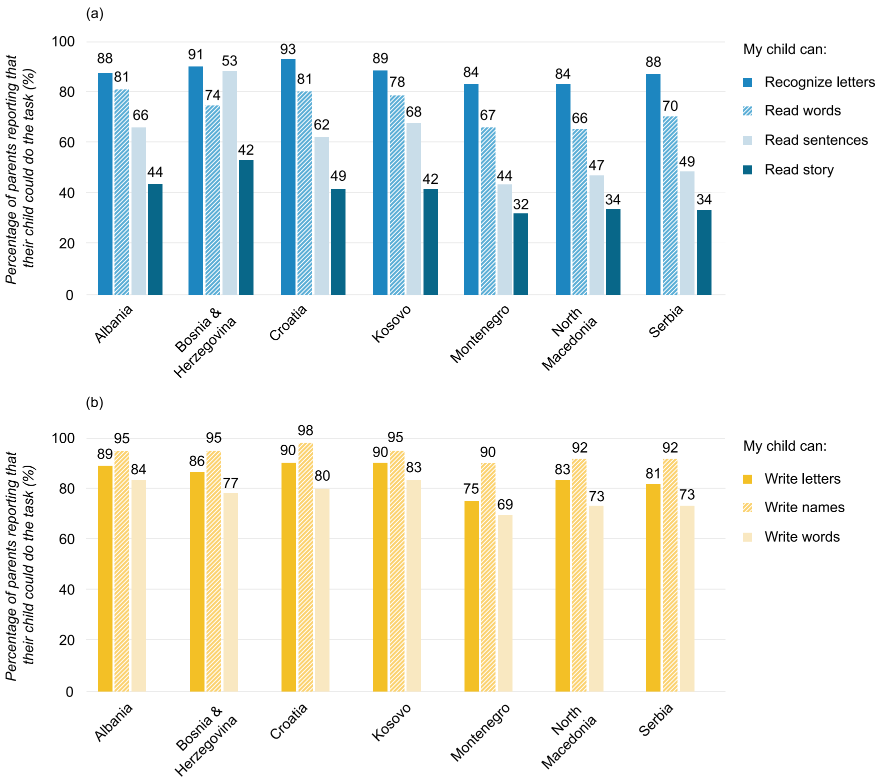

Fig. 1 Percentage of parents in the Dinaric region who reported that their child could do the **a** reading and **b** writing tasks "very well" or "moderately well" in response to the TIMSS 2019 Early Learning Survey *Notes* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population. In North Macedonia, data were available for ≥70% of students, but <85% of students

Among the education systems from the Dinaric region, there was large variation in the percentages of parents reporting that their child was able to perform the activities related to reading and writing words, sentences, or stories (Fig. 1). Two distinct groups could be distinguished among the participating entities: parents/guardians in Albania, Bosnia and Herzegovina, Croatia, and Kosovo tended to report that their children had acquired relatively high literacy competencies during the preschool period, especially regarding reading sentences and stories, while slightly lower percentages of parents/guardians in Montenegro, North Macedonia, and Serbia said that their children had acquired these cognitively demanding skills before entering school (Fig. 1).

Early Numeracy Competencies Across the Dinaric Region

According to their parents/guardians' reports, few students were unable to count by themselves before entering school (Fig. 2). Similar results were reported for the skills

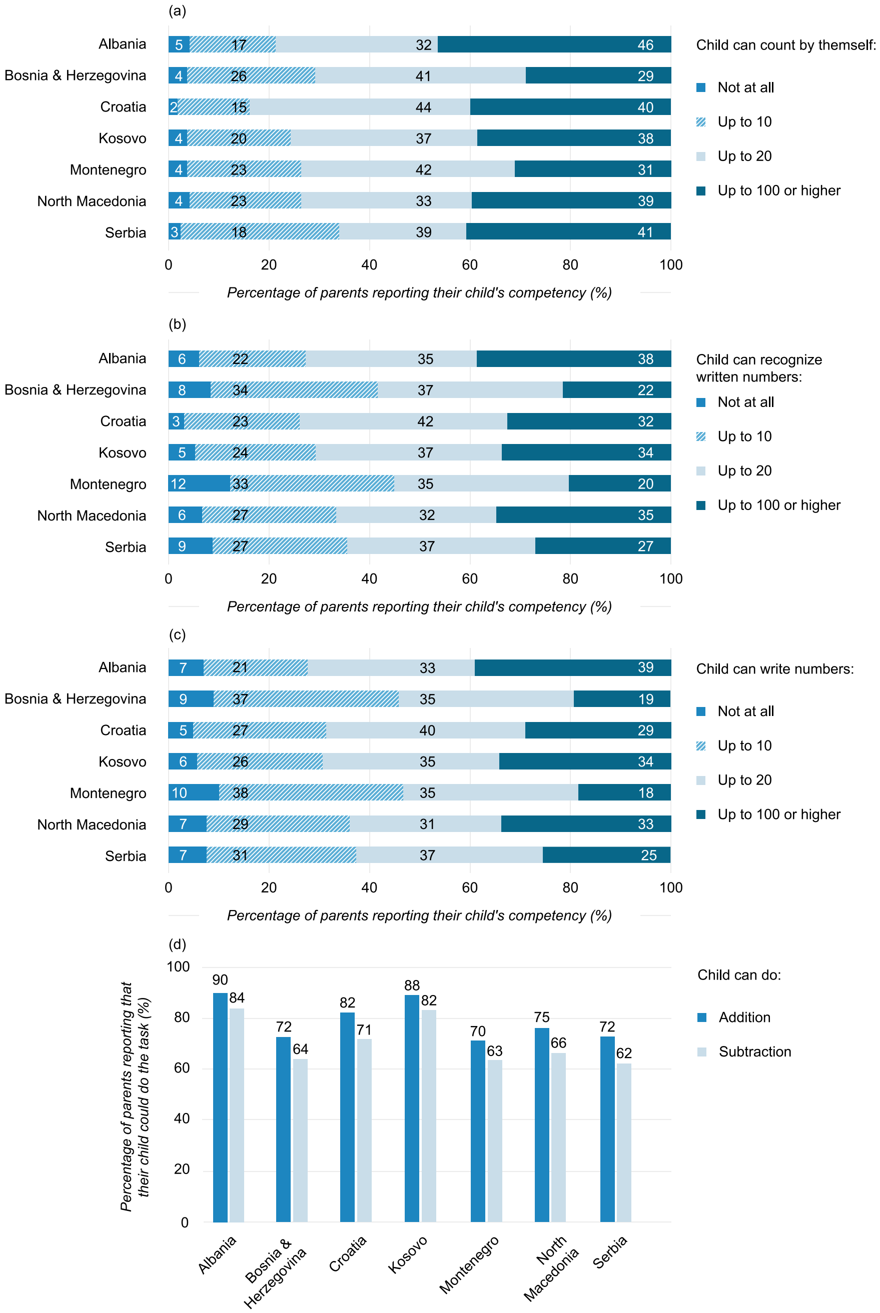

Fig. 2 Percentage of parents reporting that their child could **a** count by himself/herself, **b** recognize written numbers, **c** write numbers, and **d** add or subtract numbers *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

of recognizing or writing numbers, with the exception of Montenegro, which reported higher percentages of children entering the school system with no demonstrated ability to recognize and write numbers (12% and 10%, respectively). Recognizing and writing numbers over 20 was more challenging for preschoolers; only approximately a third of parents/guardians across the region reported their children had developed those skills. The variation among participants from the Dinaric region was also pronounced for these two categories (Fig. 2); for example, the results from Albania and Montenegro differ by approximately 20%.

Regarding the more advanced numeracy skills, such as addition and subtraction, parents/guardians' reports suggested that, on average, 79% of the children in the region were able to do addition, while 70% could do subtraction. However, again there was some variation between participating systems; for instance, there was an almost 20% point difference between Albania and Bosnia and Herzegovina (Fig. 2).

For preschoolers, writing numbers is the hardest task of all listed early numeracy tasks. Children must be capable of reproducing a graphical representation of the number without fully understanding the relationship between the symbol and concept of quantity behind it. At the same time, the development of counting is happening automatically, possibly due to the high number of traditional counting rhymes that exist in the Dinaric region.

An interesting finding for students from the Dinaric region is that as many children mastered addition as mastered counting. Acquired symbolic number, namely an understanding of the concept of the cardinality principle, as well as more highly developed counting skills (the ability to count up to 100 by the age of six) have been shown to be good indicators of later arithmetic skills (Göbel et al., 2014; Muldoon et al., 2013). It is extraordinary to find that most parents/guardians in the Dinaric region reported that, alongside abilities to count up to and beyond 20, children possessed higher or very similar values for skills related to addition. This suggests that children are capable of performing both activities at the same level. However, closer inspection of the wording of the survey question (TIMSS & PIRLS International Study Center, 2018) might provide another explanation; it could have been more specific and it did not fully define "simple addition." Although memorization of addition expressions from children's nurseries could be considered an indicator of arithmetic skills development, we note that models of numeracy development predict several competences/skills are developed (symbolic number system, estimation of quantity without counting, comparison, approximation and numerical magnitudes, and counting strategies) before children are able to personally implement "simple" written calculations or other arithmetic skills (LeFevre et al., 2010; Siegler & Braithwaite, 2017; Von Aster & Shalev, 2007).

4.2 Relating ELT and ENT to Mathematics Achievement

We first determined whether the predictor variables (ELT and ENT) and achievement were related using correlation analysis (Table 3). We found that both EL and

Table 3 Correlations between parents/guardian assessments of children's early literacy and numeracy competencies and their TIMSS 2019 mathematics achievement

Education system	Correlation between ELT and mathematics achievement		Correlation between ENT and mathematics achievement	
Albania	**0.30**	(0.03)	**0.24**	(0.03)
Bosnia & Herzegovina	**0.19**	(0.02)	**0.29**	(0.02)
Croatia	**0.30**	(0.02)	**0.33**	(0.02)
Kosovo[a]	**0.15**	(0.02)	**0.22**	(0.02)
Montenegro	**0.22**	(0.02)	**0.29**	(0.02)
North Macedonia	**0.19**	(0.03)	**0.29**	(0.02)
Serbia[a]	**0.36**	(0.02)	**0.40**	(0.02)

Notes ELT = early literacy tasks, ENT = early numeracy tasks. 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

EN competencies were significantly correlated with achievement in all participating entities. However, correlations varied considerably; Serbia had the highest correlation coefficient (0.36) and Kosovo the lowest coefficient (0.15).

We applied three regression models to explore to what extent the composite variables ENT and ELT predicted mathematics achievement (either separately and/or in combination), controlling for variables related to students' individual characteristics such as gender, home resources for learning, and preschool attendance:

(1) *Model 1* ENT (early numeracy tasks);
(2) *Model 2* ELT (early literacy tasks);
(3) *Model 3* ELT + ENT (early literacy tasks + early numeracy tasks).

We found that these variables were significant predictors of mathematics achievement in the Dinaric region (Table 4). This was generally true for all three models, with only one exception (North Macedonia, model 3). The models explained considerable amounts of variation in achievement; for example, in Model 1 for Albania, 19% of the variation in mathematics achievement of grade four students could be explained by the model. Positive values for standardized coefficients indicated positive relationships between ELT/ENT and achievement. It should be noted that values for the variance explained (R^2) varied across the region. The lowest were observed for Kosovo, Albania, and Bosnia and Herzegovina, and the highest for North Macedonia and Serbia (Table 3). In assessing the relative importance of predictor variables within the models, standardized regression coefficients were significant for each education system for models 1 and 2, but varied across the Dinaric region (Table 4). In model 3, the regression coefficients of ENT were higher than those for ELT in Bosnia and Herzegovina, Kosovo, and North Macedonia, and the 95% confidence intervals between the two scales did not overlap, suggesting that the coefficients for these participants differed. However, this did not hold in Albania, Croatia, Montenegro, and Serbia. This implies that, in the three systems where the regression coefficients for

Table 4 Amount of variance in students' mathematics achievement explained by the models, and standardized regression coefficients for early numeracy and early literacy tasks, after controlling for background characteristics (home resources for learning, preschool attendance, and gender)

Education system	Model 1 (ENT variables)				Model 2 (ELT variables)				Model 3 (ENT + ELT variables)					
	n	R^2	ENT		*n*	R^2	ELT		*n*	R^2	ELT		ENT	
Albania	3835	0.19	**0.14**	(0.02)	3800	0.20	**0.18**	(0.03)	3796	0.20	**0.14**	(0.03)	**0.08**	(0.03)
Bosnia & Herzegovina	5003	0.18	**0.24**	(0.02)	4933	0.16	**0.19**	(0.02)	4927	0.19	**0.10**	(0.02)	**0.19**	(0.02)
Croatia	3596	0.20	**0.26**	(0.02)	3592	0.20	**0.27**	(0.03)	3591	0.23	**0.18**	(0.03)	**0.17**	(0.03)
Kosovo[a]	3749	0.13	**0.18**	(0.02)	3638	0.11	**0.12**	(0.02)	3634	0.13	**0.06**	(0.02)	**0.16**	(0.02)
Montenegro	3852	0.18	**0.24**	(0.02)	3798	0.17	**0.21**	(0.02)	3789	0.19	**0.13**	(0.03)	**0.17**	(0.03)
North Macedonia	2539	0.27	**0.19**	(0.02)	2511	0.25	**0.13**	(0.02)	2502	0.27	0.05	(0.03)	**0.17**	(0.02)
Serbia[a]	4151	0.33	**0.27**	(0.02)	4123	0.31	**0.24**	(0.02)	4120	0.34	**0.15**	(0.02)	**0.19**	(0.03)

Notes Statistically significant ($p < 0.05$) regression coefficients are shown in bold. Standard errors appear in parentheses. n = the number of students included in the regression mode, R^2 = the proportion of variance in achievement explained by the stated independent variable (ELT, ENT or ENT + ELT) including the background variables (home resources for learning, preschool attendance and gender)

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

ENT were higher, ENT was a more powerful predictor of mathematics achievement than ELT, when accounting for both measures.

Our analyses indicated that the relative contributions of home resources for learning, student gender, and preschool attendance toward student achievement varied across all three models (Tables 5, 6 and 7). As expected, home resources were found to be a more consistent significant predictor of mathematics achievement than the predictor variables ENT, ELT or ELT + ENT, respectively (i.e., the regression coefficients were larger, indicating a larger association or relationship; Cohen et al., 2003). The regression coefficients for home resources remained similar across participating systems in all our analyses, although regression coefficients were notably larger for North Macedonia and Serbia than for other systems. Conversely, gender and length of preschool attendance (<3 years, or ≥3 years) were less important contributors for all three models.

The negative regression coefficients for gender imply that boys tended to have higher mathematics achievement than girls, after controlling for all other factors included in this model. However, our analyses revealed that gender had very little impact on achievement in Bosnia and Herzegovina, Croatia (Model 1–3), Montenegro (Models 2–3), and Serbia (Model 2), and no significant impact in other systems and models. Preschool attendance was also shown to be a weak predictor of mathematics achievement. Our research only identified significant regression coefficients related to <3 years preschool attendance in Kosovo (Model 1–3) and in Bosnia and Herzegovina (Model 3). Equally, regression coefficients were low, but significant for preschool attendance of three years or longer in only Kosovo and North Macedonia.

Table 5 Standardized regression coefficients for the control variables in Model 1 (ENT)

Education system	Home resources for learning scale		Gender (girl)		Preschool attendance (<3 years)		Preschool attendance (≥3 years)	
Albania	0.36	(0.03)						
Bosnia & Herzegovina	0.31	(0.02)	−0.06	(0.02)				
Croatia	0.29	(0.03)	−0.09	(0.02)				
Kosovo[a]	0.26	(0.03)			0.08	(0.03)	0.06	(0.03)
Montenegro	0.30	(0.02)						
North Macedonia	0.40	(0.03)					0.08	(0.04)
Serbia[a]	0.40	(0.02)						

Notes Only statistically significant ($p < 0.05$) regression coefficients are shown, empty cells indicate values were not significant. Standard errors appear in parentheses
[a]National defined population covers 90–95% of the national target population

Table 6 Standardized regression coefficients for the control variables in Model 2 (ELT)

Education system	Home resources for learning scale		Gender (girl)		Preschool attendance (<3 years)		Preschool attendance (≥3 years)	
Albania	0.34	(0.03)						
Bosnia & Herzegovina	0.33	(0.02)	−0.09	(0.02)				
Croatia	0.30	(0.02)	−0.14	(0.02)				
Kosovo[a]	0.26	(0.03)			0.07	(0.03)	0.06	(0.03)
Montenegro	0.32	(0.02)	−0.06	(0.02)				
North Macedonia	0.42	(0.03)					0.08	(0.04)
Serbia[a]	0.41	(0.02)	−0.05	(0.02)				

Notes Only statistically significant ($p < 0.05$) regression coefficients are shown, empty cells indicate values were not significant. Standard errors appear in parentheses
[a]National defined population covers 90–95% of the national target population

Table 7 Standardized regression coefficients for the control variables in Model 3 (ENT + ELT)

Education system	Home resources for learning scale		Gender (girl)		Preschool attendance (<3 years)		Preschool attendance (≥3 years)	
Albania	0.34	(0.03)						
Bosnia & Herzegovina	0.31	(0.02)	−0.07	(0.02)	−0.05	(0.03)		
Croatia	0.28	(0.03)	−0.12	(0.02)				
Kosovo[a]	0.25	(0.03)			0.07	(0.03)	0.06	(0.03)
Montenegro	0.30	(0.02)	−0.04	(0.02)				
North Macedonia	0.40	(0.03)					0.07	(0.04)
Serbia[a]	0.37	(0.02)						

Notes Only statistically significant ($p < 0.05$) regression coefficients are shown, empty cells indicate values were not significant. Standard errors appear in parentheses
[a]National defined population covers 90–95% of the national target population

The ENT Variable and Content Domains

Given that the ENT variable was shown to be a relatively strong predictor of mathematics achievement for the Dinaric region in TIMSS 2019, we investigated the extent to which ENT predicated achievement could be attributed to the different content domains covered in TIMSS 2019 (number, measurement and geometry, and data). As in our previous regression models, variables related to home resources for learning, preschool attendance, and gender were used as controls.

Three regression models were used to evaluate this question with different dependent variables:

(1) *Model number*: student achievement in the subdomain "number" predicted by ENT and control variables;
(2) *Model measurement and geometry*: student achievement in the subdomain "measurement and geometry" predicted by ENT and control variables;
(3) *Model data*: student achievement in the subdomain "data" predicted by ENT and control variables.

We found that ENT significantly predicted achievement not only for numeracy tasks, but also for measurement and geometry, and data tasks (see Tables S.5, S.6 and S.7 in the supplementary materials available for download at www.iea.nl/publications/RfEVol13). As we already noted for the relation between ENT and the overall achievement scores in mathematics for TIMSS 2019, the proportion of variance and regression coefficients were highest for Serbia, followed by North Macedonia. The explained variance ranged from 20 to 38% in all three cognitive domains; there was also a high correlation for the "number" domain in Croatia and Bosnia and Herzegovina, explaining up to 21% of the variance. Taking control variables into consideration, we observed patterns that were broadly similar to those obtained for Models 1–3, with home resources remaining a significant factor for all three models and for all Dinaric TIMSS participants. Gender and preschool attendance were also weakly significant, but had only low impact in a few instances across the Dinaric region.

4.3 Gender Differences

Gender differences in estimates of ELT skills were significant for all participants from the Dinaric region in favor of girls (Fig. 3). Estimates for girls' ELT skills ranged from 10.0 in Montenegro to 10.9 in Kosovo (the average estimate for girls in the Dinaric region was 10.5). Estimates for boys' ELT skills ranged from 9.6 in Montenegro to 10.6 in Albania and Kosovo (the average estimate for boys in Dinaric region was 10.1).

In contrast, differences between girls and boys were smaller for ENT than for ELT skills. Significant differences were found in only three of the participating systems; all favored boys, but these differences were not as pronounced as the consistent gender difference observed for the ELT variable. Estimates for girls ENT skills ranged from 9.6 in Montenegro to 10.6 in Albania (the average estimate for girls in the Dinaric region was 10.1). Estimates for boys' ENT skills ranged from 9.6 in Montenegro to 10.6 in Albania (the average estimate for boys in Dinaric region was 10.2).

When assessing the relations between ELT and ENT estimates and mathematics achievement by gender, correlation analyses showed significant, but weak to moderate positive associations among those variables (Table 8), indicating that

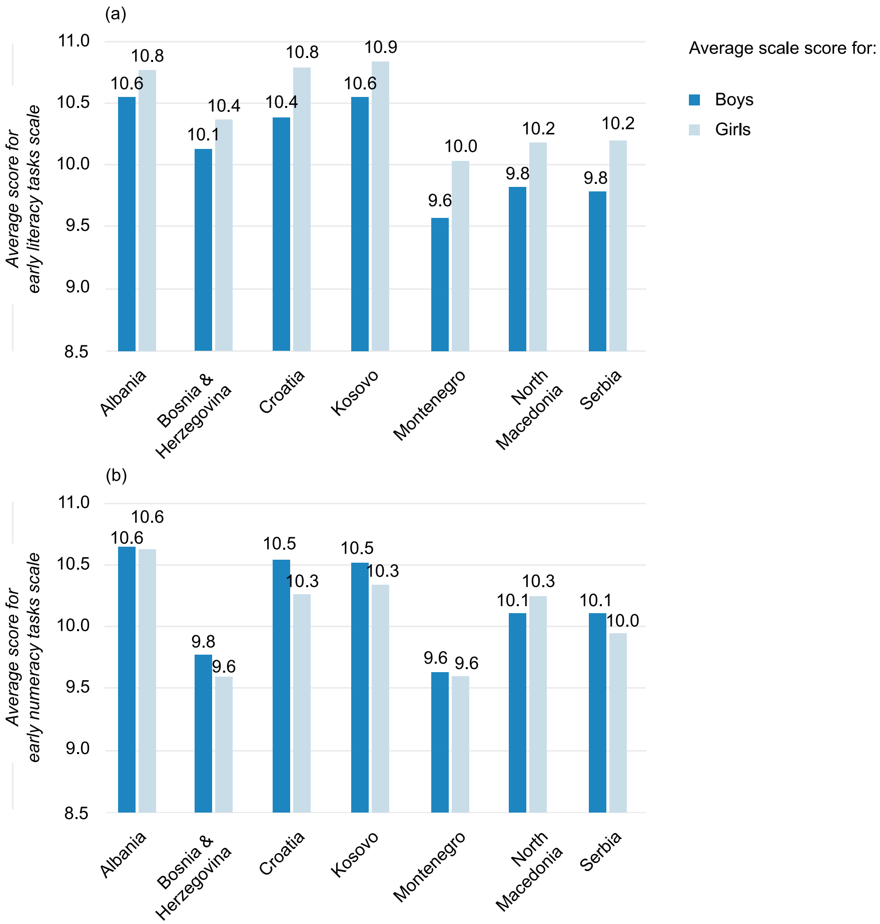

Fig. 3 Difference in parents/guardians' assessment of their child's **a** preschool literacy competency and **b** preschool numeracy competency by gender *Notes* Differences were statistically significant ($p < 0.05$) in all participating education systems for the early literacy tasks, but only statistically significant in Bosnia and Herzegovina, Croatia, and Kosovo for the early numeracy tasks. In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

higher ELT/ENT scores were related to better achievement on average across all students.

Overall, the correlation coefficients for ELT, both for girls and boys, tended to be lower than the correlation coefficients for ENT, but the differences were largest in Bosnia and Herzegovina and North Macedonia (average ELT_{boys} $r = 0.26$, ELT_{girls} $r = 0.24$, compared to average ENT_{boys} $r = 0.31$, ENT_{girls} $r = 0.28$). For the ELT variable, two TIMSS participants attained moderate coefficients for both girls and boys (Serbia and Croatia). For the ENT variable, Albania, Kosovo, and North Macedonia had correlation coefficients of <0.3 for both boys and girls (indicating there were only

Table 8 Correlations between parents/guardian assessments of children's early literacy and numeracy competencies and their TIMSS 2019 mathematics achievement, by gender

Education system	Correlation coefficient between ELT and mathematics achievement				Correlation coefficient between ENT and mathematics achievement			
	Boys		Girls		Boys		Girls	
Albania	0.31	(0.04)	0.29	(0.03)	0.28	(0.04)	0.21	(0.03)
Bosnia & Herzegovina	0.20	(0.03)	0.19	(0.02)	0.30	(0.02)	0.26	(0.02)
Croatia	0.32	(0.03)	0.32	(0.03)	0.34	(0.03)	0.30	(0.03)
Kosovo[a]	0.16	(0.03)	0.14	(0.03)	0.23	(0.02)	0.21	(0.02)
Montenegro	0.24	(0.02)	0.21	(0.03)	0.31	(0.02)	0.27	(0.03)
North Macedonia	0.19	(0.04)	0.17	(0.04)	0.29	(0.03)	0.29	(0.03)
Serbia[a]	0.39	(0.03)	0.34	(0.03)	0.41	(0.03)	0.40	(0.03)

Notes All correlation coefficients were statistically significant ($p < 0.05$). Standard errors appear in parentheses

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

small associations between variables according to Cohen's standard for evaluation; see Cohen et al., 2003), while in Croatia and Serbia, the correlation coefficients were >0.3 for both girls and boys (indicating only moderate correlations existed).

5 Discussion and Conclusions

We aimed to examine the relationship between early literacy and numerical competencies for grade four students in the Dinaric region and their subsequent mathematics achievement in the TIMSS 2019 assessment. We found that the skills related to early literacy and early numeracy competencies were relatively strong predictors of student achievement in mathematics, in agreement with previous studies (Duncan et al., 2007; Moll et al., 2015), including those studies which used TIMSS data from earlier cycles (Soto-Calvo & Sánchez-Barrioluengo, 2016; Radišić & Ševa, 2017).

Parents/guardians from the Dinaric region generally estimated their children as being able to do literacy and numeracy tasks "moderately well" on the TIMSS scale "Could do literacy and numeracy tasks when beginning primary school" (Mullis et al., 2020, exhibit 5.18), although the average on this scale for the Dinaric region appeared to be a little higher than the EU average reported in TIMSS 2011 by Soto-Calvo and Sánchez-Barrioluengo's (2016) study.[2] The average ENT and ELT values

[2] For the participating education systems from the Dinaric region, the ELT average was 10.3 and the ENT average was 10.2 in TIMSS 2019. Calvo and Sánchez-Barrioluengo (2016) calculated an ELT average of 9.73 and an ENT average of 9.74 for EU education systems from the TIMSS 2015 data.

for Croatia were similar in TIMSS 2019 to their previously reported results from TIMSS 2011, whereas, between TIMSS 2015 and TIMSS 2019, average ENT and ET values decreased in Serbia.[3]

However, the majority of parents/guardians reported that their children could recognize letters from alphabet systems used in the Dinaric region (Latin and Cyrillic letters), and write their own name. The most likely explanation for those results is that these activities are recognized as representative for school readiness, since they are part of assessment at the school entrance. Although writing your own name is one of the developmental milestones in the emergent writing system (Puranik & Lonigan, 2011), it is interesting that recent findings are not conclusive on whether this skill, represented by knowledge concerning letter names, letter sounds, or more complex alphabetic principles (Drouin & Harmon, 2009; Molfese et al., 2011), is to be considered a good indicator of children's conceptual literacy knowledge.

When it comes to the numeracy competencies, our findings contribute toward understanding of the relation between early numeracy skills and different content domains of mathematics at school level, such as functional numeracy, geometry, data, or measurement. Early numeracy ability has been linked to later numeracy ability up to the age of adolescence in several studies (Geary et al., 2013). Our results extend this further by relating early numeracy with the domains of geometry and measurement, and data. Results from a previous study on longitudinal predictors of mathematics performance (LeFevre et al., 2010) found that early numeracy skills were related to numeration and calculation skills, but did not find any relationship to geometry and measurement skills later in schooling. This apparent variation in findings may be attributed to the different tasks used to measure geometry and measurement competencies. For example, TIMSS tasks related to geometry content domains involve measurement as well as numerical knowledge and skills (for example, students may be asked to calculate the perimeter of a rectangle). However, the tasks used in LeFevre et al. (2010) may have included a greater proportion of vocabulary items related to geometry, language-mediated processing on spatial arrays, and sequencing and patterning questions. Our findings were also broadly in agreement with numerous previous studies about the contribution of home resources for learning toward student achievement in mathematics (Cankaya & LeFevre, 2016).

Interestingly, we found that the association between preschool attendance and mathematical achievement was not significant, although some previous research has suggested otherwise (Yoshikawa et al., 2016). This is perhaps because preschool education may not have a long-term effect (Magnuson et al., 2007), but it may also be possible that the positive effect of preschool education is more pronounced for children from diverse and at-risk families who attend high-quality preschool programs (Throndsen et al., 2020). We did not consider these aspects of preschool education in our analyses. As to gender effects, our results are consistent with a large meta-analysis by Lindberg et al. (2010), which showed that there were no gender differences in mathematics performance (and that male and female variances

[3] In Serbia, the average ELT value was 10.6 and average ENT was value was 10.3 for TIMSS 2015. In TIMSS 2019, these values had decreased to an ELT value of 10.0 and an ENT value of 10.0.

were closely equivalent). Given that our data was based on information collected from parents/guardians, we cannot dismiss the possibility that perceptions about the mathematical capacities and performance of some participants from the Dinaric region may be colored by their caregivers' beliefs and prejudices, and by established social gender stereotypes in the region (Steele, 1997, 2003).

Finally, our analyses showed distinct variance among the different parental groups in their overall reports on children's early literacy and numeracy competencies. This may be attributed to the effect of age differences in sampling the Dinaric region; in some of the education systems, preschool refers to children of age four to five, while, in other systems, this could refer to children of age five to six. Observed dissimilarities could result from the different levels of understanding among parents/guardians about what constitutes early literacy and numeracy competencies and what is age appropriate. This lack of knowledge about developmental trajectories is recognized as one of the main factors related to parental misrepresentation and overestimation of children's capabilities (Zippert & Ramani, 2017).

The limitations of this study are mainly related to the nature of the variables used in TIMSS and more generally in large-assessment studies, where the data on the relation between early cognitive competencies and later school achievement are captured only at a superficial level using few questions. In addition, when collecting information from parents/guardians about their children's development of mathematical competencies, parents/guardians are not always certain about placing their children's mathematical competencies in a comparative framework, especially when it comes to advanced number skills. They tend to overestimate their child's abilities for different number tasks, including the concept of cardinality, counting skills, and symbolic and non-symbolic arithmetic (Fluck et al., 2005; Zippert & Ramani, 2017). In TIMSS, the data on early cognitive skills of students are gathered from retrospective parental reports (TIMSS & PIRLS International Study Center, 2018), a fact that should be accommodated when considering parental estimations of their children's EL and EN skills.

The findings of our study suggest a range of possible avenues for researchers from the Dinaric region to investigate and explore in more depth, including further analysis of not only the early numeracy variables recognized in the literature as meaningful predictors of mathematics achievement (e.g., symbolic versus non-symbolic mathematical competencies) but also the measures that might provide a deeper understanding of parental attitudes and practices. The findings provide a good basis for the creation and improvement of numeracy development programs for parents/guardians, and provide robust data for policymakers about the impact of early childhood mathematics in current preschool curricula (Clements & Sarama, 2008; Thiel & Perry, 2018).

The results imply that parental estimates regarding the development of mathematical competencies before entering school are culturally conditioned. Traditionally, parents/guardians in the Dinaric region believe that children are supposed to know how to write and read words as well as perform simple addition before entering first grade. Results from TIMSS 2019 show that, in Dinaric region, parents/guardians still have relatively high expectations when it comes to their children's early numeracy skills. However, small differences across the region are noticeable, possibly due to a shift in parental beliefs, attitudes, and practices related to this topic. Future TIMSS cycles will enable researchers and policymakers to identify potential changes and to develop appropriate programs for parents/guardians, helping them to facilitate numeracy development in their children in more effective and age-appropriate ways.

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The Role of Learning Resources, School Environment, and Climate in Transforming Schools from Buildings to Learning Communities

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Abstract International large-scale assessments can play a critical role in identifying factors that have an effect on student learning and achievement. IEA's Trends in International Mathematics and Science Study (TIMSS), as the only international study of primary level mathematics and science education, is increasingly important in supporting continuous improvement in the quality of education and education systems. TIMSS also collects background information about the material and non-material factors that potentially affect teaching and learning processes, and the 2019 cycle of TIMSS provided a unique opportunity to analyze the role these factors play in education across the Dinaric region. Previous research has suggested that there are two especially important sets of socioeconomic background variables that need to be taken into consideration when analyzing possible factors related to student achievement and their attitudes toward teaching and learning at school. These are, firstly, personal student characteristics and their home resources and, secondly, school climate and material resources. Modeling of the TIMSS 2019 data for the Dinaric education systems indicated that material, environmental, and school climate factors were only weakly associated with student achievement across the region, explaining less than 12% of the variance in student achievement in science and less than 11% of the variance in mathematics achievement. These results indicate that education authorities in the region should not automatically assume that the material characteristics of the school environment, as well as elements of school climate, are the best or only areas for potential improvement. Access to home learning resources, parental support, and students' and teachers' attitudes toward learning and teaching

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seem to be more important factors in explaining differences in student achievement across the Dinaric region than previously perceived.

Keywords Bullying · Safety · School climate · School environment · School material resources · Trends in International Mathematics and Science Study (TIMSS)

1 Introduction

Around the world, education authorities are interested in identifying factors that have an effect on their students' achievement, instigating educational reforms that enhance positive elements of their systems and diminish any negative effects. International large-scale assessments (ILSAs) are viewed as increasingly important in supporting continuous improvement in the quality of education and education systems. Such worldwide assessments, like those conducted by the International Association for the Evaluation of Educational Achievement (IEA) and the Organisation for Economic Cooperation and Development (OECD), as well as others emerging from European Union (EU) initiatives, report the influence of material and non-material factors on teaching and learning processes. IEA's Trends in International Mathematics and Science Study (TIMSS) is especially important for science, technology, engineering, and mathematics (STEM) because it is the only international study of those subjects at the primary school level.

In general, TIMSS has shown that student achievement around the globe has improved since the study began collecting data and measuring trends in 1995, with many national systems showing increasing achievement at both grades four and eight for the mathematics and science subjects. As Mullis said in 2016: "The positive trends indicate education is improving worldwide, and it's not at the expense of equity between high and low achieving students" (TIMSS PIRLS International Study Center, 2016). With this in mind, we investigated school resources and characteristics of the school environment across the Dinaric region; our aim was to understand what underlying factors promote schools as good, successful, and open places for teaching and learning.

Seven participants from the Dinaric region took part in TIMSS 2019, namely Albania, Bosnia and Herzegovina, Croatia, Kosovo,[1] Montenegro, North Macedonia, and Serbia. Croatia and Serbia both also participated in TIMSS 2015 (where they tested grade four students).[2] Both achieved results above the international average in

[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).

[2] Slovenia also participated in TIMSS 2015 (and achieved above the TIMSS international average results in mathematics and science), but did not participate in TIMSS 2019 survey and thus could not take part in this comparative analysis of the Dinaric region.

TIMSS 2015 for grade four science, with Serbia also scoring above the TIMSS international average in grade four mathematics (Croatian student achievement for grade four mathematics was around the TIMSS international average). Both education systems also reported an increase in student achievement in mathematics and science between TIMSS 2011 and TIMSS 2015, mirroring the global trend of improvement in student achievement in the subjects assessed by TIMSS. However, while this improvement continued for mathematics in the 2019 cycle of TIMSS in Croatia, a decline in science achievement was noted (despite still scoring above the TIMSS international average). Meanwhile, in Serbia, both assessment areas showed a decline in student achievement between TIMSS 2015 and TIMSS 2019, and the student mathematics achievement score declined below their TIMSS 2011 score (although still remaining above the TIMSS international average). All other Dinaric systems represented in this report recorded grade four student achievement scores below the TIMSS 2019 international average; among this group, Albania's results were closest to the TIMSS 2019 international average and Kosovo's results furthest from the TIMSS 2019 international average for both the mathematics and science assessment areas.

We were interested in whether available school resources, the school environment, and school climate could be linked to student achievement in the Dinaric region. Prior research (Kutsyuruba et al., 2015) has indicated that these factors may play an important part in developing successful schools and students, but, given that cultural factors may also be involved, the data collected by TIMSS 2019 provides the first opportunity to establish the interacting associations between these factors and student achievement across the Dinaric region.

For the Dinaric participants that were involved in TIMSS 2015 and earlier cycles, there has already been an initial exploration of these concepts and their potential effect. School principals reported that almost three-quarters of all students participating in TIMSS 2015 were "affected" or "affected a lot" by the shortage of resources for mathematics and science instruction. In the Dinaric region at that time, 18% of Croatian schools reported "more than 25% students coming from economically disadvantaged homes (and not more than 25% from economically affluent homes);" in Slovenia this figure was 23%, and it was 44% in Serbia. For all three participants, better achievement results were noted for students in schools where "more than 25% of the student body comes from economical affluent homes (and not more than 25% from economically disadvantaged homes)" than for students in schools in that fell into the other two groups, which contained proportionally more students from disadvantaged homes (Martin et al., 2016; Mullis et al., 2016a). Almost a fifth of primary schools in Croatia, a quarter of primary schools in Slovenia, and half of the primary schools in Serbia contained students from homes with (relatively) harsh socioeconomic conditions, and it is perhaps not unexpected that this would have a negative effect on learning and teaching in these schools. Many ILSAs, such as OECD's Programme for International Student Assessment PISA and IEA's TIMSS and Progress in International Reading Literacy Study (PIRLS), have highlighted the importance of home environment in supporting student success (Martin et al., 2016; Mullis et al., 2016a, 2017, 2020; OECD, 2019c).

Similarly, teachers surveyed in TIMSS 2015 reported having "moderate to severe problems" with school conditions and resources for 17% of students in Slovenia, 23% of students in Croatia and 35% of students in Serbia. It is interesting to note that, in all three participants, students from schools that teachers had identified as strongly affected by such problems nevertheless tended to record higher average achievement in mathematics and science than less affected students. The TIMSS 2015 international results indicated that, generally, students with teachers who reported that their school had no problems with resources had the highest achievement, and students with teachers who reported that their school was "affected a lot" by problems with conditions and resources had the lowest average achievement among their peers (Martin et al., 2016; Mullis et al., 2016a), which seems more in line with expectations. To explain the apparent deviation in the relationship between material resources at school and achievement in the Dinaric region, some research has suggested that, in conditions when material resources are lacking, teachers (and other staff) tend to give more attention to students' learning and are more available and willing to help as a form of compensation (OECD (2019a).

Another general conclusion from TIMSS 2015 was that according to parents, principals, and teachers, as well as students themselves, the majority of grade four students were attending good schools. On average, across all TIMSS 2015 participants, 58% of parents were reportedly very satisfied with students' school performance, 52% of teachers were very satisfied with their jobs, more than half the teachers and principals reported that their school achieved a high level of academic success or that there was very strong emphasis on academic success in their school (>60%), and the majority of students (66%) reported a strong sense of school belonging. In the Dinaric region, the patterns found followed these general conclusions (Martin et al., 2016; Mullis et al., 2016a).

In TIMSS 2015, school climate was represented by a composite TIMSS "Safe and Orderly School" scale (Martin et al., 2016; Mullis et al., 2016a). In general, TIMSS 2015 found that the majority of grade four students were in safe school environments (56%, according to teachers) and, according to principals, 59% of schools had "hardly any discipline problems." Conversely, 16% of all students reported that they were bullied about once a week in their schools, which perhaps challenges teachers' and principals' generally positive perceptions of school safety and school climate. The percentage of students that reported being bullied in TIMSS 2015 was close to the TIMSS international average in Slovenia (14%), but below the TIMSS international average in Croatia and Serbia (8%). In TIMSS 2015, 76% of students in Croatia attended schools where hardly any discipline problems were reported by their principals. Principals in Serbia and Slovenia were more critical than principals in Croatia about the state in their schools (they reported that while around 50% of students were in schools with "hardly any problems", more than one third of them were in schools with "minor problems"). When teachers were asked to assess safety and order in their schools, they were more cautious than principals in their assessment, with around half reporting that students were in "very safe and orderly schools" in Croatia (48%) and Serbia (52%), while Slovenian teachers were more critical in their assessment (around 29%). In Serbia and Slovenia, students belonging to the schools that teachers reported as being very safe and orderly also tended to achieve the highest scores in mathematics in science. In Croatia, there was no significant difference in the achievement between the groups.

Almost half of the students in Serbia (49%), and more than a half of the students in Croatia (61%) and Slovenia (82%) had teachers reporting that teaching mathematics and science was somewhat or very limited by student needs (Martin et al., 2016; Mullis et al., 2016a). In Croatia and Slovenia, students whose teachers reported that teaching was not at all limited achieved the best scores in mathematics. This was also true for the science achievement results for Slovenia, but it was interesting that students whose teachers reported that teaching was somewhat or very limited by students needs only scored a few points less on the TIMSS achievement scale. Serbia's results were quite different, and students whose teachers reported that teaching was very limited by students needs tended to achieve the best scores in both mathematics and science. The TIMSS 2019 data showed similar patterns for Croatia and Serbia (Mullis et al., 2020).

While it is important to assess conditions in schools, as a source of material and environmental support to promote student learning, a student's home resources for learning (both in terms of material assets and cultural capital) are well-proven indicators of student success in school (Matković et al., 2019; Meinck et al., 2018). In TIMSS 2015, students whose parents reported many home resources for learning had much higher achievement than students whose parents reported some or few resources. The difference in achievement between the students with many home resources (17–18%) and those with few resources (8–9%) was 142 points for mathematics and 141 for science. A similarly massive difference was reported by PIRLS 2016, and, in both TIMSS 2015 and PIRLS 2016, students whose parents reported often spending time with their children on early literacy and numeracy learning activities had a higher achievement than students whose parents did so only sometimes or almost never (Mullis et al., 2017).

The conceptual model of effective schools within the PIRLS and TIMSS studies was also put to test. An effective school was perceived as safe and orderly, had adequate facilities and equipment and well-resourced classrooms, was staffed with well-prepared teachers, it supported academic success, and provided effective instruction. Martin and Mullis (2013, p. 8) concluded, "After controlling for home background, of the school environment variables, Schools Are Safe and Orderly was related to higher achievement in at least one subject in 15 countries, and Schools Support Academic Success in 10 countries. Students Engaged in Reading, Mathematics, and Science Lessons was the most powerful school instruction variable, related to higher achievement in at least one subject in 15 countries, again after controlling for home background. All in all, a school that was safe and orderly, promoted academic excellence, and provided engaging instruction, could be considered to have several important characteristics for effectiveness."

Resources for education are generally focused on physical conditions for schooling, such as having enough space for classes, and ensuring basic utilities and perhaps specialized classrooms are available. More recent discussion on material resources in schools often refers exclusively to the availability of information and communication technologies (ICT) in schools, namely whether students have access to equipment such as laptops, tablets, broadband internet, interactive classrooms, and e-libraries. Both of these aspects are addressed in the TIMSS background questionnaires (TIMSS & PIRLS International Study Center 2018). Digital skills have been noted as being increasingly important in almost all aspects of teaching and learning, in acknowledgment of the need to prepare today's students to function as tomorrow's digital workers (Fraillon et al., 2020).[3] The integration of ICT is brings some new innovative forms of teaching in classrooms all over the world, having both advantages and disadvantages (Eickelmann, 2011).

OECD's PISA also researches the relation between student achievement and material investments in education, and has repeatedly concluded that investing in the school system initially has positive effects on achievement, but a point is eventually reached when additional investments have a more modest effect on student results and other factors become more important. Essentially, when everything material has been resolved, less tangible elements of the quality of processes of teaching and learning will still need to be tackled to achieve more advanced results. Nevertheless, there are always exceptions, as OECD (2019a, p. 56) noted, "While an inadequately resourced education system cannot deliver good results, Estonia, with a level of expenditure on education that is about 30% lower than the OECD average, is nevertheless one of the top-performing OECD countries in reading, mathematics and science."

When international large-scale assessments deliver their results, additional research on available data is performed in almost every country around the world. In Croatia, PISA 2006 data showed that home socioeconomic indicators, along with the region of residence, explained 24% of the variance in students' science achievement and confirmed how important these factors are for student achievement (Gregurović & Kuti, 2010). As PISA only tests students aged 15, more information is needed at other school levels to make informed decisions about schooling. Reflecting on the results from international data prompts at least two questions about the relationship between material resources available to students and their success measured in terms of knowledge attainment in important learning areas. First, can provision of resources in school overcome the lack of resources at the individual (student, home) level? Secondly, can school characteristics, such as open school climate or a positive school culture oriented towards achievement and academic belonging, overcome a lack of material resources both on the individual and school level?

In general, previous studies have established more indicative connections between student achievement and school environments and school climate (Bear et al., 2014; OECD, 2019b; Schulz et al., 2010), than between student achievement and school material resources. For instance, TIMSS 2015 results have shown that, for almost all grade four students, a positive sense of school belonging was related to higher average mathematics and science achievement (Martin et al., 2016; Mullis et al., 2016a).

[3] Here the term "digital" does not simply refer to digital machines and processes, but to the entire political, social, and economic context and infrastructure within which they have emerged. We now live in a "digital age" (Burston et al., 2010, p. 215).

Having in mind that one of the most important goals of every teaching process is to help students become future prosperous adults by putting emphasis on both cognitive outcomes and affective dimensions (attitudes, values, and beliefs), educational systems that aim to be successful should go beyond procurement of material resources. Investing in the continuous professional development of teachers and principals is commonly recommended as a means of ensuring quality education, but other recommendations include investment in developing transversal (lifelong learning) skills or widening use of ICT in school (Drigas & Vasiliki, 2015; OECD, 2019d; UNESCO [United Nations Educational, Scientific and Cultural Organization], 2014; Webb & Cox, 2004).

2 Methodology and Research Questions

We aimed to investigate whether a particular set of contextual factors was related to achievement, and if and to what extent these factors represented important elements of school life. Our research was designed to address the relative importance of two factors that previous research has suggested may be associated with student achievement. Firstly, how important were school material resources and the school physical environment (in terms of general wealth or plurality of school possessions, i.e., important school equipment and spaces or lack of thereof), school location, and principals' perceptions of the affluence of the families from which enrolled students come from. Secondly, how important was the overall school climate? The elements of school climate here include the social determinants of everyday school life, such as student issues that affect teaching, safe and orderly school environments (as reported by teachers), and bullying among students (as reported by students).

From this we distil three critical research questions:

(1) *How well equipped with material resources for learning are schools across the Dinaric region?*
(2) *What can TIMSS tell us about the learning environment in schools across the Dinaric region?*
(3) *How comparable are important aspects of school climate across the Dinaric region?*

We used data collected by TIMSS 2019 from seven educational systems across the Dinaric region in our analyses. These included students' achievement results at grade four in mathematics and science, and contextual information derived from responses to the students', teachers' and principals' questionnaires. For more information about samples, methods, procedures, and data that we used, see Sect. 5 and the TIMSS 2019 technical report (Martin et al., 2020).

2.1 Indicators and Variables Used

We identified several variables and scales in the TIMSS 2019 international reports as being of potential interest for our research (Table 1). We investigated one of the main aspects of schooling by creating two indexes to assess the availability of material resources in schools, one for mathematics and one for science. These indexes combined teachers' and principals' responses to questions about whether the school possessed a number of specific items (such as computers or a library) and the prevalence of different conditions posing obstacles for teaching into a simple summative "Index of School Material Resources" (see Table 1 and Tables S.8 and S.9 in the supplementary materials available for download at www.iea.nl/publications/RfEVol13).

The Index of School Material Resources combines information collected by TIMSS 2019 on the availability of computers during mathematics/science lessons, existence and size of the school library, existence of classroom libraries, provision of digital learning resources, and instruction being affected by mathematics/science lessons resource shortages. The Index of School Material Resources for teaching science comprised one additional variable about the availability of a dedicated science laboratory in the school. For both mathematics and science, we split the derived index into three categories: (1) few resources available, (2) some resources available, and (3) many resources available in the school (see Table S.10 in the supplementary materials available for download at www.iea.nl/publications/RfEVol13).

Among the contextual data TIMSS collects, there are several indicators regarding the school environment. In the school questionnaire, principals were asked whether the school is situated in an urban or rural settlement and about student composition in their school (if more students come from disadvantaged homes or more students come from affluent home backgrounds). We analyzed the relationship between student achievement and the factors creating the school environment (whether the school was located in an urban or rural environment and the school principal's assessment of the school composition). These demographic determinants have been of interest to researchers for decades, in their attempts to define what conditions underlie student achievement; higher student achievement has been linked to urban and/or wealthier environments (see chapter "Scaffolding the Learning in Rural and Urban Schools: Similarities and Differences" for more information on this topic).

The third factor that we addressed was school climate, which we reduced to the aspect of perceptions of safety and order within school. Defining school climate is complex, despite often being cited as an important explanatory factor for many student outcomes (Brand et al., 2008; Cohen et al., 2009; Hoy et al., 1991). TIMSS reports have consistently shown a positive relationship between student achievement and teachers' and principals' reports that the school is safe and orderly (Martin et al., 2016; Mullis et al., 2016a, 2020). The TIMSS scale on student bullying in school, reported by students themselves, is also important element of assessing the overall safety and state of interrelations within the school and thus included into this analysis (Martin et al., 2020). In TIMSS frameworks bullying is defined as

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

Aspect	Variables/scale	Description	Values/response options	Reference
School material resources	Index of School Material Resources	Index based on principals' and teachers' reports regarding the availability of five resources • Computers available during mathematics lessons • Existence and size of school library • Existence of classroom libraries • Provision of digital learning resources • Shortage of resources for mathematics lessons affecting instruction • Science laboratory (index for science only)	Index with three categories: (1) Many resources (2) Some resources (3) Few resources	Table S.8[b] and Table S.9[b]
	Classroom teaching limited by students not ready for instruction scale[a]	Scale of teachers' estimates on how much their teaching in the sampled class is limited by eight student attributes Response options: not at all, some, a lot	The scale is divided into an index with three categories: (1) Very little (2) Some (3) A lot	Martin et al. (2020), p. 16.138

(continued)

Table 1 (continued)

Aspect	Variables/scale	Description	Values/response options	Reference
	Availability of computers for mathematics lessons/Availability of computers for science lessons	Teachers' responses to three items • Each student has computer • Class has computers that students can share • School has computers that class can use sometimes	There were two response options per item: (1) Yes (2) No	Fishbein et al. (2021), Supplement 1, pp. 77 and 82
School environment	School composition by socioeconomic background	Principal's report on the share of students in the school coming from: • Economically disadvantaged homes • Economically affluent homes Response options: 0–10%, 11–25%, 26–50%, more than 50%	Index with three categories: (1) More affluent: Schools where more than 25% of the student body comes from economically affluent homes and not more than 25% from economically disadvantaged homes (2) Neither more affluent nor more disadvantaged: All other possible response combinations (3) More disadvantaged: Schools where more than 25% of the student body comes from economically disadvantaged homes and not more than 25% from economically affluent homes	Fishbein et al. (2021), Supplement 3, p. 19

(continued)

Table 1 (continued)

Aspect	Variables/scale	Description	Values/response options	Reference
	School location	Principals' responses to the question: which best describes the immediate area in which your school is located? Response options: urban (densely populated), suburban (on fringe or outskirts of urban area), medium size city or large town, small town or village, remote rural	School location was recoded into two categories: (1) Urban (urban, suburban, medium city) (2) Rural (small town, remote rural)	Fishbein et al. (2021), Supplement 1, p. 95
School climate	Safe and orderly school[a]	Scale of teachers' agreement with eight statements about the school	The scale is divided into an index with three categories: (1) Very safe and orderly (2) Somewhat safe and orderly (3) Less than safe and orderly	Martin et al. (2020), p. 16.144
	Student bullying[a]	Scale of students' agreement with eleven statements about the frequency of experiencing bullying at school during the current school year	The scale is divided into an index with three categories: (1) Never or almost never (2) Almost monthly (3) Almost weekly	Martin et al. (2020), p. 16.69

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

For Tables S.8 and S.9, please consult the supplementary materials available for download at www.iea.nl/publications/RfEVol13 "repeated aggressive behavior that is intended to harm students who are physically or psychologically less strong, and takes a variety of forms ranging from name calling to inflicting mental and physical harm" (Mullis and Martin 2017, p. 68). For some, this may be perceived as narrowed perspective of the concept of school climate, which is why we chose to analyze both the physical and social dimensions of school life in an attempt to provide a multidimensional approach. We thus undertook a comparative analysis of teachers' perspectives on safety and order at school and students' reports on bullying (aggregated at school level). As many national authorities around the world are aware, and the TIMSS 2019 international report reconfirmed (Mullis et al., 2020), the question of school safety (i.e., student bullying) remains an important problem in education. The teacher Safe and Orderly School scale encompasses of eight statements: one asking about conditions outside of the school (i.e., safety in the neighborhood), three about teachers' subjective feeling of safety and order within the school, and another three about students' adherence to school discipline (respecting the rules, teachers and property). We categorized students as being in "very safe and orderly schools" if, on average, their teachers agreed a lot with four of the eight statements and agreed a little with the other four statements.

Another indicator that we used to assess school climate was the TIMSS 2019 scale named "Classroom Teaching Limited by Students Not Ready for Instruction," which is composed of eight variables collected by the TIMSS teacher questionnaire. These questions assess teachers' perceptions of the severity of different limitations that negatively affect their classes. Teachers were asked whether their students lacked prerequisite knowledge or skills, suffered from lack of basic nutrition or not enough sleep, were absent from class, disruptive or disinterested, had to deal impairments (either mental, emotional or psychological), or did not understand the language of instruction.

We used these variables as predictors in regression analyses that investigated whether those elements of school life were related to student achievement.

3 Results

3.1 Material Resources for Learning in Schools

3.1.1 Index of School Material Resources

As explained in Sect. 2.1, we created two indexes to explore the effects of school material resources, one for mathematics and one for science; the science material resources index contained one additional variable (availability of a science laboratory in the school). Not having a science laboratory in school was related to lower achievement results in science only in one system (Albania). In Montenegro, there was no difference in science achievement among the students in schools with or without a science laboratory, and in Bosnia and Herzegovina, Croatia, and Kosovo, the difference was small and insignificant. In Montenegro and Serbia, students from schools without science laboratories achieved higher scores in science (more than 10 points higher on average) than those in schools with a science laboratory.

We further examined principals' reports about conditions for teaching related to shortage of resources. Across the Dinaric region, relatively few students were affected either "somewhat" or "a lot" by shortages of resources for mathematics and science instruction, with the lowest percentages reported in Kosovo, Albania, and North Macedonia (<8%), and the highest percentage of affected students in Serbia (20%).

These results seem to differ from teachers' reports; this may be because principals are either less aware of the resource problems reported by their teachers or less willing to admit classroom resource issues. The distribution of material resources for mathematics lessons varies significantly across the region (Fig. 1). Data from Bosnia and Herzegovina, Croatia, Montenegro, North Macedonia, and Serbia were quite consistent, with more than half to two-thirds of students belonging to the intermediate category that enjoys "some resources" (from 57% in North Macedonia to 76% in Croatia). In Albania and Kosovo, however, almost two-thirds of all students attended schools where principals indicated that their school was equipped with comparatively few resources. Only six percent of students in Albania were reported as having "many resources" and, in Kosovo, no students fell into this category. In interpreting these statistics, it is important to note that our school material resources scale and/or constructed index was comprised of physical objects and spaces, while, in the TIMSS 2019 schools questionnaire, principals responded to questions on shortages directly aimed at identifying specific issues, such as providing contents and tools that assisted

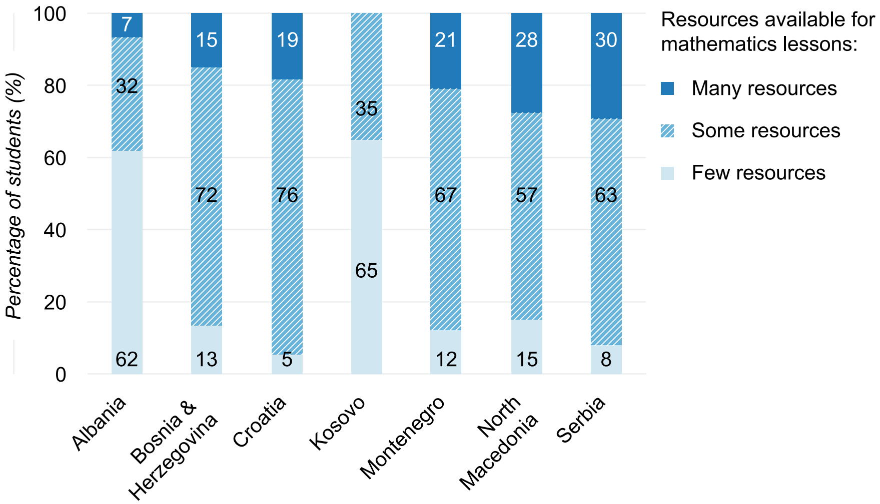

Fig. 1 Index of School Material Resources for Mathematics. Percentage of students in schools with different amounts of resources for mathematics lessons. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

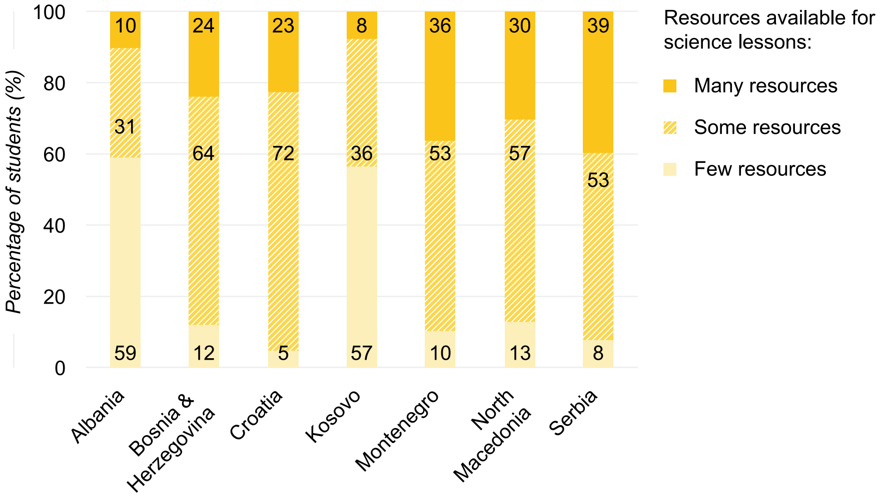

Fig. 2 Index of School Material Resources for Science. Percentage of students at schools with different amounts of resources for science lessons. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

teaching, along with questions about the availability of specialized staff (teachers); this last question was of particular interest to STEM education in the Dinaric systems.

The distribution of material resources for science lessons was very similar (Fig. 2). In Montenegro, North Macedonia, and Serbia, principals' reports indicated that around half the students belonged to the intermediate category of "some resources". Around two-thirds of students were in this category in Bosnia and Herzegovina (64%) and Croatia (72%), and around a third in Albania (31%) and Kosovo (36%). Croatia and Serbia had the smallest number of students in the category with "few resources" (5% and 8%, respectively), while Albania and Kosovo had the smallest number of students in the category of "many resources" (10% and 7%, respectively).

Using the Index of School Material Resources, we found that, in three of the Dinaric participants, differences in mathematics achievement among students at schools were related to the amount of resources. In Albania, on average, students at schools with some resources scored 40 points more than students at schools with only few resources, and students at schools with many resources scored, on average, 73 points more than their peers at schools with few resources. In Croatia, students at schools with few resources, on average, scored 25 points less on the mathematics scale than students at schools with some or many resources. In Serbia, there was a 35 point achievement gap between students at schools with low resources and those at schools with many resources. However, we found no significant similar achievement gaps in Bosnia and Herzegovina, Kosovo, Montenegro, and North Macedonia. Regarding science achievement, we found similarly that students at schools with more resources on average tended to score higher on the TIMSS assessment, except in Montenegro; however, the achievement gap was only significant in Albania (Fig. 3).

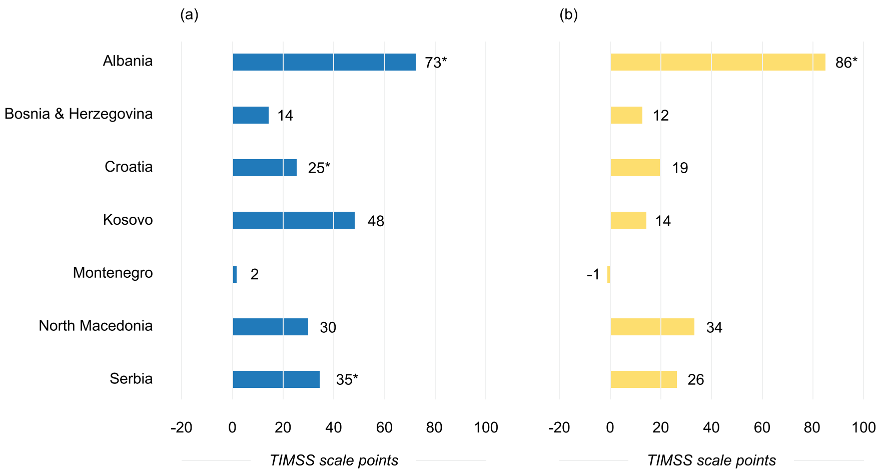

Fig. 3 Difference in **a** mean mathematics achievement and **b** mean science achievement between TIMSS achievement scores for students at schools with many resources and students at schools with few resources. *Notes* *The difference is statistically significant ($p < 0.05$). In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

3.1.2 Information and Communication Technology Resources

We found that, on average across the Dinaric region, most students were in schools that were equipped with computers for class use, with the highest percentages in Croatia (97% both for mathematics and science lessons) and the lowest in Kosovo (54% for mathematics lessons) and Macedonia (63% for science lessons) (Fig. 4). When teachers were asked whether each student had a computer to use in mathematics and/or science classes, the situation differed; the highest percentages were in Bosnia and Herzegovina (36% for mathematics and 30% for science), and lowest in Kosovo and Serbia (≤3%). The computer-student ratio ranged widely across the region, from 0.14 in Albania and Kosovo, 0.22 in Serbia, 0.24 in Croatia, 0.25 in Montenegro, and 0.41 in Bosnia and Herzegovina, to 0.77 in North Macedonia.

As well as providing hardware, there is a more sophisticated aspect to ICT in schools, reflected by the construction of online networks through interactive tools and the publication of online content for teaching and learning, such as providing digital learning resources. The progress toward full integration of ICT into teaching and learning has been largely gradual up until 2020, when the COVID-19 pandemic threw education systems around the world into "overnight" digitalization, whether they were prepared for it or not. Across the Dinaric region, TIMSS 2019 data indicated that the provision of "online learning management systems" differed substantially (Table 2). Principals reported that students' access to digital learning resources was good (Table 2).

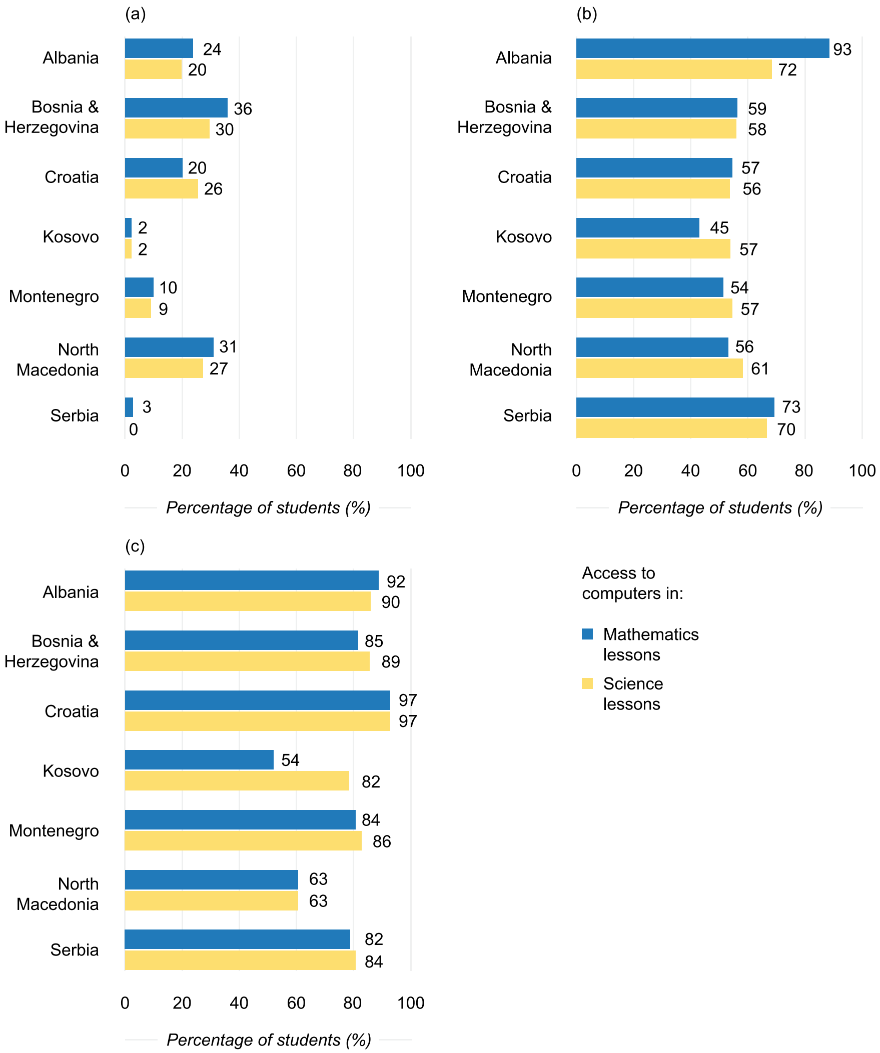

Fig. 4 Student access to computers in school for mathematics and science lessons: **a** percentage of students in classes where each student has a computer; **b** percentage of students in classes that have computers for students to share; and **c** percentage of students in schools that have computers for class use. *Note* In Kosovo and Serbia the national defined population covers 90–95% of the national target population.

3.2 School Environments Across Dinaric Countries

In terms of school location, more than half of the students are located in urban areas in all seven participants, with the highest percentage in Montenegro (85%) and the lowest percentages in Croatia and Kosovo (57%). In general, more students

Table 2 Principals' reports of access to digital resources in TIMSS 2019

Education system	Schools have access to online learning management systems (%)		Students have access to digital learning resources (%)	
Albania	15	(2.9)	26	(3.8)
Bosnia & Herzegovina	27	(3.3)	47	(4.2)
Croatia	50	(4.3)	80	(3.6)
Kosovo[a]	13	(3.0)	31	(4.3)
Montenegro	46	(0.5)	63	(0.5)
North Macedonia	62	(4.6)	68	(3.8)
Serbia[a]	71	(3.5)	76	(3.4)

Notes Standard errors appear in parentheses.
[a]National defined population covers 90–95% of the national target population

attend urban schools, and more disadvantaged students tend to attend schools situated in rural areas (see chapter "Scaffolding the Learning in Rural and Urban Schools: Similarities and Differences" for a more detailed analysis of this topic).

According to their principals, the percentage of students at more disadvantaged schools ranged from 13% in Croatia to 42% in Albania. Principals in North Macedonia reported that 66% of students were in more affluent schools; this was the highest perceived percentage for that category in the Dinaric region.

Previous research (Mullis et al., 2016a; OECD, 2019a) has shown that student achievement in mathematics is related to student home socioeconomic status or school principals' perceptions of family affluence. Our analysis of the TIMSS 2019 results confirmed these findings. The students from more affluent schools tended to achieve the best TIMSS mathematics scores in every system in the Dinaric region except Kosovo. In five participants, the mathematics achievement of students at more affluent schools was higher than that of students from more disadvantaged schools, with the biggest achievement gaps in North Macedonia (44 points) and Albania (39 points). In Bosnia and Herzegovina and Kosovo, there was no statistically significant difference between these groups.

As with mathematics, students from more affluent schools tended to achieve the best TIMSS science scores in every system in the Dinaric region except Kosovo. In six participants, the science achievement of students at more affluent schools was higher than that of students from more disadvantaged schools, with the biggest achievement gaps in North Macedonia (50 points) and Albania (42 points). In Kosovo, there was no statistically significant differences between these groups.

We also assessed results related to the TIMSS scale "Teaching Somewhat or Very Limited by Students not Ready for Instruction" (Mullis et al., 2020, exhibits 10.10 and 10.11). Teachers generally reported that relatively few limitations were created by students who were not yet ready for instruction, at least in comparison with other TIMSS participants. In Albania, 71% of students attended schools that were affected "very little" by students not ready for instruction; in Kosovo 63% of students attended schools that were affected "very little" and, in North Macedonia, this was 60%. In the other participants, less than half of the students had teachers who reported facing few issues (49% in Croatia and Serbia, 46% in Montenegro, and 45% in Bosnia and Herzegovina). At least a third of students in the region had teachers that reported experiencing "some" or "a lot" of limitations due to students not ready for instruction.

3.3 School Climate: Safety and Order at Schools

When we assessed perceptions of safety and order in schools, we found that teachers' perceptions of this dimension of school climate differed quite considerably across the region (Table 3).

Teachers of almost all students in Albania perceived their schools as very safe and orderly places, but only about half of the students in Croatia had teachers who thought their schools were very safe and orderly. In general, across the Dinaric region, only small percentages of students attended schools perceived by their teachers as "less then safe and orderly" ($\leq$3%), and, in most participating systems, except Croatia, there were also fairly low percentages of students in schools that teachers perceived as "somewhat safe and orderly" (Table 3).

According to students, student bullying was present and relatively widespread in the Dinaric region. The percentages of students who reported frequent (monthly or weekly) bullying ranged from 15% of students in Albania to 32% of students in North Macedonia. Numerous national and international reports have reported findings on school violence in the Dinaric region. For example, when looking at adolescent experiences, the United Nations Children's Fund (2017) reported that a quarter of

Table 3 Percentage of students by how safe and orderly their school environment was, according to their teachers

Education system	Teacher reported school was:					
	Very safe and orderly (% students)		Somewhat safe and orderly (% students)		Less than safe and orderly (% students)	
Albania	97	(1.3)	3	(1.3)	0	(0.0)
Bosnia & Herzegovina	80	(2.8)	14	(1.7)	0	(0.0)
Croatia	47	(3.2)	52	(3.2)	1	(0.7)
Kosovo[a]	91	(2.3)	9	(2.4)	0	(0.0)
Montenegro	85	(1.7)	14	(1.7)	0	(0.0)
North Macedonia	76	(3.4)	22	(3.4)	1	(0.7)
Serbia[a]	73	(4.2)	24	(4.0)	3	(1.4)

Notes Standard errors appear in parentheses
[a]National defined population covers 90–95% of the national target population
Source Mullis et al. (2020), exhibits 8.7 and 8.8

students in Albania and North Macedonia experienced bullying in schools. Dinaric educational systems have strongly promoted zero violence policies in schools in response to this problem, and prevention programs have also been developed to tackle internet and cyber-bullying.

We analyzed the TIMSS 2019 data on bullying at school level in relation to school material resources, for both mathematics and science, and identified no significant differences between the schools belonging to the groups with few and many resources for learning (Figs. 5 and 6).

In general, we note that the education systems that scored higher on the Indexes of School Material Resources were not experiencing lower levels of bullying in schools.

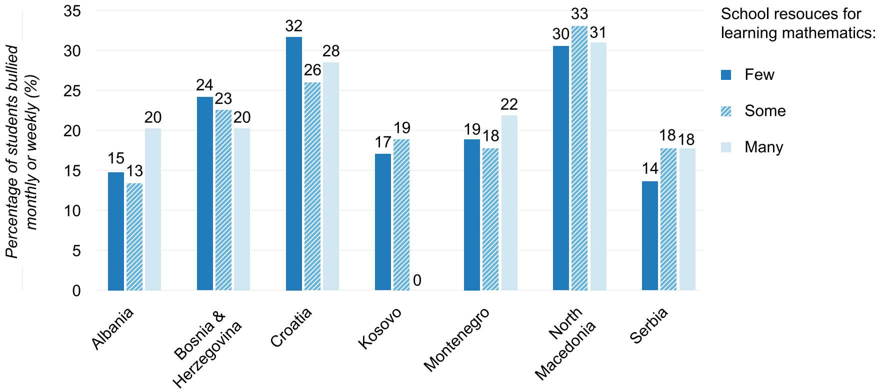

Fig. 5 Percentages of students being bullied monthly or weekly in schools versus school resources for learning mathematics. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

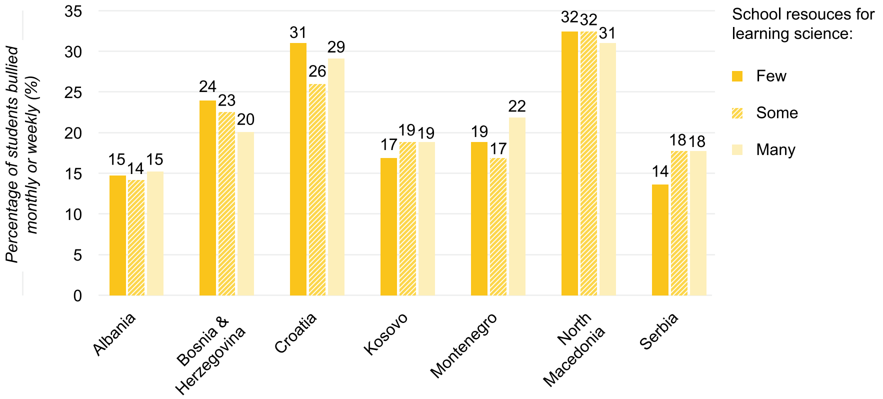

Fig. 6 Percentages of students being bullied monthly or weekly in schools versus school resources for learning science. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

A focus on developing more intangible elements, such as a supportive school climate, a culture of achievement, and trust in school as an institution, may result in better environments for teaching and learning within schools.

3.4 Impact of the Schools' Material Resources, Environment, Composition and Climate on the Achievement Results (Regression Analysis)

Having investigated the effects of several school-related factors on achievement, we undertook multivariate regression modeling to obtain a more comprehensive picture how all these factors were interrelated with achievement. The regression analyses revealed that the importance and significance of the factors varied across the region. We found that the Index of School Material Resources, and the school environment and climate factors explained only two percent of variance in student achievement in mathematics in Bosnia and Herzegovina, Croatia, and Montenegro, six percent of variance in Serbia, seven percent in Kosovo, and up to 11% of variance in Albania and North Macedonia (Table 4). The regression models also only explained two percent of variance in student achievement in science in Bosnia and Herzegovina, Croatia, and Montenegro, seven percent of variance in Kosovo and Serbia, and up to 12% of variance in Albania and North Macedonia (Table 5). The low power of variables related to school resources, school environment, and school climate in explaining student achievement strongly suggests that factors related to students' home resources and the personal characteristics of students (interests, motivation, beliefs), and teachers' and teaching characteristics together play a much greater part in supporting student achievement, as other chapters in this book confirm.

4 Conclusions

Around the world, education authorities are interested in supporting better learning for all and international large-scale assessments play a critical role in identifying and supporting solutions that affect student achievements (Mihaljević Kosor et al. 2019). Although ILSA results sometimes lead researchers and policymakers to suggest that student achievement can be improved simply by something as obvious as investing in material resources, our research reveals that the answers are much more complex. Looking at the Dinaric region alone, factors related to material resources, school environment, and school climate did not show uniform or particularly strong effects on student achievement, although there were some interesting patterns that were aligned with the wider international results. In the TIMSS 2019 international results, higher average achievement in mathematics and science at grade four was associated with fewer school resource shortages and higher school emphasis on academic success

Table 4 Amount of variance in mathematics achievement explained by the model, standardized regression coefficients of schools' material resources, environment, composition, and climate

Education system	Number of students (*n*)	Variance (R^2) explained by model	Standardized regression coefficients							
			Index of School Material Resources for Mathematics		School location in urban area	School composition		Teaching somewhat or very limited by student needs	Safety and order at school	Student bullying at school
			Some resources	Many resources		Neither disadvantaged nor affluent	More affluent			
Albania	3547	0.10	**0.14** (0.04)	0.11 (0.04)	0.04 (0.05)	0.00 (0.05)	**0.19** (0.05)	0.09 (0.05)	−0.07 (0.04)	**0.11** (0.05)
Bosnia & Herzegovina	5007	0.02	0.01 (0.05)	0.06 (0.05)	0.06 (0.03)	0.00 (0.04)	0.06 (0.04)	0.08 (0.04)	0.02 (0.04)	0.05 (0.03)
Croatia	3675	0.02	0.10 (0.07)	0.09 (0.07)	0.10 (0.04)	0.06 (0.05)	**0.10** (0.05)	0.00 (0.04)	−0.02 (0.04)	0.05 (0.05)
Kosovo[a]	2710	0.07	0.05 (0.04)		0.14 (0.04)	0.07 (0.06)	**0.15** (0.06)	0.10 (0.06)	−0.07 (0.05)	**0.17** (0.05)
Montenegro	4399	0.02	−0.03 (0.02)	0.03 (0.02)	0.01 (0.02)	0.04 (0.03)	**0.10** (0.03)	0.10 (0.02)	−0.03 (0.02)	**0.07** (0.02)
North Macedonia	2871	0.11	0.01 (0.10)	−0.02 (0.10)	0.15 (0.05)	0.04 (0.05)	**0.19** (0.07)	0.09 (0.06)	0.04 (0.05)	**0.15** (0.05)
Serbia[a]	4217	0.06	0.05 (0.07)	0.08 (0.07)	0.18 (0.03)	0.03 (0.05)	0.10 (0.04)	0.05 (0.04)	−0.08 (0.04)	0.07 (0.05)

Notes Statistically significant ($p < 0.05$) coefficients are shown in bold. Blank cells indicate there was insufficient data to report achievement. Standard errors appear in parentheses. R^2 = the proportion of variance in the outcome variable that is explained by the set of predictor variables
[a]National defined population covers 90–95% of the national target population

Table 5 Amount of variance in science achievement explained by the model, standardized regression coefficients of schools' material resources, environment, composition, and climate

Education system	Number of students (n)	Variance (R^2) explained by model	Standardized regression coefficients							
			Index of School Material Resources for Science		School location in urban area	School composition		Teaching somewhat or very limited by student needs	Safety and order at school	Student bullying at school
			Some resources	Many resources		Neither disadvantaged nor affluent	More affluent			
Albania	3547	0.11	**0.13** (0.04)	0.19 (0.04)	0.02 (0.05)	0.02 (0.05)	**0.18** (0.05)	0.08 (0.05)	−0.09 (0.04)	0.09 (0.06)
Bosnia & Herzegovina	5007	0.02	0.05 (0.05)	0.09 (0.05)	0.06 (0.03)	0.03 (0.04)	0.05 (0.04)	0.07 (0.04)	0.03 (0.04)	0.02 (0.03)
Croatia	3675	0.02	0.05 (0.07)	0.05 (0.07)	0.11 (0.04)	0.07 (0.05)	**0.10** (0.05)	0.00 (0.03)	−0.01 (0.03)	0.05 (0.04)
Kosovo[a]	2710	0.09	0.04 (0.05)	−0.04 (0.06)	0.20 (0.04)	0.07 (0.06)	**0.15** (0.06)	0.10 (0.06)	−0.06 (0.05)	**0.20** (0.05)
Montenegro	4399	0.03	−0.03 (0.03)	0.02 (0.03)	0.03 (0.02)	0.05 (0.03)	**0.11** (0.03)	0.10 (0.02)	−0.05 (0.02)	**0.09** (0.02)
North Macedonia	2871	0.12	−0.01 (0.12)	−0.04 (0.11)	0.17 (0.05)	0.05 (0.06)	**0.21** (0.07)	0.09 (0.06)	0.04 (0.05)	**0.17** (0.06)
Serbia[a]	4217	0.06	0.05 (0.08)	0.04 (0.08)	0.18 (0.04)	0.05 (0.05)	0.13 (0.04)	0.05 (0.04)	−0.06 (0.04)	0.09 (0.05)

Notes Statistically significant ($p < 0.05$) coefficients are shown in bold. Standard errors appear in parentheses. R^2 = the proportion of variance in the outcome variable that is explained by the set of predictor variables

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

(Mullis et al., 2020). Regarding some elements of school climate, higher average achievement in mathematics and science, at both grade four and grade eight, was associated with students having a greater sense of school belonging and experiencing little or no bullying. At the system level, the results of PISA 2018 for 15-year-olds also indicated "that instruction hindered by a lack of educational materials was associated with lower reading scores in all participating countries and economies. School systems that showed more equity in the allocation of material resources tended to score higher in reading" (OECD, 2020, p. 196).

We found that the amount of material resources in schools was related to grade four students' mathematics and science achievement in four of the Dinaric participants (Albania, North Macedonia, and Serbia), and related only to their mathematics achievement in Croatia. We found that schools with more students coming from affluent backgrounds tended to have the highest achievement in every participating system except Kosovo. Other research found that that there was a stronger emphasis on academic success in schools that are better equipped (see chapter "Characteristics of Principals and Schools in the Dinaric Region"). According to their teachers' perceptions, almost all students in Albania to about half of the students in Croatia were taught in very safe and orderly schools. There was not a high prevalence of bullying in the Dinaric region, although around a third of students in Croatia and North Macedonia reported that they were bullied monthly or weekly; this is a worrying level of bullying, and educational professionals in the region should devote more attention to finding solutions to tackle this issue.

Although many education systems in the Dinaric region still have much to improve in terms of equipping schools with better material resources, our study highlights the importance of effective practice, and developing a supportive school climate and culture of achievement. "Ensuring that all schools have adequate and high-quality material resources, and the appropriate support, is key if students from all backgrounds are to be given equal opportunities to learn and succeed at school" (OECD, 2020, p. 16). As the definition of school material resources has broadened to include ICT skills and the associated digital tools and resources, school systems face a whole new level of procurement.

Our study has confirmed that, beside the physical environment and material resources that support learning in schools, there are additional, less tangible dimensions of school life, which are equally important for the successful achievement of educational goals. The most important task of educational systems and school authorities is still to set and maintain both material factors (resources) and social factors of school functioning (such as safety, order, support, and emphasis on achievement goals), and often the core aim is to improve student achievement. But, ideally, schools should provide equal opportunities for students that come from challenging or deprived environments; it is important that schools are not just buildings but also active catalysts of change through learning processes. Theory and ILSA results suggest that a good physical environment and sufficient material resources, together with supportive teachers, the existence of peer practices (for teachers and students), innovative methods, an open climate for discussion, and willingness to cooperate with parents and/or the wider community, establishes a productive setting for better learning outcomes. Where schools do not have a shortage of material resources (such as space, equipment, or staffing), a critical factor for success is supporting healthy social relationships and fostering an open school climate, providing a school environment free from bullying and other stress factors. Our analyses showed that school-level variables only explained low levels of variance across the Dinaric region; consequently we conclude that home resources, the sociocultural capital of parents/guardians, and their willingness to participate in their child's schooling must play a major role in student achievement, together with students' attitudes toward the subject matter and their schools. While upgrading the material aspects of the educational environment is something that schools can influence and work hard on improving, good results can also be obtained by creating strong and healthy teaching and learning communities.

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Teachers, Teaching and Student Achievement

Ivana Đerić, Ines Elezović, and Falk Brese

Abstract Education policymakers, researchers, and practitioners around the world have dedicated considerable attention to teachers and their instructional practice in their efforts to improve student outcomes. The professional characteristics of teachers and their classroom behaviors may be important in determining how students acquire knowledge and develop skills in mathematics and science, and the relationships between teacher quality, instructional practice, and grade four student outcomes are consequently of great interest to researchers and policymakers. Analysis of IEA's Trends in International Mathematics and Science Study (TIMSS) data indicates that grade four students are taught by teachers with similar educational backgrounds across the Dinaric region. Teacher quality (as measured by experience, level of education, and professional development) was related only to some aspects of instructional practice in the Dinaric region. Teacher quality was not a statistically significant predictor for student achievement in mathematics and science, although teachers' formal education and years of experience were related to some aspects of student achievement.

Keywords Instructional practice · Student achievement · Teacher quality · Trends in International Mathematics and Science Study (TIMSS)

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1 Introduction

Educators and researchers have consistently recognized and empirically shown that teachers and their classroom behaviors contribute more to student achievement than other systemic factors in education (Creemers & Kyriakides, 2008). Many countries have increased the educational requirements for class teachers in primary education to improve the quality of teaching and thereby student achievement in mathematics and science. Traditionally, formal education and experience are used as the principal measures of teacher quality (Burroughs & Chudgar, 2017). Formal teaching qualifications may also include participation in continuous professional development (PD) (Nilsen et al., 2018). Goe (2007) defined teacher quality as a combination of teachers' backgrounds (teacher qualifications and teacher characteristics), a process measure (teacher practices), and an outcome measure (teacher effectiveness). Some characteristics of teachers' classroom behavior were ambiguous in terms of their relevance for student achievement in mathematics and science across education systems (Blömeke et al., 2016; Nilsen et al., 2018; OECD [Organisation for Economic Cooperation and Development], 2020); however, these studies also claimed that the professional knowledge and skills of teachers had equally important effects on student achievement, regardless of the specific characteristics of education systems, teaching practices, and student behavior in different settings. For example, cognitive activation, supportive classroom interactions, and classroom management have a positive effect on students' achievement in mathematics and science (Decristan et al., 2016).

In short, the importance of teacher characteristics, instructional practice, and their relation to student achievement is evident from the literature. In this chapter, we examine the status of the teaching profession, initial education, and professional development, describing the similarities and differences across the education systems in the Dinaric region. Our regional analyses of IEA's Trends in International Mathematics and Science Study (TIMSS) 2019 provide in depth information about the relationships between the quality of teachers, instructional practice in participating classes, and grade four student outcomes on the TIMSS test. This supplies an evidence base for future investigation into the effectiveness of the strategies for improvement suggested by this research. Seven participants from the Dinaric region took part in TIMSS 2019, namely Albania, Bosnia and Herzegovina, Croatia, Kosovo,[1] Montenegro, North Macedonia, and Serbia.

2 Teachers and the Teaching Profession in the Dinaric Region

Teachers who work in primary schools (e.g., at grades one to four) are called class teachers in all education systems in the Dinaric region. The classes are taught by

[1] All references to Kosovo in this document should be understood to be in the context of United Security Council resolution 1244 (1999).

one teacher, except in specific cases, when some subjects may be taught by specialized subject teacher (e.g., English language). In the majority of TIMSS classes in the Dinaric region, class instruction is delivered in official languages and/or the languages of national minorities; the region is ethnically and culturally diverse. Most teachers of lower grades in primary school acquire their degree from teacher training faculties (state and/or private) across the Dinaric region. These faculties are oriented towards pedagogical, methodical, and didactical studies into subjects taught in primary education. In Albania, Croatia, Kosovo, and Serbia, a master's level qualification (ISCED [International Standard Classification of Education] 7; see UNESCO [United Nations Educational, Scientific and Cultural Organization] Institute of Statistics, 2012 for an explanation of the ISCED classifications) is the minimum level of initial teacher education required for employment in primary schools. In Bosnia and Herzegovina, Montenegro, and North Macedonia, a bachelor level qualification (ISCED 6) is required for teachers of grade four students. After completing their academic studies, to gain employment as a teacher, candidate teachers must also pass a state examination for teacher certification (except in Bosnia and Herzegovina). In most education systems in the Dinaric region, young teachers enter an initiation program at the beginning of their careers to introduce them to the teaching profession. Professional orientation is provided through different types of mentoring by more experienced teachers. All education systems in the region have an induction period, which varies slightly in duration and ranges from a minimum of six months to, more commonly, a full year of probation before a teacher can be fully registered as a professional (Pantić et al., 2011).

Teachers from the Dinaric region have an obligation to develop professionally during their careers by attending state-organized training courses. The state agencies and institutes have the leading role in creating professional development policies and in their implementation. While some education systems in the Dinaric region have mechanisms in place to accredit providers and programs, others are struggling to implement a coherent system (e.g., Bosnia and Herzegovina). Across the region, training programs are provided by public, scientific, and professional associations and/or private institutions. Most teachers from the region choose the programs they wish to attend from a list of accredited training programs approved by the state agencies.

There are between-systems differences in the amount of time teachers need to dedicate to PD across the Dinaric region. Croatian teachers are obliged to participate in PD programs in accordance with a proscribed number of hours at the state, county, and school level (Elezović & Muraja, 2020; Viorel, 2017). Teachers from Kosovo, depending on career development paths, and on the criteria and conditions for licensing by the type of license, must ensure that they have the number of required hours of PD (Mehmeti et al., 2019). Teachers in North Macedonia are expected to log at least 60 h of PD over three years (OECD, 2019a), while teachers from Albania must undertake at least three days training per year (Vrapi & Alia, 2020). Serbian teachers are required to undertake 64 h of various PD activities annually. A required number of teacher PD training hours is not stipulated at the state level in Bosnia and

Herzegovina or Montenegro (Duda et al., 2013; Popić & Džumhur, 2020). Nevertheless, policymakers and school leaders need to ensure that PD opportunities are available for all teachers across the region.

High-quality PD activities are recognized as crucial if education systems are to ensure that all teachers possess and maintain the relevant competencies to be effective in modern classrooms (Viorel, 2017). Several studies have shown that teachers in the Dinaric region face very similar challenges concerning PD. Firstly, PD programs in the Dinaric area are usually designed as one-off seminars and courses (Pantić et al., 2011). In Bosna and Herzegovina, Kosovo, Montenegro, and North Macedonia, teachers and researchers have expressed concern both about the quality and the availability of training courses (Mehmeti et al., 2019; Mićanović & Vučković, 2014; OECD, 2019a). In Serbia, seminars are still often fragmentary, unrelated to teaching practice, insufficiently intensive, and lack the necessary follow-up and support, according to educational experts, school principals, school counselors, and experts in pedagogy and psychology (Đerić et al., 2014). Likewise, educational authorities have observed that teacher training in Bosnia and Herzegovina is outdated, does not follow current education trends, and does not support the progress of teachers (Popić & Džumhur, 2020). By contrast, the OECD's Teaching and Learning International Survey (TALIS) 2018 found that a very high percentage of Croatian teachers (86%) reported that the PD activities that they attended had a positive impact on their teaching practice (OECD, 2019b). However, for most teachers across the Dinaric region, the budget devoted to PD is insufficient to access opportunities to become involved in PD activities (OECD, 2009; Viorel, 2017). For teachers across the region, which teacher competencies should be developed, which professional knowledge should be offered to teachers within PD training, how much time needs to be dedicated to PD, and how PD activities can be organized efficiently remain open questions.

Teachers who participated in OECD's Programme for International Student Assessment (PISA) 2018 from the Dinaric region education systems "rely heavily on traditional pedagogy, such as lecturing to students and encouraging them to memorize information set out in the curriculum" (OECD, 2020, p. 65). This last report showed that pedagogical methods in the region (as perceived by students) were still largely traditional and associated with lower student performance. Prior to TIMSS 2019, little data had been gathered on the quality of instructional practice in the primary grades of elementary school across the Dinaric region. In addition, there was a lack of comprehensive and joint research on the quality of instructional practices in the Dinaric region, especially for mathematics and science in lower grades. Our analyses of the TIMSS 2019 data examines the relationship between quality of teachers, instructional practice in classrooms, and grade four students' achievement.

3 Methods and Research Questions

Over time, an extensive literature has been developed on teacher quality, instructional quality, and students' outcomes based on international data (e.g., Đerić et al., 2017;

Nilsen & Gustafsson, 2016). Several education systems from the Dinaric region did not participate in previous TIMSS assessments of students in mathematics and science at grade four (e.g., Bosnia and Herzegovina, Kosovo, Montenegro, and North Macedonia). Added to this, there are not many regional or national studies examining the relations between teacher quality, instructional practice, and outcomes for representative samples of grade four students in the Dinaric region. Our interest is in describing the "teachers' profile" for the sampled TIMSS 2019 grade four classrooms in the Dinaric region and examining whether, and to what extent, teacher quality and instructional practice contribute to grade four student achievement in mathematics and science. We look in depth at: (1) teacher quality; (2) instructional practice; (3) the relationship between teacher quality and instructional practice; and (4) instructional practice as a factor related to student achievement in mathematics and science.

For our analyses, we focused on three research questions:

(1) What are the similarities and differences, in terms of teacher quality and instructional practices, across the different education systems of the Dinaric region?
(2) Is teacher quality related to aspects of instructional practice across the Dinaric region?
(3) Does the instructional practice of teachers contribute to student achievement when controlling for teacher quality? If so, does student achievement in mathematics and science depend on the relationship between teacher quality and instructional practice?

3.1 Sample and Data Sources

Teachers who complete TIMSS questionnaires represent the teachers of a national sample of students (Martin et al., 2020). We used the data obtained from teacher questionnaires in conjunction with achievement test data measuring students' mathematics and science outcomes. Instruments were administered in both the official language and minority languages of the respective education systems in the Dinaric region (except in Serbia, where materials were administrated only in the official language). Teachers' data are interpreted by the percentage of students who are taught by teachers with a specific characteristic. More general information about the analysis methods, sample characteristics, and data sources that we used are available in Sects. 5 and 5.1.

3.2 Variables and Measures

We identified several variables and scales in the TIMSS 2019 international reports as being of potential interest for our research (Table 1, see also Table S.11 in the supplementary materials at www.iea.nl/publications/RfEVol13).

Table 1 List of the variables and scales used in analyses

Variables	Description	Values/Response options	References
Teacher's years of experience	Years of experience as a teacher altogether	Number (years)	Fishbein et al. (2021, Supplement 3, p. 71)
Teacher education	Teacher's highest level of formal education completed	Recoded from seven to three categories (1) Did not complete Bachelor's or equivalent level (2) Bachelor's or equivalent level (3) Completed postgraduate degree	Fishbein et al. (2021, Supplement 3, p. 71)
Mathematics/science teachers' major subject of study	Combination of teachers' reports on major area of study and specialization	There were three categories: (1) Major in primary education and mathematics (2) Major in primary education but not in mathematics (3) Others	Fishbein et al. (2021, Supplement 3, p. 71)
Professional development teaching mathematics/science	Numbers of hours teachers devoted to professional development in teaching mathematics/science in the past two years (recoded from five to three categories)	(1) 16 h and more (2) 6–15 h (3) Less than 6 h	Fishbein et al. (2021, Supplement 3, pp. 80 and 86)
Professional development needs in teaching mathematics/science	Teachers indication of needs for professional development in teaching mathematics (seven areas) or teaching science (eight areas)	There were two response options per item: (1) Yes (2) No	Fishbein et al. (2021, Supplement 3, pp. 80 and 86)
Instructional time for teaching mathematics/science	Teacher reports on the time spent on teaching mathematics/science to the TIMSS class in a typical week	Number (minutes)	Fishbein et al. (2021, Supplement 3, pp. 76 and 81)
Instructional practice in mathematics	Teachers reports on frequency of asking students to apply what they have learned to new problem situations on their own every or almost every lesson	Index with four categories: (1) Every or almost every lesson (2) About half of the lessons (3) Some lessons (4) Never	Fishbein et al. (2021, Supplement 3, p. 76)

(continued)

Teacher Quality

A set of questions in the TIMSS grade four teacher questionnaire (TIMSS & PIRLS International Study Center, 2018) asked teachers about their educational background: namely, their formal education, specialization, experience, the number of hours they

Table 1 (continued)

Variables	Description	Values/Response options	References
Instructional practice in science	Teachers reports on frequency of asking students to use evidence from experiments or investigations to support conclusions	Index with four categories: (1) Every or almost every lesson (2) About half of the lessons (3) Some lessons (4) Never	Fishbein et al. (2021, Supplement 3, p. 81)

had devoted to PD in teaching mathematics and science, and whether they had participated in PD during the last two years.

Instructional Practice

Teachers were asked to report how often they performed various activities in the TIMSS sampled mathematics and science classes they were teaching to ("In teaching mathematics/science to this class, how often do you ask students to do the following?"). Our measure of instructional practice is based on their responses to two of the items: namely, how often they asked students in their teaching to "apply what they have learned to new problem situations on their own" during mathematics lessons, and "use evidence from experiments or investigations to support conclusions" during science lessons.

Student Outcomes

Student outcomes include both mathematical achievement and science achievement in the TIMSS 2019 test. Mathematical and science achievement are represented by five plausible values representing student achievement and all five plausible values were used in our analyses.

4 Results and Discussion

4.1 Teacher Quality in the Dinaric Region

The educational background of mathematics and science teachers was similar across the Dinaric region. Most grade four students had teachers that possessed a bachelor's degree or an equivalent qualification (ISCED level 6), but not a postgraduate degree. Teachers from Albania and Croatia had the highest levels of education; more than half of them had some kind of postgraduate university degree (M.A., Ph.D., or other postgraduate qualification). For most teachers from the Dinaric region, this level of formal education is in line with the policy recommendations and requirements of the European Union (EU) (Table 2). Several large-scale studies suggest that, while teachers in many education systems are well educated (Mullis et al., 2020; Schleicher,

Table 2 Average number of years of experience as a teacher and percentage of students by level of their mathematics and science teachers' formal education

Education system	Subject	Average number of years of teaching experience		Teachers' level of formal education (% of students)*					
				Did not complete bachelor's degree		Completed bachelor's degree or equivalent but not a postgraduate degree		Completed postgraduate university degree	
Albania	Mat	22	(0.9)	22	(4.2)	19	(3.4)	59	(5.0)
	Sci	22	(0.9)	20	(4.1)	19	(3.4)	61	(4.9)
Bosnia & Herzegovina	Mat/Sci	18	(0.5)	29	(3.4)	67	(3.3)	4	(1.1)
Croatia	Mat/Sci	22	(0.7)	37	(2.7)	13	(2.5)	50	(3.4)
Kosovo[a]	Mat/Sci	16	(1.1)	16	(3.1)	77	(3.5)	8	(2.1)
Montenegro	Mat/Sci	20	(0.6)	22	(2.7)	75	(2.9)	3	(1.0)
North Macedonia	Mat/Sci	19	(1.0)	18	(3.0)	76	(3.5)	6	(2.9)
Serbia[a]	Mat/Sci	24	(0.7)	24	(3.4)	62	(3.8)	15	(2.5)

Notes Standard errors appear in parentheses. In Albania, teachers could be separated by subject: Mat = mathematics teachers, Sci = science teachers, but in other systems this was not possible

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

*Numbers reflect different classification/recognition of levels of teacher's formal education achieved by older teachers before Bologna reform of Tertiary education across the region (Duda, Golubeva &; Clifford-Amos, 2013; Protner, 2020)

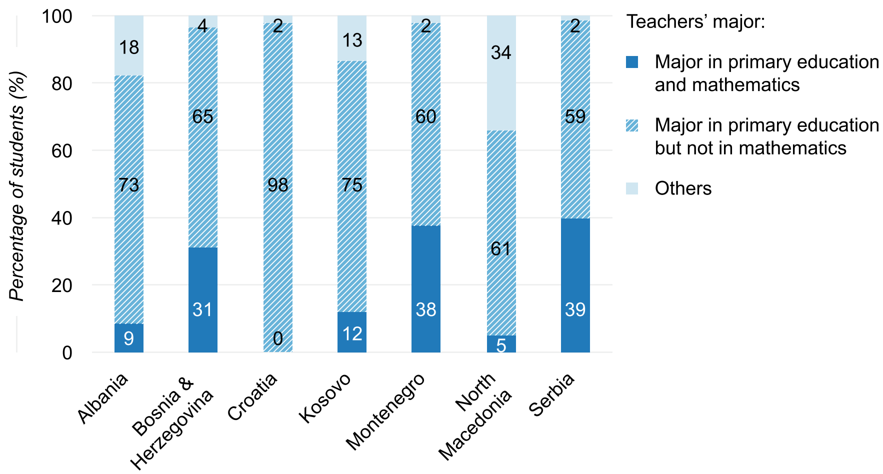

Fig. 1 Percentage of students taught by teachers whose major subject of study was mathematics. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

2020), there is still a notable percentage of teachers around the world that possess low levels of formal education.

Most students in the Dinaric region had teachers who, on average, were slightly more experienced (Table 2) than their colleagues in the other education systems that participated in TIMSS 2019. Teachers from Bosnia and Herzegovina, Kosovo, and North Macedonia, on average, had less than 20 year of teaching experience, which was closer to the international average (mean = 17 years; Mullis et al., 2020). Serbian grade four students had most experienced teachers in the region.

Teachers were also asked what their major or main area(s) of study were during their academic education. For most teachers, the focus of their academic education was teaching primary education, without any specialization in mathematics and science (Figs. 1 and 2); this finding is consistent with the pedagogical orientation of teacher training faculties across the Dinaric region. Most students had teachers whose major subject of study was teaching in elementary schools/primary education. Only very few students (<10%) were taught by teachers who studied for a degree in mathematics or science or another academic subject. The PISA 2018 report found no relationship between teacher qualifications and student outcomes in the Western Balkans (OECD, 2020). While a recent study showed that teacher specialization could be linked to effective teaching practices and student achievement of grade four students in Sweden (Johansson & Myberg, 2019), initial teacher education is often insufficient to prepare primary and secondary teachers for their challenging jobs. Highly qualified teachers must possess full state certification, a master's degree, and demonstrate subject matter competency in each of the academic subjects they teach. Teachers also need high quality PD activities to develop relevant competencies to be effective in modern classroom conditions (OECD, 2020; Viorel, 2017).

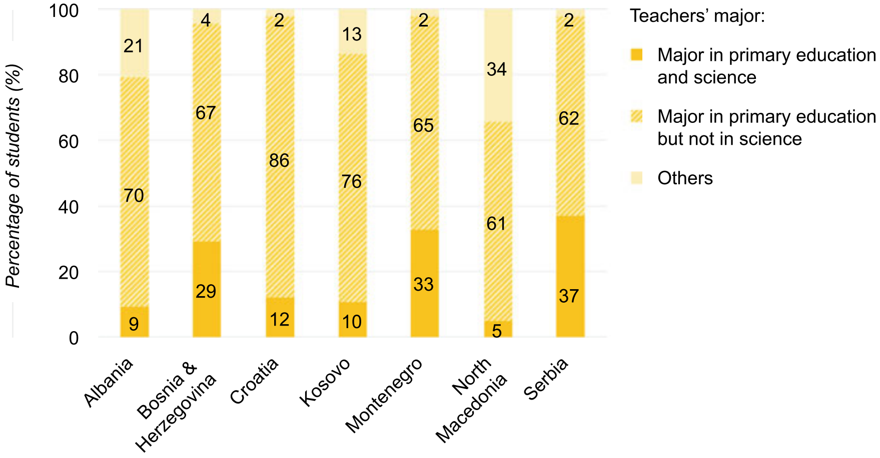

Fig. 2 Percentage of students taught by teachers whose major subject of study was a science. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

As part of the TIMSS 2019 teacher questionnaire, teachers in the Dinaric region reported how many hours they had spent undertaking formal PD activities (such as workshops and seminars) related to teaching mathematics and science over the last two years. We divided the data collected into the following three categories: (1) 16 h and more; (2) 6–15 h; and (3) less than six hours. In general, the level of PD across the region was low (Figs. 3 and 4).

Overall, Dinaric grade four students were taught by class teachers that spent more time on PD activities that were related to teaching mathematics than teaching science, although the difference was not prominent (except for Albania and Montenegro). Almost 40% of the students from Kosovo had teachers who devoted 16 h or more PD to teaching mathematics, which is significantly higher level than was reported by teachers from other education systems in the Dinaric region. Alarmingly, more than half the students from Bosnia and Herzegovina (85%), Croatia (65%), North Macedonia (61%), and Albania (54%) were taught by teachers who reported dedicating less than six hours to PD in mathematics over the previous two years. The figures reported for teacher PD related to teaching science were even lower than those for mathematics. A large percentage of grade four students from Bosnia and Herzegovina (81%) and North Macedonia (76%) have teachers who dedicated less than six hours to PD in science. The largest percentage of grade four students (23%) whose teachers reported spending 16 h or more on PD in science was in Kosovo.

Teachers of the grade four students in the Dinaric region spent more time on PD for mathematics than for science teaching, but there was also wide variation among teachers across the region in terms of overall time invested in PD. Teachers from Kosovo reported investing the greatest amount of time on PD in mathematics and science, while teachers from Bosnia and Herzegovina, Croatia, and North Macedonia

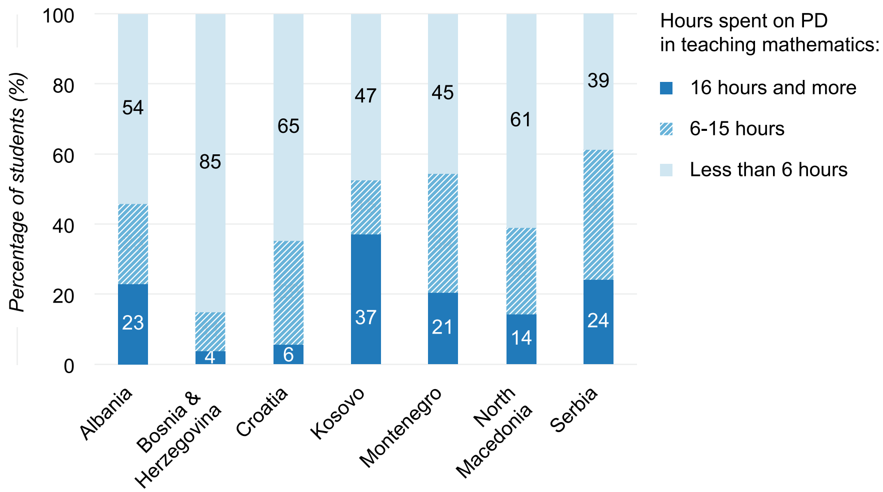

Fig. 3 Percentage of students taught versus number of hours their teachers devoted to professional development in teaching mathematics over the previous two years. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

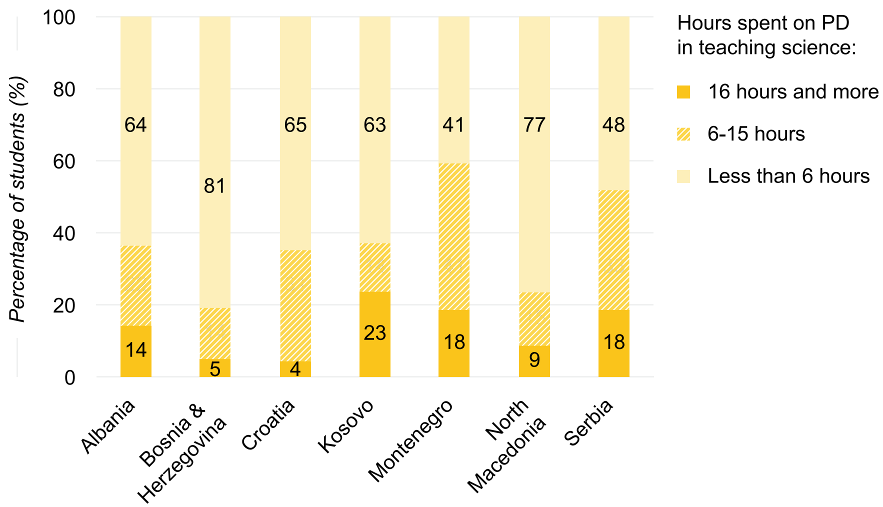

Fig. 4 Percentage of students taught versus number of hours their teachers devoted to professional development in teaching science over the previous two years. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

reported little time was invested on PD. Recent study shows that long-term PD programs are more effective, both in terms of the overall amount of time that the activity takes, and the total amount of hours spent (Barrera-Pedemonte, 2016).

Teachers were further asked if they had participated in content-specific (but not necessarily formal) PD activities over the previous two years. The question included the following categories of answers for both subject areas: (1) content; (2) pedagogy/instruction; (3) curriculum; (4) integrating technology into instructions: (5) improving students' critical thinking or problem-solving skills; (6) assessments; (7) addressing individual students' needs; and (8) addressing students' language needs in learning mathematics or science. However, grade four teachers across the whole region stated that the most pressing future need in the field of mathematics and science PD was integrating technology into instruction (Tables 3 and 4). This is in line with the development and application of technologies to other areas of society, and growing interest in teaching children and youth how to use ICT at school and in everyday life (IEA, 2021).

Many teachers across the region noted a need for PD in addressing individual student needs and improving students' critical thinking and problem-solving skills (Tables 3 and 4). Their interest in these themes indicates that teachers of grade four students are aware of the generic competencies they should focus on developing in their students. We can postulate that a desire for support to help them develop skills in innovative teaching methods is seen as a way to improve teaching efficiency and enhance students' results. Analysis of the TIMSS data across many education systems supports the conclusion that students of teachers at grade four who improved their professional knowledge of mathematics content through undertaking PD activities tend to have higher achievement scores than other students (Liang et al., 2015).

4.2 Instructional Practice in the Dinaric Region

There was large reported variation in the time devoted to mathematics and science instruction among the education systems in the Dinaric region (see also chapter "Opportunity to Learn Mathematics and Science"). On average, grade four students from Kosovo and Serbia received significantly more hours of mathematics teaching per week than other students in the region (Fig. 5). The time spent on science lessons showed even greater variation, ranging from an average time of 92 min per week in Albania to 137 min per week in Croatia.

According to the TIMSS 2019 data, the amount of instructional time that students spent in classrooms per week varied widely by subject in the Dinaric region (Fig. 5). In four of the education systems (Albania, Kosovo, Montenegro, and Serbia) grade four students spent at least twice as much time on mathematics compared to science. Across the region, students from Serbia (245 min per week) and Kosovo (240 min per week) spent the greatest amount of time on learning mathematics, while students from Croatia devoted the greatest amount of time to learning science (137 min per week). Recent research has shown that the amount of time that students spend on

Table 3 Percentages of students whose teachers indicated various needs for future professional development related to teaching mathematics

Education system	Percentage of students (%) whose teachers indicated a need for professional development related to													
	Content		Pedagogy/Instruction		Curriculum		Integrating technology in instruction		Improving students' critical thinking skills		Assessment		Addressing individual student's needs	
Albania	53	(3.7)	65	(3.2)	57	(3.9)	78	(3.3)	60	(4.2)	52	(4.2)	59	(4.3)
Bosnia & Herzegovina	29	(3.1)	30	(3.0)	28	(2.8)	72	(3.5)	63	(3.4)	36	(3.4)	54	(3.6)
Croatia	63	(3.3)	59	(3.6)	58	(3.5)	90	(2.7)	87	(2.6)	77	(3.3)	83	(2.7)
Kosovo[a]	74	(5.3)	74	(5.0)	84	(3.0)	84	(3.6)	83	(3.6)	83	(3.6)	80	(3.5)
Montenegro	50	(2.4)	49	(2.1)	57	(2.8)	81	(2.4)	66	(2.5)	50	(2.8)	63	(2.7)
North Macedonia	42	(4.4)	43	(4.4)	43	(4.8)	63	(4.2)	54	(4.4)	42	(4.4)	55	(3.8)
Serbia[a]	24	(3.3)	30	(3.5)	27	(3.5)	64	(4.0)	56	(4.2)	36	(4.0)	49	(3.6)

Notes Standard errors appear in parentheses
[a]National defined population covers 90–95% of the national target population

Table 4 Percentages of students whose teachers indicated various needs for future professional development related to teaching science

Education system	Percentage of students (%) whose teachers indicated a need for professional development related to															
	Content		Pedagogy/Instruction		Curriculum		Integrating technology in instruction		Improving students' critical thinking skills		Assessment		Addressing individual student's needs		Integrating science with other subjects	
Albania	55	(4.1)	60	(4.1)	59	(4.2)	75	(3.8)	66	(4.4)	53	(4.7)	63	(4.3)	67	(4.1)
Bosnia & Herzegovina	34	(3.3)	34	(3.0)	31	(3.0)	73	(3.6)	60	(3.5)	31	(3.1)	50	(3.5)	61	(3.9)
Croatia	71	(2.6)	61	(3.5)	58	(3.4)	88	(2.6)	85	(2.8)	79	(2.8)	80	(2.7)	79	(3.1)
Kosovo[a]	80	(3.7)	77	(4.2)	84	(4.0)	88	(3.0)	84	(3.5)	82	(3.7)	87	(2.9)	86	(3.3)
Montenegro	59	(2.8)	56	(2.8)	59	(2.4)	81	(2.3)	66	(2.3)	50	(2.6)	65	(2.6)	63	(3.1)
North Macedonia	45	(4.2)	47	(4.3)	43	(4.7)	60	(4.2)	64	(4.3)	48	(4.7)	52	(4.5)	53	(4.7)
Serbia[a]	30	(3.5)	38	(4.0)	32	(2.8)	61	(3.9)	54	(4.4)	36	(3.3)	44	(3.5)	54	(4.3)

Notes Standard errors appear in parentheses
[a]National defined population covers 90–95% of the national target population

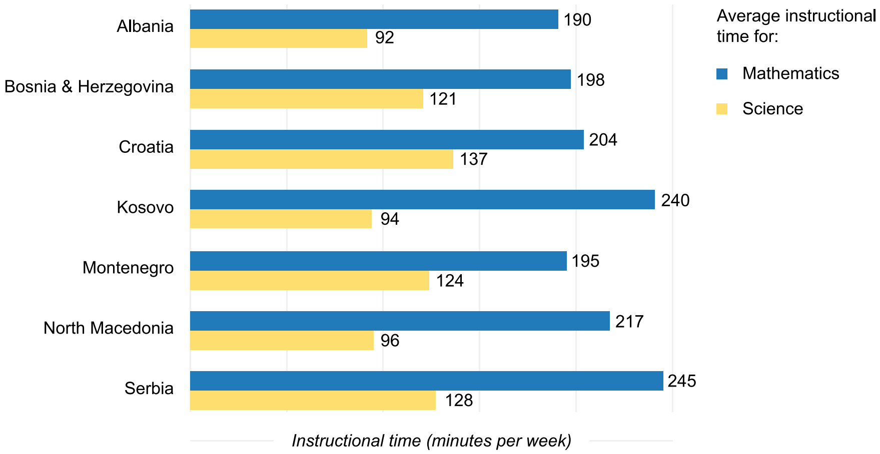

Fig. 5 Average instructional time spent on teaching mathematics and science per week (minutes) *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

learning mathematics and science on weekly basis in Eastern European education systems is significantly related to student achievement (Lavy, 2015). Some authors have suggested that, based on extended analysis of international data, "differences in instruction time play a less important role than previously thought for explaining international gaps in student achievement" (Bietenbeck & Collins, 2020, p. 9); however, this divergence among international studies may be partly due to the differing criteria used to measure instruction time in the international data.

Teachers in different education systems have different teaching styles, shaped by beliefs and attitudes about teaching, and what they have learned during their initial teacher preparation programs and during subsequent PD. To better understand those different teaching styles, and investigate which styles were more successful, the TIMSS 2019 teacher questionnaire asked about specific activities that teachers undertook during their mathematics and science lessons (Tables S.12 and S.13 provide more detailed results for both mathematics and science, respectively; see supplementary materials at www.iea.nl/publications/RfEVol13). A very high percentage of grade four students (>80%) had teachers who stated that in almost half of the mathematics lessons, students listened while teachers explained new content in mathematics or demonstrated new ways of problem solving or just memorizing rules, procedures, and facts. More than 90% of students across the whole region were asked by their teachers in at least half of their mathematics lessons to practice procedures on their own and apply what they have learned to new problem situations, except in Albania and Kosovo, where this percentage was drastically lower. In all participating education systems, working in mixed ability groups was more common than working in groups with similar abilities for both mathematics and science lessons. In science classes, the most common instruction activities that grade four teachers from the region applied were explaining new content to the students, reading textbooks and other sources, and memorizing facts and principles. Observing and describing natural phenomena, such as weather or plant growth, was also frequently done. Teachers were less likely to ask students to work more independently and creatively, or to work on activities requiring higher order cognitive skills. Examples of such activities include designing and conducting experiments, presenting, and interpreting results and using them to draw conclusions. It is noticeable that, according to the teachers' reports, students in Albania and North Macedonia engaged in such activities more often than other students in the Dinaric region.

In teaching mathematics and science in the Dinaric region, the instructional methods of problem-solving, research, and experimental teaching methods were not sufficiently represented. Our results can be compared with a previous analysis of TIMSS 2015 data for teaching practices in Serbia, Croatia, and Hungary (Đerić et al., 2017). TIMSS 2019 results showed that most students of the teachers in the region implemented procedures that were more teacher-centered, while students played largely passive roles during mathematics and science classes. For example, the data indicate that students of science listened to teachers explain concepts, read lessons from the textbooks, and they remembered the facts and principles (Mullis et al., 2020). These instructional practices are very important when building the basic knowledge of younger students, especially in the fields of mathematics and science. Nevertheless, it was relatively rare for teachers to use innovative teaching practices, such as asking their students to plan and conduct experiments or work in the field and outside the classroom; this reinforces earlier TIMSS findings in Serbia (Mirkov & Lalić Vučetić, 2018), as well as in other education systems in the region (Martin et al., 2016; Mullis et al., 2016, 2020).

PISA 2018 also found that teachers in this region were using less adaptive instruction and more teacher-directed instruction (OECD, 2020). Teachers may choose more traditional roles and procedures, believing that these are effective ways of working with grade four students, or they may lack the confidence (either in themselves or their students) to apply more innovative methods. But, with appropriate support, students of this age can be effectively engaged in investigation, gathering and analyzing data, and in drawing conclusions based on evidence (Đerić et al., 2017, 2020; Mullis et al., 2020).

Students participating in TIMSS 2019 reported that they know what their teachers expect from them, that the teachers explain contents clearly, and that teachers answer their questions and provide help and support in learning. Compared to their peers across the region, students from Croatia and Serbia were less likely to agree that their teachers applied these instructional practices in mathematics and science classes (Mullis et al., 2020). It seems that students in the Dinaric region generally perceive traditional forms of teaching and learning as engaging. Fauth et al. (2014) stressed that it was necessary to be cautious when interpreting such data because, with students of this age, the overall popularity of the teacher affects the student's evaluation of the quality of their classes.

4.3 Relationship Between Teacher Quality and Instructional Practice in the Dinaric Region

Recent evidence from international studies has suggested that teacher quality is significantly related to instructional quality (Blömeke et al., 2016). To establish whether teacher quality was related to instructional practice across the Dinaric region, we investigated the quality of teachers as a construct expressed by the length of their teaching experience, level of formal education, and time dedicated to PD (more than 15 hours), and examined the relationship of this construct with instructional practice of teachers for both mathematics and science. However, we found that there was no consistent relationship between teacher quality and instructional quality across the Dinaric region; teacher quality indicators were related to only a few aspects of instructional practice or not at all. In some cases, teachers who were more experienced and better educated, and those who spent more time on PD activities, appeared to be more willing to use cognitive-activation strategies that require students to use higher levels of thinking (e.g., use evidence from experiments or investigations to support conclusions).

4.4 Instructional Practice as a Factor in Student Achievement in the Dinaric Region

To investigate whether the characteristics of teachers and classes can be used as predictors of student achievement in mathematics and science, we undertook multivariate linear regression analyses (see Chapter 1). Such multilinear modeling aims to answer whether the instructional practice of teachers is related to student achievement when teacher quality variables are controlled, and vice versa. Both mathematics and science models explained less than three percent of the variance in student achievement in mathematics and science; few predictors were significant, and their contributions were small (Tables 5 and 6). Thus, even if the factors related to professional characteristics of teachers and the quality of their teaching had shown to be significant predictors of achievement, they would only have explained a small amount of the achievement in mathematics and science.

Across the Dinaric region, we found that teacher quality measures were not statistically significantly predictors of student achievement in mathematics and science, although there were some exceptions where their level of formal education and years of the working experience had an effect (see Sect. 4.3). Our findings are consistent with other studies that noted "measurable" teacher characteristics explained only a small portion of the variance in student achievement (Đerić et al. 2017; Munoz and Chang 2007), and this creates a clear dilemma for policymakers. In general, this lack of variance in developed education systems contributes to the problems associated with observing an impact on learning outcomes. So, instead of focusing on identifying differences among teachers who have increasingly similar backgrounds, it is

Table 5 Amount of variance in students' mathematics achievement explained by the model, standardized regression coefficients for teacher quality and instructional practice

Education system	Number of students (n)	Variance (R^2) explained by model	Standardized regression coefficients											
			Number of years of experience (reference: 0–10 years)				Level of formal education (reference: did not complete bachelor's degree)				Undertook more than 15 h PD in teaching mathematics		Instructional time spent on mathematics (minutes per week)	
			11–20 years		> 20 years		Bachelor or equivalent		Postgraduate university degree					
Albania	3163	0.01	0.02	(0.07)	0.06	(0.06)	0.04	(0.05)	0.00	(0.06)	0.06	(0.06)	−0.07	(0.06)
Bosnia & Herzegovina	4559	0.02	0.04	(0.04)	0.05	(0.04)	0.06	(0.03)	**0.07**	(0.03)	0.01	(0.02)	**0.14**	(0.05)
Croatia	3712	0.01	0.01	(0.06)	−0.02	(0.06)	−0.04	(0.04)	−0.04	(0.04)	−0.02	(0.05)	**−0.09**	(0.04)
Kosovo[a]	3315	**0.03**	**0.14**	(0.04)	−0.02	(0.05)	−0.01	(0.05)	0.00	(0.06)	**0.07**	(0.03)	0.02	(0.05)
Montenegro	4067	0.00	0.02	(0.04)	0.00	(0.04)	0.06	(0.04)	0.04	(0.03)	0.02	(0.03)	0.01	(0.03)
North Macedonia	2652	0.03	−0.05	(0.08)	0.05	(0.08)	0.11	(0.07)	0.12	(0.07)	0.11	(0.07)	0.08	(0.06)
Serbia[a]	4221	0.01	0.03	(0.06)	0.07	(0.05)	0.11	(0.06)	0.04	(0.05)	0.02	(0.04)	−0.01	(0.03)

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

Table 6 Amount of variance in students' science achievement explained by the model, standardized regression coefficients for teacher quality and instructional practice

Education system	Number of students (*n*)	Variance (R^2) explained by model	Standardized regression coefficients											
			Number of years of experience (reference: 0–10 years)				Level of formal education (reference: did not complete bachelor's degree)				Undertook more than 15 h PD in teaching science		Instructional time spent on science (minutes per week)	
			11–20 years		> 20 years		Bachelor or equivalent		Postgraduate university degree					
Albania	2944	0.01	0.02	(0.08)	0.03	(0.07)	0.04	(0.06)	0.04	(0.07)	0.10	(0.08)	0.00	(0.09)
Bosnia & Herzegovina	4418	0.01	0.00	(0.05)	0.01	(0.04)	0.05	(0.04)	0.04	(0.04)	0.03	(0.04)	−0.06	(0.04)
Croatia	3715	0.00	0.00	(0.05)	−0.01	(0.06)	−0.03	(0.03)	−0.02	(0.03)	0.00	(0.04)	−0.03	(0.04)
Kosovo[a]	3566	**0.03**	**0.16**	(0.04)	0.01	(0.05)	0.01	(0.05)	0.07	(0.05)	0.01	(0.04)	0.03	(0.04)
Montenegro	4188	0.01	0.04	(0.04)	0.00	(0.05)	0.05	(0.04)	0.06	(0.04)	0.01	(0.03)	0.04	(0.03)
North Macedonia	2639	0.02	−0.07	(0.09)	0.05	(0.08)	**0.14**	(0.07)	0.10	(0.10)	0.05	(0.09)	−0.01	(0.07)
Serbia[a]	4187	0.01	0.04	(0.07)	0.07	(0.06)	0.10	(0.06)	0.05	(0.05)	−0.01	(0.04)	0.03	(0.03)

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

equally important to improve the processes involved in the preparation, recruitment, mentoring, promotion, and dismissal of teachers (Rivkin et al. 2005).

5 Conclusions

There were previously few national and/or regional studies examining the relationships between teacher quality, instructional practice, and student outcomes in the Dinaric region. Here, we were able to use data based on representative samples of grade four students from TIMSS 2019, together with TIMSS measures of teacher quality and instructional practice, to analyze the contribution of these teacher variables to student achievement in mathematics and science across the Dinaric region.

The educational background of mathematics and science teachers is similar across the Dinaric region. Teacher education in the region increasingly follows existing EU requirements. Most students in the Dinaric region have teachers who, on average, are slightly more experienced than their colleagues in other education systems that participated in TIMSS 2019, however, the level of PD for those teaching mathematics and sciences is quite low across the Dinaric region. Responses to the TIMSS 2019 teacher questionnaire indicate that mathematics and science teachers in the region are aware of which competencies they should develop in students and that they need support in acquiring more innovative teaching methods. The future needs for PD that they identified are consistent with current trends in the field of education and new social circumstances regarding the use of ICT. Decision makers should take these teacher observations into account and adjust future PD activities accordingly. Facilitating easier access to PD opportunities and raising the quality and relevance of these programs can also increase teacher participation and help teachers to strengthen their practice, knowledge, and skills (OECD, 2020). Policymakers and teachers in the Dinaric region could use this information to improve PD and control the successful implementation of changes in the next TIMSS cycle.

According to our analyses, teacher quality measures were not statistically significant predictors for student achievement in mathematics and science in most education systems in the Dinaric region. Teacher quality was related only to some aspects of instructional practice. TIMSS 2019 data (Mullis et al., 2020) showed that most teachers in the Dinaric region based their standard practice on more traditional teacher-centered activities (e.g., students read lessons from the textbooks and remember the facts and principles), while modern teaching methods suggest that it is beneficial for students to play more active roles in mathematics and science classes. Dinaric teachers who are more educated, more experienced, and those who spend more time on PD activities are more willing to use cognitive-activation strategies that require students to use higher cognitive levels of thinking (e.g., use evidence from experiments or investigations to support conclusions).

Even though teacher quality and instructional practice have not been shown as key factors in predicting student achievement in mathematics and science, their importance should not be overlooked. It is necessary to be cautious when interpreting the results and to carefully review the different aspects. Precisely which characteristics and behaviors of teachers in the classroom affect student achievement in the Dinaric region remains unclear. Effectiveness studies conducted over several decades on diverse hierarchical levels (individual, class, and school level) provide some answers (Creemers & Kyriakides, 2008), giving us an opportunity to get closer to describing the ideal profile of an efficient teacher, who can optimally guide and support their students. Such studies provide information on possible identification and systematization of student, teacher, and school characteristics that influence achievement, enabling improvement in teaching practices and overall quality (Teodorovic, 2011).

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Characteristics of Principals and Schools in the Dinaric Region

Beti Lameva, Ženeta Džumhur, and Mojca Rožman

Abstract The principal in a school is a manager and school leader who is responsible for advancement and implementation of various processes in the school. They take responsibility for compliance and accountability, support the teaching staff in their professional activities, and aim to build and maintain a school environment that promotes student achievement and good school-community relations. An important element of IEA's Trends in International Mathematics and Science Study (TIMSS) is the research into the home, community, school, and student factors associated with student achievement in mathematics and science. To accomplish this, data about the contexts for learning are collected through questionnaires completed by students and their parents/guardians, teachers, and school principals. Analysis of data from TIMSS 2019 for participants in the Dinaric region (Albania, Bosnia and Herzegovina, Croatia, Kosovo, Montenegro, North Macedonia, and Serbia) was used to determine whether the level of education, years of experience of the principal, the location of the school, and/or school composition have significant effects on student achievement and thus potentially identify elements that facilitate academic achievement among students. The TIMSS school questionnaire asks principals to provide assessments of the literacy and numeracy skills of students when they first start schooling, the socioeconomic background of the students attending the school, the availability of instructional resources, the school's emphasis on academic success, and discipline and school safety. While previous research has suggested that principals' years of experience and educational attainment are positively related to student achievement, there was little evidence for this in this regional sample of education systems. In three of the seven TIMSS participants in the Dinaric region, students from schools with a

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socioeconomically more affluent student body tended to achieve higher scores in mathematics and science. In four of the seven TIMSS participants, schools that placed strong emphasis on academic success tended to have higher levels of student achievement. The findings suggest that school principals in the region can best improve their students' achievement by focusing on encouraging student motivation and providing additional instructional resources for socioeconomically disadvantaged children.

Keywords Achievement · Leadership · Mathematics · School education · School principals · Science · Trends in International Mathematics and Science Study (TIMSS)

1 Introduction

What organizational features make a school a better place for teachers to teach and for students to learn has always been a very important question. Hoy (2012) identified three characteristics of schools that made a positive difference to student achievement after controlling for socioeconomic status (SES), namely (1) collective efficacy, (2) collective trust in parents and students, and (3) the academic emphasis of the school. In addition, school location can play an important role in education; schools in urban areas differ from schools in rural areas, and usually the former are associated with higher student performance. There are several explanations for this. Urban schools are usually larger, enjoy greater responsibility for resource allocation, and are less likely to experience staff shortages. Urban schools tend to have a higher proportion of qualified teachers, and higher student to teacher ratios than schools in rural areas and towns (OECD [Organisation for Economic Cooperation and Development], 2013; for additional research into the effects of school location, see also chapter "Scaffolding the Learning in Rural and Urban Schools: Similarities and Differences").

In public schools (state-funded), principals are also responsible for implementing standards, programs, and regulations set by higher educational authorities (such as government ministries) and related bodies. The role that principals play in schools is very important, as they are not only the administrators but also the initiators of many processes. As school managers, they should be school leaders who improve school processes and support high achievement among students (Malere & Ozola, 2019). Principals serve as the public representatives of their school. Elementary school principals provide direction and manage the overall operations of schools. They set and oversee academic goals, and ensure that teachers have the equipment and resources to meet those goals. Principals may establish and supervise additional programs in their school, such as counseling, extracurricular activities, and before- and after-school daycare. Principals clearly have an important management role, including responsibilities for teachers, curricula, and school budgets. They further facilitate cooperation with the students' parents and the local community by listening to and addressing their concerns. Research has indicated that school environment created by the principal may have a significant influence on students' mathematics and reading achievement (Alhosani et al., 2017; Dhuey & Smith, 2014).

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, elementary school principals typically undertake the following activities:

- manage school activities and staff, including teachers and support personnel;
- establish and oversee class schedules;
- implement and maintain curriculum standards;
- observe and evaluate teachers' performance;
- meet with parents and teachers to discuss students' progress and behavior;
- assess and prepare reports on test scores and other student achievement data;
- organize professional development programs and workshops for staff;
- establish and coordinate security procedures for students, staff, and visitors; and
- manage the school budget, including the provision of school supplies, and maintenance.

Some research has suggested that the "formal" characteristics of principals may play an important role in student attainment. For example, a systematic review by Osborne-Lampkin et al. (2015) reported that principals' years of experience and educational attainment were positively related to student achievement.

1.1 Framing the Research Questions

Our research analyses focus on connecting the professional characteristics of principals with school characteristics across the Dinaric region. We examined the relationship of these characteristics with student achievement to explore differences and similarities across the region.

Our review of the TIMSS 2019 regional data was designed to address four critical questions:

(1) *What are the licensing or certification requirements for principals across the Dinaric region?*
(2) *What is the qualification level of principals? Is there an association between student mathematics and science achievement and principals' education levels across the Dinaric region?*
(3) *How many of years of professional experience do principals across the region have generally? Is there an association between student mathematics and science achievement scores and this experience?*

[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).

(4) *Do school characteristics (school location, school composition by socioeconomic background, and school emphasis on academic success) differ among Dinaric education systems? Are these characteristics related to variation in student achievement?*

2 Variables

For our research analyses, we selected relevant data collected by the TIMSS 2019 student school questionnaires, the latter completed by school principals (Table 1; for more details on the questionnaires, see TIMSS & PIRLS International Study Center, 2018). We analyzed the associations between these variables and student achievement scores in the TIMSS 2019 mathematics and science assessments using basic and advanced methods to estimate percentages, means, correlations, and develop regression models. We conducted statistical computations using established standard procedures for handling data from large-scale assessments (see Sect. 5 for more details on the data sources, and the analysis methods and tools that we used).

In addition to the data collected by the TIMSS 2019 study, we collected information about specific requirements for principals across the region by preparing a short additional questionnaire that we distributed to national research coordinators in the Dinaric region. We used this questionnaire to collect information on:

- relevant qualifying criteria for school principals;
- certification for school principals;
- models of professional development for school principals; and
- number of years that school principals or school directors have held their mandate.

3 Results

3.1 Characteristics of School Principals and Relation to Student Achievement

In the Dinaric region, principals generally required at least five to eight years work experience in the education sector after acquiring their teaching degree before becoming a school principal, except in Kosovo where only three years of work experience were required (Table 2). By law, in Montenegro, Bosnia and Herzegovina, North Macedonia, and Kosovo, school principals require a recognized university degree. In Croatia, school principals require a postgraduate university degree, with a total of at least eight years of work experience in schools or other institutions in the education system or in state administration bodies responsible for education (where at least five years should be acquired in education in school institutions). Albania, Montenegro, North Macedonia, and Serbia have also implemented a model of professional development for school principals. Principals must complete a specialized

Table 1 List of variables and scales used in our analyses

Variable	Description	Values/response options	Reference
Principals' years of experience	Years of experience as a principal	Number of years	Fishbein et al. (2021) Supplement 1, p. 100
Principals' education	The highest completed level of principals' formal education	Did not complete bachelor's or equivalent level Bachelor's or equivalent level Master's or equivalent level Doctor or equivalent level	Fishbein et al. (2021) Supplement 1, p. 100
School location	Size of population in area of school location	More than 500,000 people 100,001 to 500,000 people 50,001 to 100,000 people 30,001 to 50,000 people 15,001 to 30,000 people 3001 to 15,000 people 3000 people or fewer	Fishbein et al. (2021) Supplement 1, p. 95
School emphasis on academic success scale[a]	The scale is based on thirteen items that measure the principal's perception of students', parents' and teachers' focus on student achievement	Higher values represent more emphasis on academic success	Martin et al. (2020) p. 16.124
Home resources for learning scale[a]	Based on students' and parents' reports regarding the availability of five resources: • 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 Index: Many resources, Some resources, Few resources	Martin et al. (2020) p. 16.39

(continued)

Table 1 (continued)

Variable	Description	Values/response options	Reference
School composition by socioeconomic background	Principal's report on the share of students in the school coming from: • Economically disadvantaged homes • Economically affluent homes Response options: 0–10%, 11–25%, 26–50%, more than 50%	More affluent: Schools where more than 25% of the student body comes from economically affluent homes and not more than 25% from economically disadvantaged homes More disadvantaged: Schools where more than 25% of the student body comes from economically disadvantaged homes and not more than 25% from economically affluent homes Neither more affluent nor more disadvantaged: All other possible response combinations	Fishbein et al. (2021) Supplement 3, p. 19

Note [a]These 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 information on scale construction, please see Yin and Fishbein (2020)

Table 2 Overview of qualifications required for a school principal position in the Dinaric region

Education system	Minimum years of experience in education	Does principal need to complete a specialized school leadership training program	Is there an established model of professional development for school principals?	Number of years that the school principal appointment lasts
Albania	5	Yes	Yes	Unlimited
Bosnia and Herzegovina	5	No	No	4
Croatia	8	No	No	5
Kosovo	3[a]	Yes	No	4
Montenegro	5	Yes	Yes	4
North Macedonia	5	Yes	Yes	4
Serbia	8	Yes	Yes	4

Note [a]In 2019, this changed from three to four years school leadership training program in Albania, Kosovo, Montenegro, North Macedonia, and Serbia; in Albania, Montenegro, North Macedonia, and Serbia, successful completion of this program gives school principals a license, which indicates that they have met the required level of general and professional competencies. In all education systems in Dinaric region, the school principal is selected after an open call has been issued, and, in general, school principals in the Dinaric region are appointed for a term of four years, although, in Croatia, their appointment is for five years and, in Albania, for an unlimited period. In Croatia and Serbia, principals can be reappointed multiple times; in Serbia, their prior position in school is held for two terms. In Bosnia and Herzegovina, Kosovo, Montenegro, and North Macedonia, the school principal can be appointed to a school no more than twice consecutively. All this is regulated by national legislation.

Across the Dinaric region, Croatia reported the highest percentage of school principals with a master's or a doctorate degree level qualification (96%), followed by Albania (51%) (Table 3). In most other systems in the region, the majority of schools are managed by a principal holding a degree at bachelor level or an equivalent (Table 3).

For each level of principal qualification, we also analyzed the related percentages of students and their achievement differences in mathematics and science (see Table S.14 in the supplementary materials available for download at www.iea.nl/publications/RfEVol13). We found that the association between student achievement and principal education was only significant in Montenegro, where grade four students in schools where principals had completed a postgraduate degree tended to have a significantly higher achievement than students in schools where principals had only completed a bachelor's degree or equivalent. They obtained, on average, 16 score

Table 3 Percentage of principals by educational level

Education system	Percentage of school principals who:					
	Did not complete bachelor's degree		Completed bachelor's degree or equivalent but not a postgraduate degree		Completed postgraduate university degree	
Albania	4	(1.6)	45	(4.8)	51	(5.0)
Bosnia & Herzegovina	7	(1.9)	77	(3.3)	16	(3.0)
Croatia	1	(0.6)	3	(2.8)	96	(2.9)
Kosovo[a]	14	(3.8)	53	(5.3)	33	(5.6)
Montenegro	7	(2.3)	78	(3.5)	15	(2.8)
North Macedonia	1	(0.8)	78	(3.9)	21	(4.0)
Serbia[a,1]	2	(1.6)	65	(5.5)	33	(5.5)

Notes Standard errors appear in parentheses

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

[1]For Serbian principals that graduated after 2005, a postgraduate master's degree is obligatory, according to Serbian law (Teodorović et al., 2019)

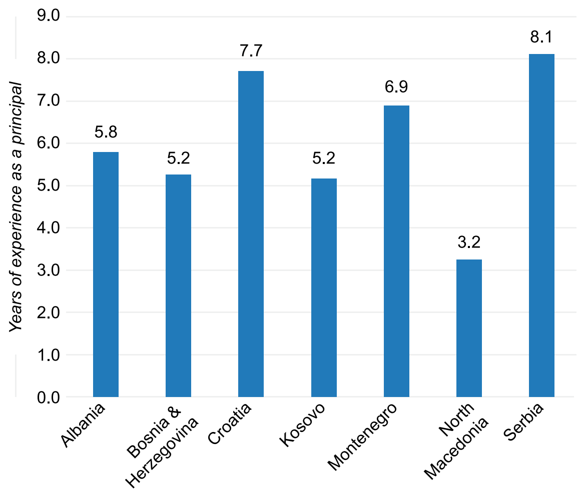
points more in the TIMSS grade four mathematics test and 14 score points more in the TIMSS grade four science test.

One of the primary development strategies for principals is experience acquired during the course of their work, with a general expectation that principals become more effective with increased experience working in a position of that level. On average, across the Dinaric region, principals had less experience than the international TIMSS average (10 years); principals in North Macedonia had notably low levels of experience, while Serbia reported the highest average (Fig. 1; for a more detailed analysis, see Table S.15 in the supplementary materials available for download at www.iea.nl/publications/RfEVol13).

When we analyzed the percentage of students by their principal's number of years of experience, we found that, in North Macedonia, a staggering 71 percent of students were learning in primary schools managed by principals that had less than five years of experience (Fig. 2). This percentage was also significant in Kosovo (34%) and Bosnia and Herzegovina (57%). While Albania had the lowest percentage of principals with less than five years of experience, 28 percent of grade four students still had a principal with little experience of the role. The TIMSS international average was 31 percent; students in the Dinaric region are thus more likely to have less experienced principals than students in other parts of the world. Looking at the same topic from another angle, only about nine percent of students in North Macedonia learn in schools managed by principals with at least 10 years of experience, which is lower than in other systems in the region (13% in Bosnia and Herzegovina, and >30% in Croatia, Kosovo, Serbia, and Montenegro).

However, we found that the TIMSS 2019 grade four data for the Dinaric region did not provide any evidence of a relationship between student achievement and principals' work experience. Calculating the correlation coefficient between the number of years of experience as a principal with the achievement of the students yielded

Fig. 1 Average number of years of experience of school principals
Note In Kosovo and Serbia, the national defined population covers 90–95% of the national target population



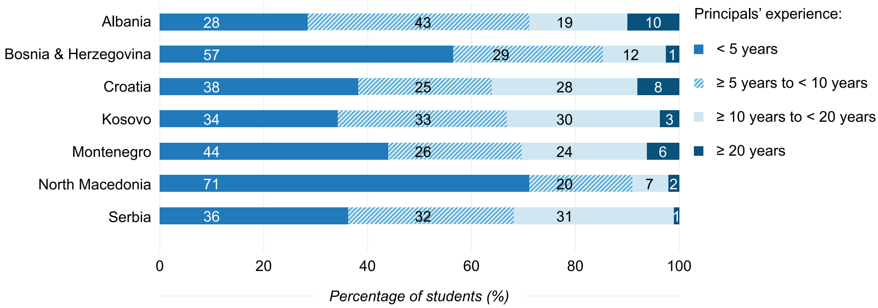


Fig. 2 Percentage of grade four students by their principal's number of years of experience
Note In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

no statistically significant results. Earlier research on this topic is ambiguous. Our findings are in agreement with some studies, where the data suggested that the experience of principals had no close relationship with academic achievement of students (Brockmeier et al., 2013; Gentilucci & Muto, 2007). In contrast, Dhuey and Smith (2014) reported that principal characteristics had significant effects on student achievement in mathematics and reading, and identified a weak relationship between principals' levels of education and student test scores.

3.2 Characteristics of School

A variety of factors contribute to student achievement in mathematics and science, including student behaviors and student, teacher, and school characteristics. We focused on the school characteristics of school location, school composition by socioeconomic background, and school emphasis on academic success.

When comparing education systems across the Dinaric region, formative characteristics are important for contextualizing the findings. The number of people who live in the city, town, or area where the school is located may have an impact on students achievements in the Dinaric region. The Dinaric region generally has low levels of urbanization, and at least two-thirds of the region's students attend schools located in villages or small towns. However, there is still considerable variation in school locations across the region (Fig. 3). In Albania and Kosovo, a third of students attend a school located in an area with 3000 people or less, while, conversely, nearly a third of students in Serbia learn in schools located in a place with more than 100,000 people (Fig. 3).

We investigated whether student achievement was related to school location by comparing the TIMSS mathematics and science achievement of grade four students in schools in areas with >30,000 people to that of grade four students in schools in areas with ≤30,000 people (Table 4). Our results indicated that students from bigger

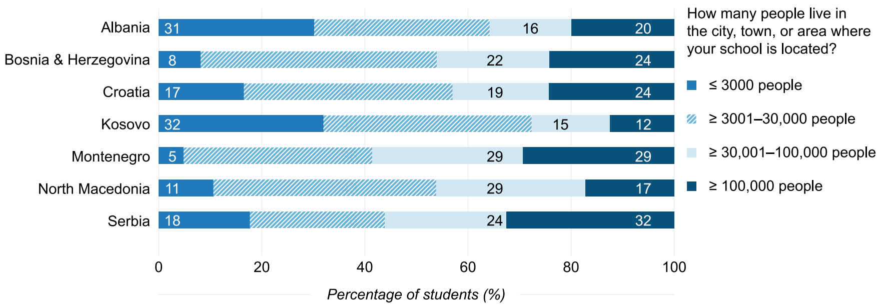


Fig. 3 Percentage of students by school location
Note In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

Table 4 Mathematics and science achievement difference by school location

Education system	Difference in student achievement			
	Mathematics achievement		Science achievement	
Albania	**32**	(7.2)	**34**	(7.1)
Bosnia & Herzegovina	**14**	(5.6)	**14**	(5.8)
Croatia	13	(4.4)	**13**	(3.5)
Kosovo[a]	−6	(7.0)	−4	(8.5)
Montenegro	2	(3.1)	−1	(3.5)
North Macedonia	**31**	(11.8)	**39**	(12.9)
Serbia[a]	**38**	(5.4)	**37**	(5.7)

Notes Positive values indicate higher achievement in areas with >30,000 people compared to areas with ≤30,000 people. Statistically significant ($p < 0.05$) differences are shown in bold. Standard errors appear in parentheses
[a]National defined population covers 90–95% of the national target population

cities achieved higher scores than their peers in smaller cities or rural areas; the achievement differences for both mathematics and science were significant across most of the Dinaric region, except for Kosovo and Montenegro. This difference was most pronounced in Albania, North Macedonia, and Serbia, where it exceeded 30 points for both mathematics and science (this corresponds to one-third of the standard deviation of the achievement scale score metric).

There may be multiple reasons for similar clustering effects in the Dinaric region, for example, social segregation of residential areas (in combination with the tendency for children to attend nearby schools), fees for schools, lack of incentives for teachers to elect to work in more challenging areas, and/or better equipment in affluent schools because parents make additional financial contributions.

The social background of families is often reflected in the student intake of schools. Parents with similar backgrounds tend to send their children to schools where they will meet similar children (Cahill, 2009); this can boost the school-level effect on learning because children in more affluent schools may already start school with a higher "knowledge baseline" as a consequence of parental factors. We used the school principal responses about the socioeconomic background of the student body to group schools into three categories: "more affluent," "neither more affluent nor more disadvantaged," and "more disadvantaged" (Fig. 4).

We noted that students from different backgrounds seemed to be strongly segregated in many schools in the Dinaric region (Fig. 4). The high percentage of students learning in disadvantaged schools in Albania is particularly noteworthy (almost half of Albania's grade four students attend such schools). In Croatia, the comparable percentage was only 13 percent, while 57 percent of grade four students were reported as attending more affluent schools. In North Macedonia, only 10 percent of students attended "neither more affluent nor more disadvantaged" schools, but 66 percent attended more affluent schools.

We compared average student achievement scores for grade four students from schools with a more affluent student body with those of students from schools with a more disadvantaged student body (Fig. 5). The results indicated that students in more affluent schools tended to achieve higher mathematics and science scores in TIMSS 2019. These differences were generally significant, except in Bosnia and Herzegovina; in Kosovo, only the difference in mathematics achievement was significant. In Croatia, Montenegro, and Serbia, the difference in both subjects was around 20 points, but, in Albania and North Macedonia, the difference exceeded 39 score points, amounting to almost half a standard deviation of the scale metric.

School emphasis on academic success generally plays an important role in supporting or stimulating students in their learning, and implies effective teaching, a motivated work environment, and high levels of expectation for student success.

In TIMSS 2019, principals were asked to report on their school's emphasis on academic success. The TIMSS scale "school emphasis on academic success" (SEAS) (see Table 1) is related to a number of similar items aimed at measuring aspects of the school's emphasis on academic success and the degree of support offered by

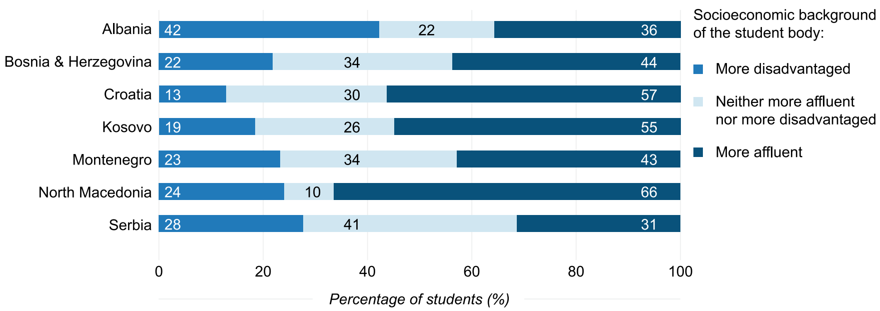


Fig. 4 School composition by principals' assessments of the socioeconomic background of the school's student body

Notes In Kosovo and Serbia, the national defined population covers 90–95% of the national target population. In Kosovo, data were available for ≥50% but <70% of the students

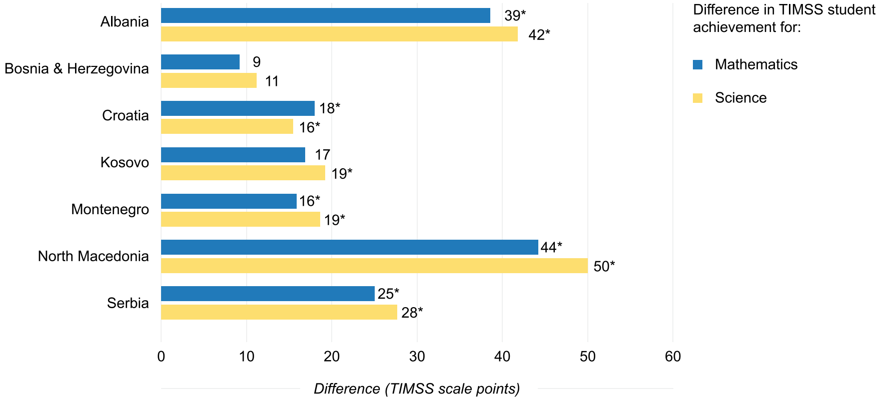


Fig. 5 Difference in grade four student achievement scores by school socioeconomic background *Notes* * Statistically significant ($p < 0.05$) differences. Positive values indicate higher achievement in more affluent schools compared to more disadvantaged schools. In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

the school organization and the school environment. Internationally, students who were classified as attending a school with "high or very high emphasis on academic success" are those with a scale score greater than or equal to 9.2. Students who were classified as attending a school with "medium emphasis on academic success" had a score lower than 9.2 (Table 5).

Overall, more than half of students in the region attended schools where principals reported there was a "very high" or "high" emphasis on academic success as part of the school's culture (Fig. 6). The average scale score across the Dinaric region ranged from 9.3 in North Macedonia to 10.3 in Montenegro (Table 5).

We analyzed the correlation between SEAS and grade four student achievement across the region (Table 5). This correlation was very weak, but positive in all participating education systems in the region for both subjects. The correlation coefficients

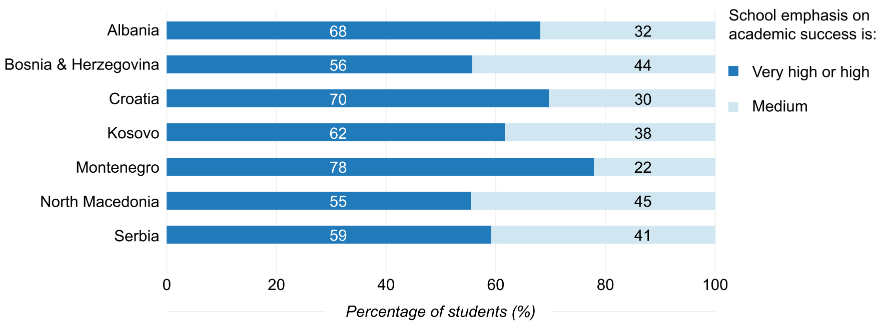


Fig. 6 Percentages of students attending schools with different emphasis levels on academic success, based on principals' assessments of their school culture

Table 5 School emphasis on academic success as reported by principals, and its correlation with grade four student achievement in TIMSS 2019

Education system	Average scale score of the TIMSS 2019 school emphasis on academic success scale		Correlation with mathematics achievement		Correlation with science achievement	
Albania	10.2	(0.1)	**0.21**	(0.04)	**0.22**	(0.05)
Bosnia & Herzegovina	9.8	(0.1)	0.02	(0.04)	0.03	(0.03)
Croatia	10.0	(0.1)	0.06	(0.04)	0.07	(0.04)
Kosovo[a]	10.1	(0.1)	**0.13**	(0.04)	**0.15**	(0.04)
Montenegro	10.3	(0.0)	0.02	(0.02)	0.03	(0.02)
North Macedonia	9.3	(0.2)	**0.21**	(0.06)	**0.23**	(0.06)
Serbia[a]	9.6	(0.1)	**0.14**	(0.05)	**0.14**	(0.05)

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

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

were statistically significant in Albania, Kosovo, North Macedonia, and Serbia. This is in line with Bandura (1993) and Hoy et al. (2006) who confirmed a strong relationship between academic optimism and student achievement; they further stated that efficacy, trust, and positive academic emphases together produce a powerful force that engenders motivation, creates collective optimism, and channels student behavior toward the accomplishment of high academic goals. Schools with academic optimism create collective beliefs that changes are possible and all students can learn, inspiring a confidence that high academic performance can be achieved.

4 Conclusions

We analyzed the characteristics of principals and schools in the Dinaric region and the relationship of these characteristics with academic achievement of grade four students in TIMSS 2019. The focus of any principal is to manage the various processes in the school and support the professional activities of their teachers to create a successful learning environment for students. While we cannot address all aspects of a principal's remit in our analyses, the TIMSS 2019 data provide useful information on their educational levels and number of years of experience as a principal, two factors that have been previously linked to student academic achievement (see Dhuey & Smith, 2014). While we were unable to identify a statistically significant relationship between these characteristics and grade four student mathematics and science achievement in our analyses of the TIMSS 2019 data, the role of the principal is undoubtedly a critical component in student achievement. They can establish a positive academic environment that embraces cognitive, emotional, and behavior elements; the positive interaction of all these elements creates a school culture of academic success.

It is essential that the management of the school creates an environment for learning and expects high achievement from the students because this facilitates and improves the achievement of the students. School principals should establish an environment and culture where all involved parties contribute toward supporting and improving student achievement.

There are also non-malleable factors that shape the learning environments of students. One of them is school location. We found that the level of urbanization of the area surrounding the school can also be related to student achievement. We observed that students in areas with more people demonstrated higher achievement scores in mathematics and science than students from schools located in less populated areas in Albania, Bosnia and Herzegovina, Croatia, North Macedonia, and Serbia (for further investigation into differences between urban and rural areas, see chapter "Scaffolding the Learning in Rural and Urban Schools: Similarities and Differences"). Conditions to promote students' learning tend to be better in urban schools, and this tendency is also reinforced by conditions for learning at home, which significantly correlates with higher student achievement.

The composition of the socioeconomic background of the student body of the school could also be related to grade four student mathematics and science achievement. In general, we found that children from more disadvantaged environments scored lower TIMSS achievement than students from more affluent schools. These differences in student achievement were statistically significant in Albania, Croatia, Kosovo (only for science), Montenegro, North Macedonia, and Serbia.

While, across the Dinaric region, TIMSS 2019 data showed no significant relationships between principal characteristics and student achievement, we caution against underestimating the importance of principals. Although we were unable to empirically prove such relationships, this does not necessarily mean they do not exist, as there may be other characteristics associated with achievement that are not reported by TIMSS, and they may be interrelated and interdependent.

An important indicator in this analysis was school emphasis on academic success (as reported by school principals). We found that the correlation between the school emphasis on academic success (as reported by their principals) and grade four student mathematics and science achievement was positive for all participating systems in the region, and statistically significant in Albania, Kosovo, North Macedonia, and Serbia. It is thus important that schools in the Dinaric region continue to promote an emphasis on academic success. School communities (principals, teachers, parents, and students) need to focus on working together to create a positive school climate that helps to establish students' confidence in their abilities and motivate them to better achievement.

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Characteristics of High- and Low-Performing Students

Rezana Vrapi, 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

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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 that 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: • 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 [a]These 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)

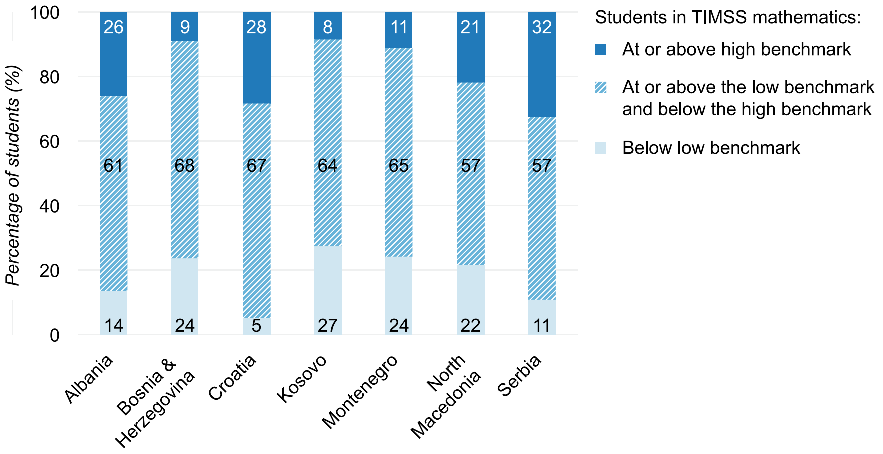

Fig. 1 Percentages of high- and low-achieving students in TIMSS 2019 mathematics. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

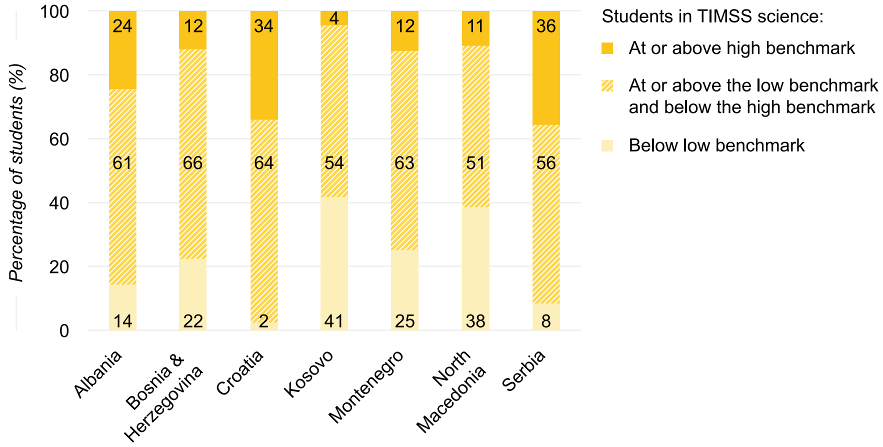

Fig. 2 Percentages of high- and low-achieving students in science TIMSS 2019. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

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

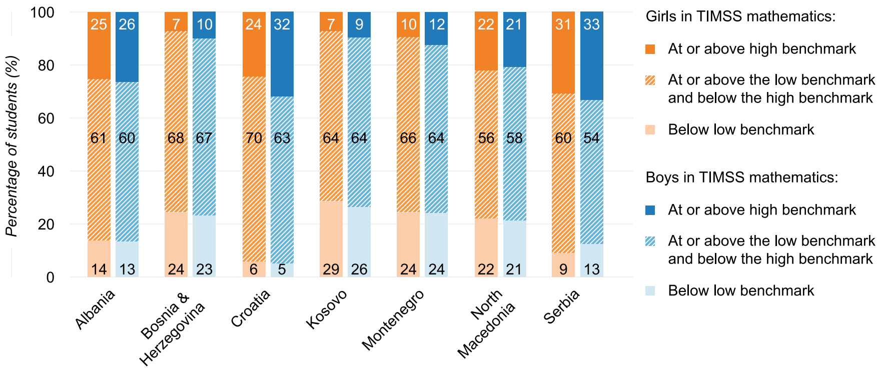

Fig. 3 Distribution of female and male students across the TIMSS international benchmarks in mathematics. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

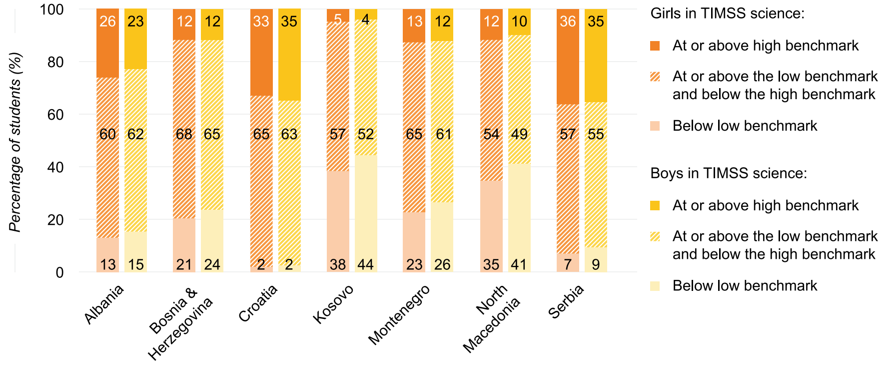

Fig. 4 Distribution of female and male students across the TIMSS international benchmark in science. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

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

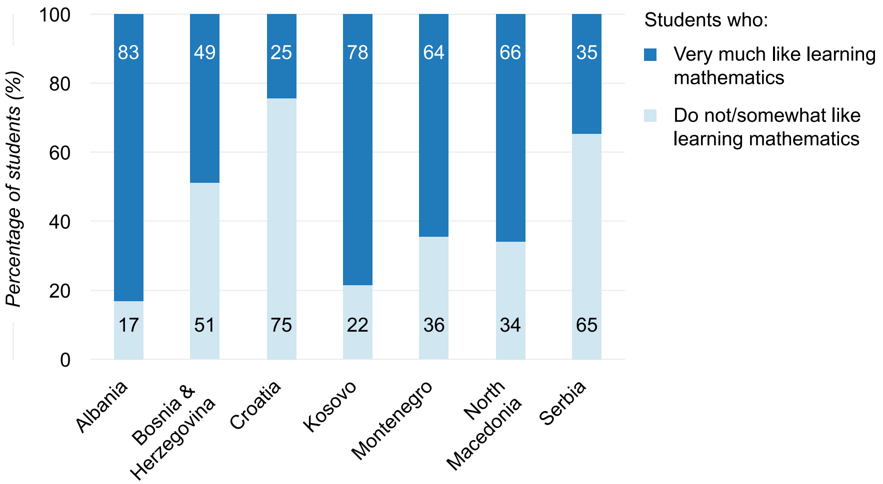

Fig. 5 Attitudes of grade four students toward learning mathematics. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

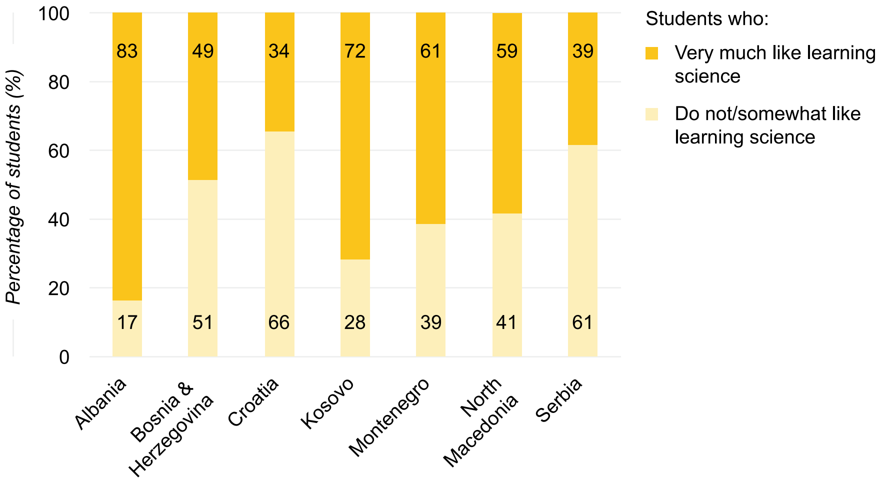

Fig. 6 Attitudes of grade four students toward learning science. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

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

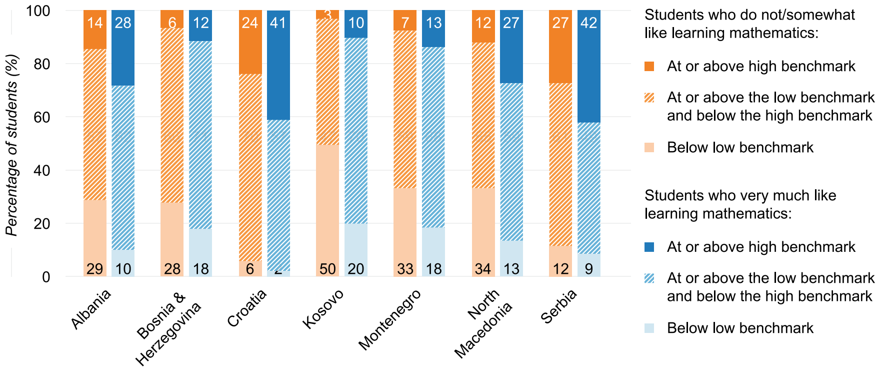

Fig. 7 Distribution of students across the TIMSS international benchmarks in mathematics and their attitudes toward learning mathematics. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

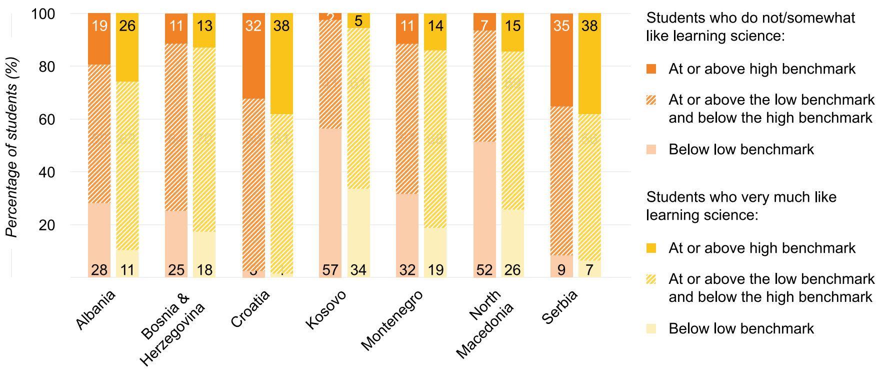

Fig. 8 Distribution of students across the TIMSS international benchmarks in science and their attitudes toward learning science. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

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

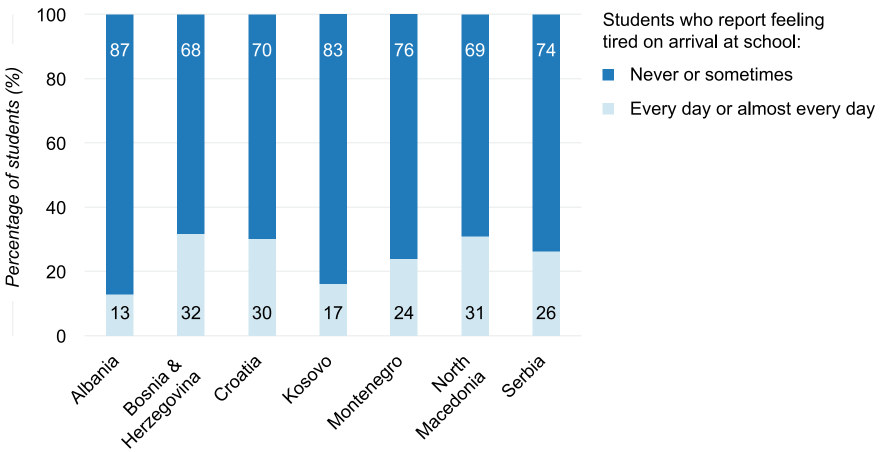

Fig. 9 Grade four students' reports of the frequency of feeling tired on arrival at school. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

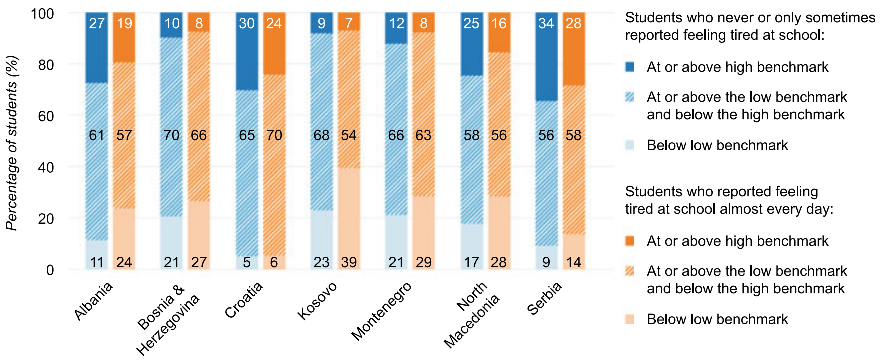

Fig. 10 Distribution of students across the TIMSS international benchmarks in mathematics and their frequency of feeling tired on arrival at school. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

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

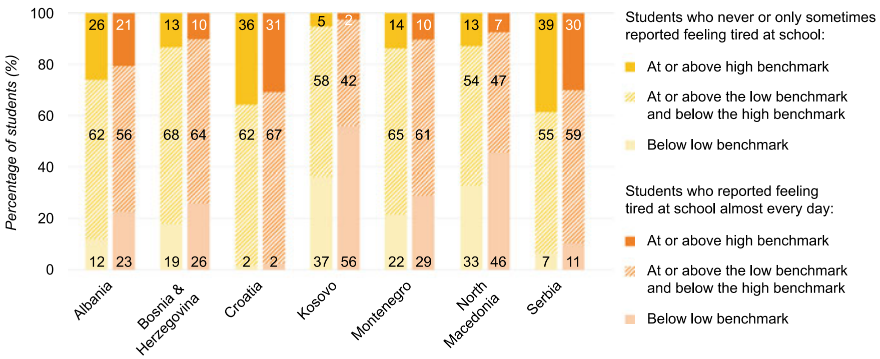

Fig. 11 Distribution of students across the TIMSS international benchmarks in science and their frequency of feeling tired on arrival at school. *Note* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

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.

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Scaffolding the Learning in Rural and Urban Schools: Similarities and Differences

Smiljana Jošić, Barbara Japelj Pavešić, Nikoleta Gutvajn, and Mojca Rožman

Abstract Education systems can be conceptualized as the scaffolding that supports the construction and development of student competences. Among other things, the size, location, and learning resources of schools can affect how efficient that system is at delivering the required support. Data from international large-scale assessments have indicated that the resources of rural schools may differ from those of urban schools; students in schools in urban and more economically developed environments often demonstrate higher achievement. Data from IEA's Trends in International Mathematics and Science Study (TIMSS) 2019 from across the Dinaric region provides information on variations in the size of schools and allocation, student achievement, and the different kinds of scaffolding/support for learning in urban and rural schools. Secondary analyses of the TIMSS 2019 data for the Dinaric region, taking into account home and school factors, show that the types of support available for student learning differed between urban and rural schools. The findings suggest that policymakers should focus on improving the learning resources available to rural schools across the region, particularly in response to their lack of technological resources for developing students' digital competencies. Concomitant investment is required for the development of teachers' competencies for the effective use of such educational resources. Educators need to compensate for lack of family support for some students; in such situations, schools need to enhance the scaffolding for learning available to children.

Keywords Achievement gap · Grade four · Location of school · Scaffolding · Trends in International Mathematics and Science Study (TIMSS)

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1 Introduction

In order to develop and master different competences through learning, students usually benefit from good support for learning: quality teaching, appropriate material resources for learning, and parents and teachers that nurture their academic aspirations. But does the learning support that students receive differ substantially by school environment? We used data collected by IEA's Trends in International Mathematics and Science Study (TIMSS) 2019 to identify whether there were differences in learning environments across the Dinaric region, specifically between urban and rural schools. Seven participants from the Dinaric region took part in TIMSS 2019, namely Albania, Bosnia and Herzegovina, Croatia, Kosovo,[1] Montenegro, North Macedonia, and Serbia. TIMSS provides an opportunity to explore the different types of support (scaffolding) for student learning, enabling us to identify which types of support were provided in the schools in rural areas in comparison with schools situated in more urban locations. We hypothesized that differences among learning of students from rural and urban areas could also be related to students' home support; we thus relate school support to differences in student achievement in science and mathematics between rural and urban schools, taking into account the support that students received, both at the home and school levels.

1.1 Scaffolding the Learning Process

Education systems can be conceptualized as the "scaffolding" that supports the construction and development of student competences (Bruner, 1983; Van de Pol et al., 2010; Wood et al., 1976). Here, we use the term scaffolding to encompass all the different ways of supporting the child in activities that they cannot perform independently (Wood et al., 1976) and where learning process is guided by others (Stone, 1998). Just as scaffolding provides support to workers in the construction of tall buildings and is no longer required when the building is successfully constructed, when a student masters a skill additional support is no longer needed and can be safely removed. In this sense, the term scaffolding reflects the temporary nature of the educational support provided as one of its important characteristics.

The concept of scaffolding offers a new perspective in the study of classroom learning and suggests that learning processes can be reframed to be more attuned to the students' needs. This metaphor of scaffolding can be used to identify different kinds of support, such as: motivating the students to work (Nedić et al., 2015; Seberová et al., 2020), focusing the student on certain task characteristics (Gunawardena et al., 2017; Panselinas & Komis, 2009), supportive parents (Goodall, 2020), using a language that the student understands, or using technical tools that facilitate various task-related activities (Fernández et al., 2001; Mercer, 2000). Sociocultural

[1] All references to Kosovo in this document should be understood to be in the context of United Security Council resolution 1244 (1999).

theorists point out that the dynamics of learning are largely determined by the variety of tools that a culture has at its disposal and the environment in which the development process takes place (Cole & Wertsch, 1996; Vygotsky, 1934, 2012). Some of these dynamics relate to cultural tools as mediators of learning, such as laboratories, libraries of graphic displays, and software programs installed on electronic devices (such as tablets and computers), which can drastically change the learning process (Kozulin, 2003). In the educational context, there are numerous examples of support, such as asking students constructive questions, using tools that can lead to more meaningful learning, and teaching students how to communicate their thoughts (Fernández et al., 2001; Mercer, 2000; Mercer & Littleton, 2007; Radišić & Jošić, 2015).

The extent to which the school emphasizes the importance of student academic success is one of the school factors underpinning student achievement (Goddard et al., 2000; Hoy et al., 1991). Setting high, but achievable goals in terms of student achievement leads to the establishment of an orderly and effective learning environment and motivates students to work and achieve better results.

The size, location, and learning resources of the school may affect the efficiency of the school as a system. Equipped with all the necessary elements (library, gymnasium, and laboratory), smaller schools are usually more effective, providing a safe and intimate learning environment (Klonsky, 2002; Wasley et al., 2000). However, research into the importance of school resources for achievement has proved inconsistent; some studies found that these resources are not critical to student success (Hanushek, 1997), while others reported that the amount of money spent by a school per student was a strong predictor of achievement (Hedges et al., 1994). For the efficient use of information technologies, employee training is certainly necessary (Fraillon et al., 2020; Laffey et al., 2003).

All these types of scaffolds can support different subjects, such as science or mathematics (Dawes, 2008; Mercer et al., 2004). The scaffolding concept can also be useful as an analytical tool to help gain a greater understanding of teaching and learning in schools at different levels of urbanization.

1.2 Urban and Rural Schools in the Dinaric Region

Defining the terms urban and rural is a rather challenging task because there does not seem to be one unambiguous answer that permits a universally understood definition to be assigned. Historically, the term rural meant something that was "outside the city walls." From the economic aspect, rural territory is used to produce, above all, food, while sociologists might characterize the rural environment as more technologically and culturally backward in development terms than an urban environment. Today, various criteria are used to analyze rural and urban concerns, such as demographic criteria, the amount and structure of the population's income, location criteria and measures of basic activity of inhabitants in a certain territory. Rural areas are thus characterized as sparsely populated places, places where people have lower incomes, and areas that have a different purposes from urban areas, primarily dominated by agricultural land that often defines the activities and professions of inhabitants. TIMSS 2019 created general international definitions of rural and urban that were based on the number of inhabitants in the region in which the school was located, but subcategories of urbanization were more precisely defined by population sizes for cities, towns, and villages in each education system (Mullis & Martin, 2017).

Students in schools in urban and more economically developed environments often demonstrate higher achievement. This may be related to the availability of better teaching staff, better local community resources, or higher socioeconomic status (SES) of families in many urban classrooms (Darling-Hammond, 1996; Erberber, 2009; Hooper et al., 2013; Mohammadpour & Abdul Ghafar, 2014; Piyaman et al., 2017). The relations between achievement and learning environment in urban and rural schools are also reflected in the education systems across the Dinaric region. For instance, in Serbia, results from the national test in mathematics and Serbian language in 2004 showed grade three students from urban areas achieved higher scores than their peers in rural schools (Baucal et al., 2007). The results also showed that differences in achievement between students from rural and urban schools could be mostly explained by their social background and different preparation for starting school, and only to a smaller extent by variance in the quality of mathematics teaching in rural and urban schools. Serbia and Albania showed similar urban–rural gaps in reading scores on the Programme for International Student Assessment 2018 (PISA) of about 45 points (OECD [Organisation for Economic Cooperation and Development], 2019).

According to a report by the United Nations Children's Fund in Bosnia and Herzegovina (UNICEF, 2020) into the situation of children in Bosnia and Herzegovina, about 60% of young people under the age of 18 lived in rural areas, but children in rural areas made up only 0.5% of the total number of children attending preschool education. Data on student achievement for rural areas are inconsistent. On the one hand, results from the 2011 Labour Force Survey (Somun-Krupalija, 2011) for the whole of Bosnia and Herzegovina and their Survey of Rural Households in 2012 (which included people living outside urban settlements; Goss, 2012) showed that the population of Bosnia and Herzegovina that lived in the countryside tended to be less educated than its urban inhabitants. Rural residents received, on average, two years less education than those in urban areas, regardless of gender (Goss, 2012). On the other hand, the reports of United Nation Development Programme (UNDP) about rural development (UNDP, 2013) as well as the Multiple Indicator Cluster Survey report (The Agency for Statistics of Bosnia and Herzegovina et al., 2013) found that the education in rural areas is improving. Villagers were becoming less disadvantaged in terms of formal education because most manage to send children in school despite the distance and the total number of children in Bosnia and Herzegovina attending high school has increased significantly, from 74% in 2006 to 92% in 2011/12 (UNDP, 2013). We caution that differences in reported statistics arise from their different focus, but also from the methodology of defining rural areas by cantons in Bosnia and Herzegovina.

Regardless of the interpretations of the fairness of education in different environments, all reports agree that the extremely complex administrative organization of the education system in the region makes it difficult to harmonize regulations on education and service delivery, especially in rural areas. Variance in preschool education across the different regions was also noted in North Macedonia, where about 32% of 0–5 year olds attended preschool education in the East and Pelagonia regions, but only eight percent in the Northeast region (World Bank, 2019). Data for North Macedonia shows that the total enrollment of children in education in rural areas was lower than in urban areas (Eftimoski, 2006).

The socioeconomic background of students from different regions is generally related to levels of education across all the Dinaric systems that participated in TIMSS. The UNDP report for 2019 (Conceição, 2019) showed that some territories face regional differences in the level of development, as measured by the UNDP's human development index, which includes an education index (EI) as one of the indicators of human development. The EI was composed of the average adult's number of years of schooling and the expected number of years of schooling for children in the region, each receiving a 50% weighting. Capital cities, like Tirana in Albania and Belgrade in Serbia, had higher EIs than other areas, showing that there were clear differences between urban and rural regions (Baucal et al., 2007; Vujnić, 2014; World Bank, 2019). A World Bank (2019) report on the effects of urbanization in Albania, Bosnia and Herzegovina, Croatia, Kosovo, North Macedonia, Montenegro, and Serbia, using data on educational inputs, suggested that regions with lower EIs were often well resourced. For example, relative to their populations, regions like Diber and Kukës in Albania had more schools and teachers and smaller classes than many more affluent regions. This partially reflects an explicit effort to ensure access to education regardless of where people live, but also reveals the demographic decline in rural areas; schools remain, but declining populations mean fewer students attend (World Bank, 2019).

A search of the literature revealed that education systems in the Dinaric region recognize dichotomous classification (urban/rural) and generally use the number of inhabitants as the classification criteria, so this was a logical choice for our research (see, e.g., Gajić, 2015; Milanović et al., 2010; Miljević-Riđički et al., 2011; Rajovic & Bulatovic 2015; Somun-Krupalija, 2011). Data collected by TIMSS 2019 provided important information about education in schools at different urbanization levels. The TIMSS 2019 contextual framework classified school location using five categories: urban, suburban, medium-sized city or large town, small town or village, and remote rural; each category was contextualized using relevant national definitions of population size (Mullis & Martin, 2017). Based on previous research into an earlier cycle of TIMSS in 2015 (see Boulifa & Kaaouachi, 2015; Webster & Fisher, 2000), for our analyses we merged the first three categories into one signifying urban areas and the other two into one signifying rural areas. We used this simplified type of classification because this enables us to obtain comparable data on schools from different education systems with nationally defined numeric criteria for urban locations. More detailed information about the Dinaric education systems can be found in chapter "Introduction to Dinaric Perspectives on TIMSS 2019" and in the TIMSS 2019 encyclopedia (Kelly et al., 2020).

1.3 Scope of the Chapter

Policymakers across the Dinaric region are interested in learning whether all students have equal access to education and whether all children have equal learning support (Boljka et al., 2018; European Commission, 2014; Krstevska & Trenceva, 2016; UNDP, 2013; OECD, 2019). The dilemma that immediately arises when considering schools in rural areas is their cost-effectiveness over educational effectiveness. In particular, the enduring question is whether schools in rural areas should be supported by national funding or whether their funding should be reduced by placing students in schools in more urban areas, while subsidizing the additional travel costs to enable students from more distant locations to attend.

Our work was guided by three key research questions:

(1) *Do schools from different urbanization levels (urban and rural) differ in other defined ways (for example, school size)?*
(2) *Do urban and rural schools differ in terms of their student achievement?*
(3) *Do urban and rural areas differ in terms of the types of scaffolding available to support student learning in schools?*

2 Data and Methods

We analyzed TIMSS 2019 data from across the Dinaric region, collected from grade four students, their parents, and their school principals (for more information, see TIMSS & PIRLS International Study Center, 2018). All the variables that we used in our analyses are available in the TIMSS international database (Table 1). We used TIMSS data for mathematics and science achievement at grade four to document the achievement gaps between schools in urban and rural areas and as outcome variables in regression models. We calculated percentages, means and regression models, and used *t*-test statistics to determine statistical group differences (for a detailed description of the data sources, methods, and procedures used in our analyses, please see Sect. 5).

As part of the TIMSS school questionnaire, principals were asked to assess the level of urbanization of the area in which their school was located. As already mentioned, we derived the categories of urban and rural that we used in our analyses from the five internationally defined categories (see Table S.17 in the supplementary materials available for download at www.iea.nl/publications/RfEVol13 for disaggregated results).

To investigate the reasons for the differences in the achievement of students in relation to the type of school, we analyzed a variety of home and school support for

Table 1 List of variables and scales used in our analyses

Variable/Scale	Description	Values/Response options	References
School location	Principals' responses to the question, which best describes the immediate area in which your school is located? Response options: urban (densely populated), suburban (on fringe or outskirts of urban area), medium size city or large town, small town or village, remote rural	School location was recoded into two categories: (1) Urban (urban, suburban, medium city) (2) Rural (small town, remote rural)	Fishbein et al. (2021, Supplement 1, p. 95)
School size	Total enrollment of students in school, as reported by principals	Number of students	Fishbein et al. (2021, Supplement 1, p. 95)
School composition by socioeconomic background	Principal's report on the share of students in the school coming from: (a) Economically disadvantaged homes (b) Economically affluent homes Response options: 0–10%, 11–25%, 26–50%, more than 50%	Index with three categories: (1) More affluent: schools where more than 25% of the student body comes from economically affluent homes and not more than 25% from economically disadvantaged homes (2) More disadvantaged: schools where more than 25% of the student body comes from economically disadvantaged homes and not more than 25% from economically affluent homes (3) Neither more affluent nor more disadvantaged: all other possible response combinations	Fishbein et al. (2021, Supplement 3, p. 19)

(continued)

Table 1 (continued)

Variable/Scale	Description	Values/Response options	References
Schools where students enter the primary grades with literacy and numeracy skills scale[a]	The scale is based on principals' estimates on how many students had each of the twelve different literacy and numeracy skills when entering the first grade of primary school	Higher values mean more students entered school with more established basic literacy and numeracy skills	Yin and Fishbein (2020, p. 16.131)
Home resources for learning scale[a]	Based on students' and parents' reports regarding the availability of five resources: • 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)
School emphasis on academic success scale[a]	The scale is based on thirteen items that measure the principal's perception of students', parents' and teachers' focus on student achievement	Higher values represent more emphasis	Yin and Fishbein (2020, p. 16.124)
Grade four student:computer ratio	The ratio between the number of grade four students in schools and number computers available for the use of grade four students at school	Number of students sharing one computer	Fishbein et al. (2021, Supplement 1, p. 95 and p. 97)

(continued)

Table 1 (continued)

Variable/Scale	Description	Values/Response options	References
Single items related to school resources	Principals' reports on: • Access to digital learning resources • Use of online learning management system • Availability of science laboratory • Availability of assistance for science experiments • Availability of a school library (if available, does it have 2000 books or less or more than 2000 books) • Availability of classroom library	Response categories (1) Yes (2) No	Fishbein et al. (2021, Supplement 1, p. 97)

Notes [a]These 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). The references provide information on exact item wording and, in the case of latent scales, some additional information (Cronbach's alpha reliability coefficients, principal component analysis of the included items, relationships between the scale and student achievement). Descriptive statistics of continuous variables are available in Table S.16 in the supplementary materials available for download at www.iea.nl/publications/RfEVol13

students, and the availability of material resources at schools, such as laboratories, libraries, and technology equipment. To assess the level of home support, we used principals' reports of student readiness for schooling and the TIMSS scale home resources for learning, and to assess the level of school support, we analyzed school emphasis on academic success and school material resources.

Students differ in the degree to which they know how to read, write and count when entering grade one. To indirectly measure how prepared students are when starting school, TIMSS asks their principals to estimate how much students know on entering school. The TIMSS scale "Schools where students enter the primary grades with literacy and numeracy skills" combines principals' responses to several items on the school questionnaire to provide a measure of students' readiness for schooling. Another factor that may mediate the effect of urbanization could be differences in parental support for schooling. The TIMSS "Home resources for learning" (HRL) scale attempts to measure this by combining student responses from the student questionnaire and the responses of their parents/guardians from the early years questionnaire to statements related to resources that are available in the home learning environment. To assess school scaffolding, we focused on two sets of data in the TIMSS database. The first was the TIMSS scale "School emphasis on academic success," (SEAS) which combines principals' responses to a number of items designed to measure their perceptions of the school community's focus on student achievement. The second was the principals' assessments of school material resources, such as availability of technology equipment, laboratories, and libraries. As an additional assessment of the material resources that may be available to students in schools, we also investigated the student: computer ratio in the grade four classrooms, the availability of online learning management systems (OLMSs), and access to digital resources in school.

To better understand how all these factors were related to student achievement, we undertook regression analyses to predict mathematics and science achievement based on the urbanization level of schools, and the home resources for learning and school emphasis on academic success scales.

3 Results

3.1 Allocation and Size of Schools in Urban and Rural Areas

We found that the percentages of urban and rural schools and the percentages of students in these schools varied across the Dinaric region (Table 2). In Albania, Croatia, Kosovo, and Serbia, about a third of schools were located in urban areas. In Bosnia and Herzegovina and North Macedonia, slightly less than half of schools were located in urban areas, while, in Montenegro, more than half of schools were located in urban areas. Regarding the percentages of students in schools by location, Montenegro reported that around 85% of students were enrolled in schools in urban

Table 2 Percentage of schools and students in schools by urbanization of location area of the school

Education system	Schools in urban areas (%)		Students in urban areas (%)		Schools in rural areas (%)		Students in rural areas (%)	
Albania	35	(3.3)	63	(2.9)	65	(3.3)	37	(2.9)
Bosnia & Herzegovina	44	(3.0)	60	(3.2)	56	(3.0)	40	(3.2)
Croatia	36	(5.0)	57	(3.3)	64	(5.0)	43	(3.3)
Kosovo[a]	32	(4.1)	57	(3.2)	68	(4.1)	43	(3.2)
Montenegro	55	(2.9)	85	(0.5)	45	(2.9)	15	(0.5)
North Macedonia	44	(2.6)	64	(3.3)	56	(2.6)	36	(3.3)
Serbia[a]	36	(5.7)	68	(3.0)	64	(5.7)	32	(3.0)

Notes Standard errors appear in parentheses
[a]National defined population covers 90–95% of the national target population

areas, while, in most of the other participating education systems, at least a third of students attended schools in rural areas.

There were large differences in the average numbers of enrolled students, both in total and at grade four, between urban and rural schools in all participating systems (Fig. 1). Schools in urban areas had significantly more students than those in rural areas. However, these size differences vary across the Dinaric region. In Kosovo, urban schools were, on average, three times as large as rural schools, and, in

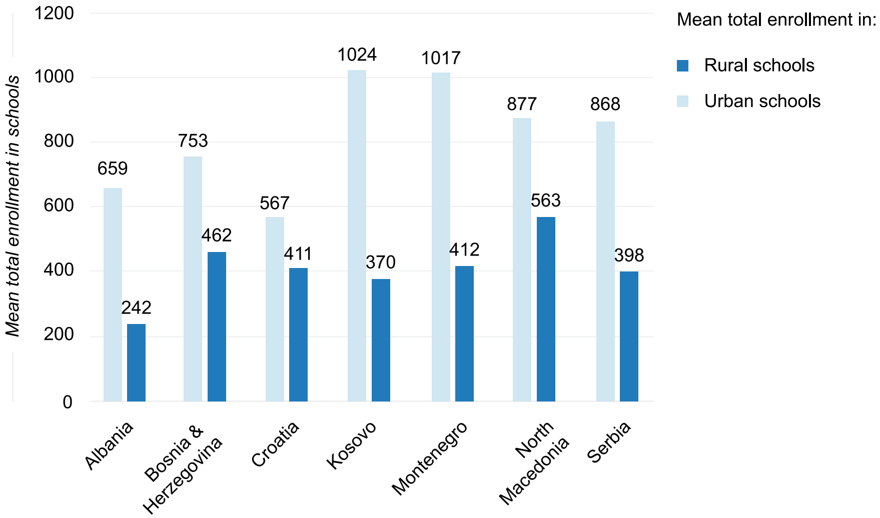

Fig. 1 School size (mean total enrollment) of urban and rural schools
Note In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

Montenegro, urban schools were about twice as large as rural schools; Croatia showed the smallest difference in school size by area (for in depth comparisons of average school size indicators by urbanization level, see Table S.18 in the supplementary materials available for download at www.iea.nl/publications/RfEVol13).

We used the variable school composition by socioeconomic background to categorize schools into three groups according to the number of enrolled students with different socioeconomic background. Across most of the Dinaric region, there were more students in more affluent schools in urban areas; the exception was Kosovo (Fig. 2). In North Macedonia and Croatia, more than 60% of students in urban schools attended more affluent schools. Conversely, rural schools were more likely to be more disadvantaged than urban schools. There was more variation within the group of school that were categorized as neither more affluent nor more disadvantaged; it is worth noting that, in North Macedonia, just five percent of students in urban areas were in this intermediate category of schools, suggesting severe social segregation existed in these urban areas.

As schools from different regions differ in terms of the socioeconomic background of their student bodies, teachers and schools in different regions experience different work conditions. Some teachers work in classes containing many students from economically affluent homes, while others work in classes where many students come from economically disadvantaged homes.

3.2 Students Achievement in Urban and Rural Areas

As our focus was on identifying the differences between urban and rural areas rather than across the region, we limited comparisons to the differences between the mean mathematics and science achievement among students in urban and rural schools, which we term the urban–rural achievement gap (Fig. 3).

First, we must note that there were statistically significant differences in student achievement depending on the urbanization of the student's school area across the whole of the Dinaric region. Students in urban schools had consistently higher mean achievement in mathematics and science than their peers in rural schools. The only exception was in Montenegro, where there was no difference in the mean achievement of students in schools of different urbanization levels in mathematics, although there was a difference for science. The biggest urban–rural achievement gaps were in Serbia and North Macedonia, in both mathematics and science; in both, the mean achievement of students in urban schools was 36–45 points higher than students attending rural schools. The achievement gaps in Albania and Kosovo were much smaller for both subjects, 18 and 25 points, respectively. Bosnia and Herzegovina, Croatia, and Montenegro formed a third group where mean achievement gaps for both subjects were less than 15 points, although still significant.

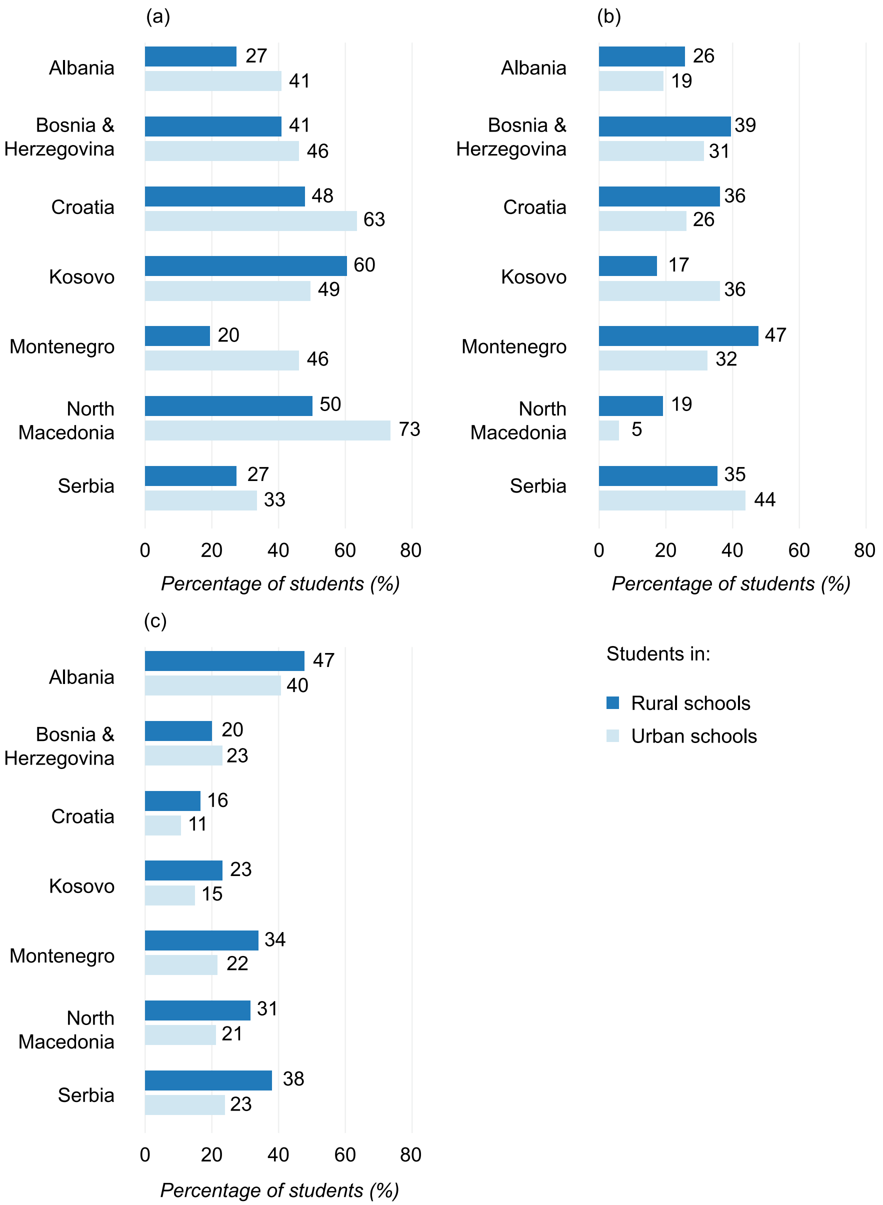

Fig. 2 Percentage of students in urban and rural schools by socioeconomic background of the student body
*Note*s Percentages add up to 100% for urbanization levels, allowing direct comparisons within and across economic groups. In Kosovo and Serbia, the national defined population 90–95% of the national target population. In Kosovo, data are available for ≥50% but <70% of students. (a) more affluent; (b) neither more affluent nor more disadvantaged; and (c) more disadvantaged

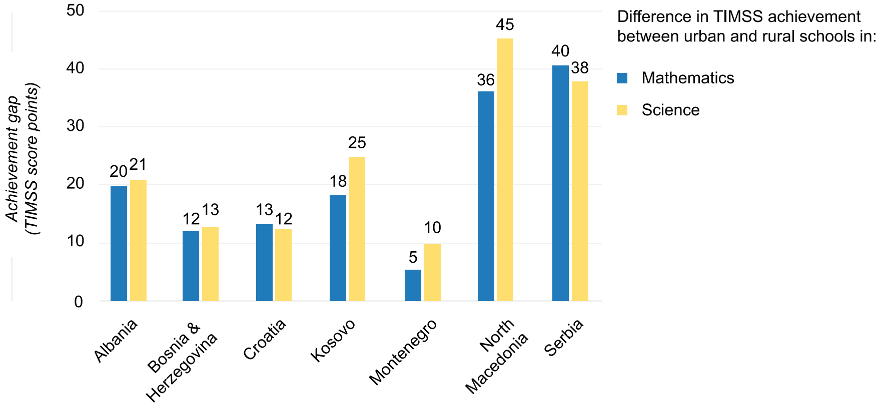

Fig. 3 Achievement difference in mathematics and science between urban and rural areas
Notes Positive values mean scores in urban areas were larger. Differences were statistically significant ($p < 0.05$) in all but in Montenegro for mathematics. In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

3.3 Urbanization and Different Kinds of Learning Supports for Students

Home Scaffolding

We used a TIMSS scale based on principals' estimates of the percentage of students in the school who possessed a range of literacy and numeracy skills when beginning primary school (the schools where students enter the primary grades with literacy and numeracy skills scale) as a measure of students' readiness for schooling. Comparing data for rural and urban schools in the seven Dinaric participants, we found that, in general, there were few statistically significant differences in readiness for school across the region. Statistically significant differences were only found in Montenegro and Serbia, where the data showed that, according to the principals, more students entering school with literacy and numeracy skills in urban schools than in rural schools; the differences were more pronounced in Serbia.

As a further indicator of the effects of urbanization, we analyzed differences in mean scores on the HRL scale; these were statistically significant for all participants (Fig. 4). This means that students in rural schools had, on average, fewer home resources (such as books, desks, their own room, and internet access) and less educated parents with lower occupational levels than their peers in urban schools. The differences the mean scores were largest in Albania, Serbia, and North Macedonia.

School Scaffolding

In general, according to principals' reports, schools across the Dinaric region placed a high emphasis on academic success (Fig. 5). However, there were statistically significant differences between schools in urban and rural areas in Croatia, Montenegro,

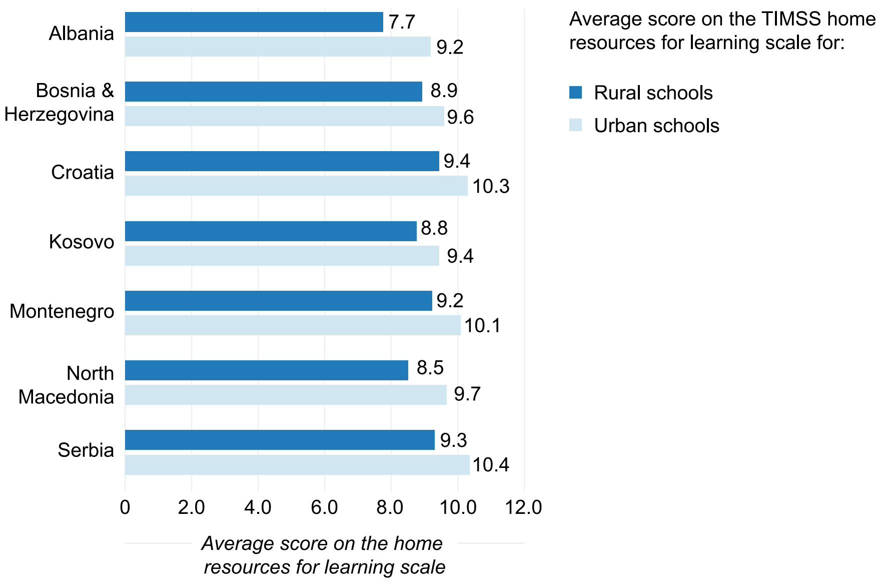

Fig. 4 Mean scores on the TIMSS scale home resources for learning for groups of urban and rural schools
Notes In Kosovo and Serbia, the national defined population covers 90–95% of the national target population. In Montenegro, data are available for ≥70% but <85% of students

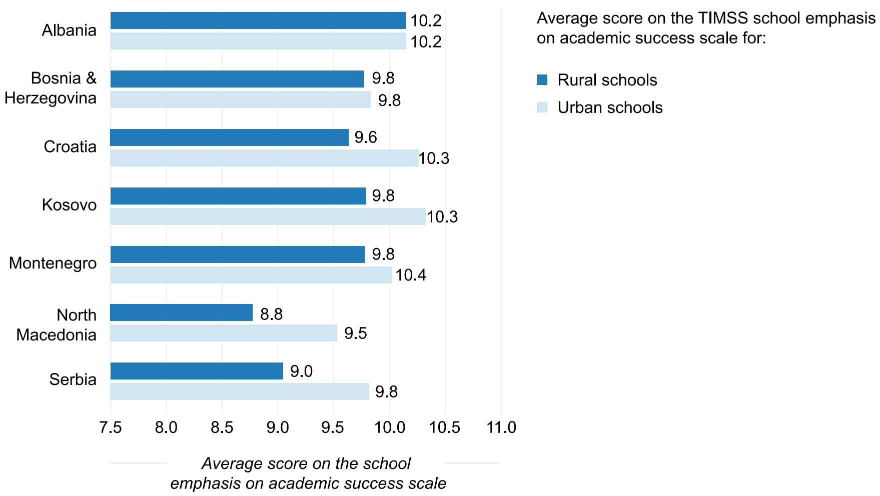

Fig. 5 Mean scores on the TIMSS scale school emphasis on academic success for groups of urban and rural schools
Note In Kosovo and Serbia, the national defined population covers 90–95% of the national target population

and Serbia. In all three of these systems, principals of urban schools tended to report higher levels of emphasis on academic success in their school community than principals of rural schools.

Our investigation of the additional material resources that may be available to students in schools, showed that the difference between percentages of students enrolled in urban and rural schools where an OLMS was available was only significant in Albania, where 19% of students in urban schools and only seven percent of students from rural schools had access to OLMSs. For the remainder of the Dinaric participants, urban and rural schools this indicator did not differ, nonetheless, the total percentage of schools using an OLMS varied across the Dinaric region (see Table S.19 in the supplementary materials available for download at www.iea.nl/publications/RfEVol13). In Albania and Kosovo, there were only low percentages of students in schools that had an OLMS, while Serbia, North Macedonia, and Croatia reported higher percentages of students were in school that had access to an OLMS.

Our assessment of the availability of technology for students in school and whether this availability differed in relation to school urbanization indicated that, overall, schools in the region were not well equipped with computers and there was considerable variation regarding availability to students (Fig. 6; see Table S.19 and S.20 in the supplementary materials available for download at www.iea.nl/publications/RfEVol13). While in most of the Dinaric education systems, there was one computer for approximately every 10 students, the availability of computers was noticeably lower in urban schools in Kosovo. In North Macedonia, a computer was shared between four students in urban schools and between two students in rural schools. The student:computer ratio was lower in urban than rural schools in Albania, Croatia, Kosovo, and North Macedonia. Kosovo had more computers per student in rural schools than in urban schools, suggesting that they had invested in providing this type of additional school scaffolding to rural communities. Access to digital resources was also inconsistent for students in Albania, Kosovo, and Montenegro, where the percentage of students in schools with access to digital resources was higher in urban than in rural areas.

Laboratories

Overall, data for schools that had a laboratory and provided assistance for conducting science experiments showed that there were few significant differences (Table 3). Students in urban schools in Albania had greater access to laboratories (26%) and were provided more assistance with conducting science experiments (21%) then their peers in rural schools (5% and 6%, respectively). Conversely, in Montenegro, a larger percentage of students in rural schools had access to laboratories (28%) and assistance with conducting science experiments (50%) than their peers in urban schools (20% and 23%, respectively). While Serbia reported no significant differences between urban and rural schools regarding the availability of laboratories, there was a significant difference in the availability of assistance for conducting science experiments. In urban schools 39% of students received this kind of support during teaching, while only 19% of students in rural schools had this support.

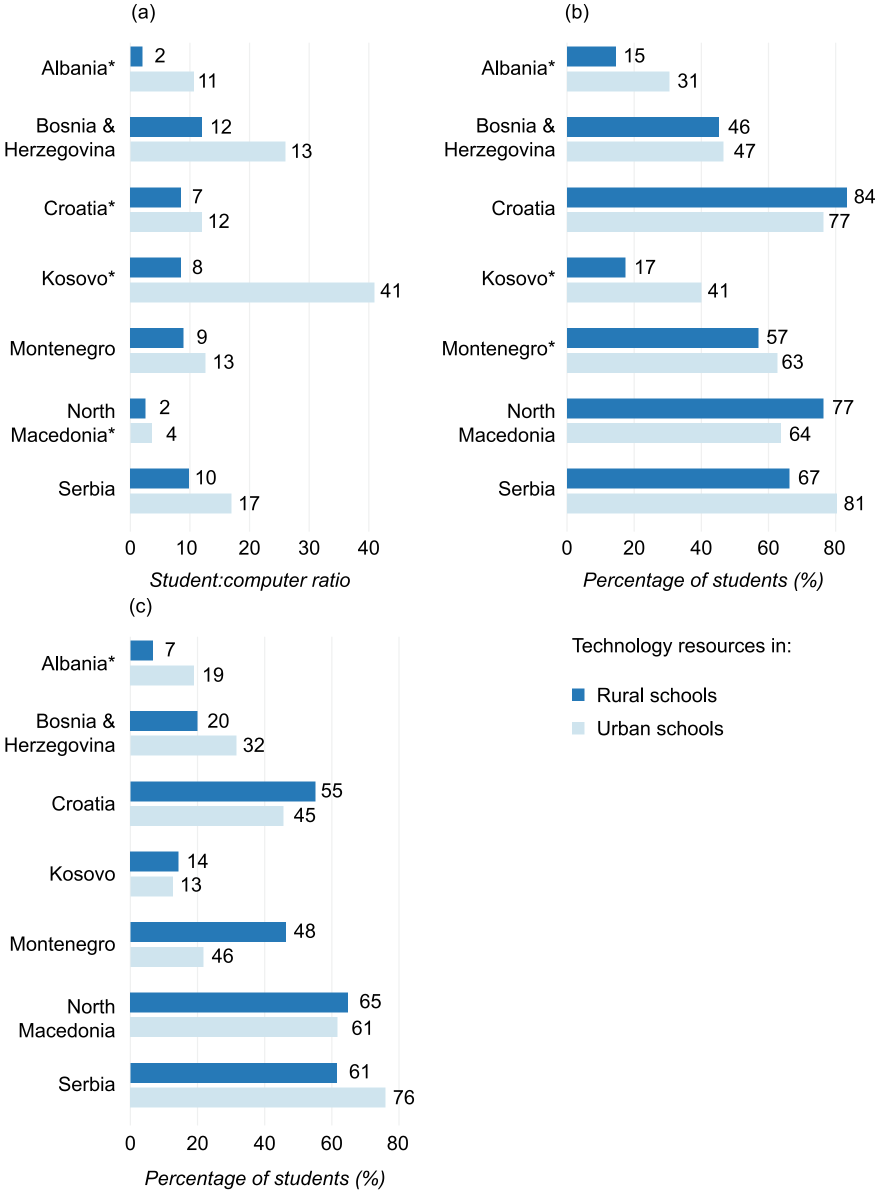

Fig. 6 Assessment of technology resources in urban/rural schools: **a** the average student:computer ratio in grade four classrooms; **b** percentage of students that had access to digital resources in school; and **c** percentage of students in schools that had access to an online learning management system *Notes* In Kosovo and Serbia, the national defined population covers 90–95% of the national target population. *differences were statistically significant ($p < 0.05$)

Table 3 Percentages of students in schools with a science laboratory and in schools that provide assistance for conducting science experiments

Education system	Percentage of students in schools where a science laboratory is available			Percentage of students in schools where assistance for conducting science experiments is available		
	Urban	Rural	Difference	Urban	Rural	Difference
Albania	26 (3.6)	5 (2.7)	**21** (4.9)	21 (4.2)	6 (2.5)	**15** (4.8)
Bosnia & Herzegovina	19 (4.8)	7 (3.2)	12 (6.6)	24 (4.8)	28 (5.7)	−5 (7.8)
Croatia	6 (2.7)	6 (3.6)	0 (4.5)	15 (3.7)	15 (4.8)	0 (6.0)
Kosovo[a]	24 (6.2)	14 (4.5)	10 (7.9)	14 (4.5)	8 (3.7)	6 (5.7)
Montenegro	20 (0.3)	28 (1.2)	−**8** (1.2)	23 (0.4)	50 (2.1)	−**27** (2.1)
North Macedonia	4 (2.2)	9 (3.9)	−5 (4.3)	38 (5.1)	25 (6.4)	14 (8.4)
Serbia[a]	11 (2.9)	10 (3.6)	1 (4.4)	39 (5.4)	21 (5.8)	**18** (7.7)

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

Libraries

When comparing the availability of school libraries in urban and rural schools, we found only Kosovo and Northern Macedonia showed significant differences (Table 4). In Kosovo, 90% of students in urban schools had access to a school library, while this percentage was lower for students in rural schools (73%). A slightly smaller percentage difference occurred in North Macedonia, where all students in urban schools had libraries compared to only 89% of students in rural schools.

Some schools reported having large libraries, containing more than 2000 books; for this factor the differences were only significant in Albania and North Macedonia. In Albania, 28% of students attending urban schools had access to large libraries, while only one percent of students in rural schools had similar resources. Data for North Macedonia indicated that large 76% of students in urban schools had access to large school libraries, compared to only 51% of students in rural areas.

Classroom libraries were available for small percentages of students in all seven TIMSS participants, but the urban–rural difference was only significant in Kosovo and Montenegro. In urban schools, 16% of students in Kosovo and 18% of students in Montenegro had classroom libraries; the comparable figures for rural schools were three percent of students in Kosovo and 11% of students in Montenegro.

3.4 Student Achievement in Urban and Rural Areas Regarding the Type of Scaffolding

To better understand how all these factors were related to student achievement, we undertook regression analyses to predict mathematics and science achievement from

Table 4 Percentages of students in schools with a library

Education system	Percentage of students in schools where a school library was available			Percentage of students in schools where the library had >2000 books			Percentage of students in schools where classroom libraries were available		
	Urban	Rural	Difference	Urban	Rural	Difference	Urban	Rural	Difference
Albania	96 (2.1)	92 (3.8)	4 (4.2)	28 (4.5)	1 (1.5)	**26** (4.8)	22 (4.2)	13 (5.2)	9 (6.4)
Bosnia & Herzegovina	100 (0.0)	100 (0.1)	0 (0.1)	84 (4.0)	75 (5.2)	9 (6.1)	5 (2.5)	3 (2.0)	2 (3.2)
Croatia	100 (0.0)	98 (2.2)	2 (2.2)	79 (4.9)	75 (6.5)	4 (8.5)	11 (3.6)	6 (3.6)	5 (5.1)
Kosovo[a]	90 (3.7)	73 (5.4)	**16** (6.5)	24 (7.0)	13 (4.7)	10 (8.9)	16 (4.4)	3 (2.2)	**13** (5.0)
Montenegro	100 (0.0)	100 (0.0)	0 (0.0)	85 (0.2)	85 (0.7)	0 (0.8)	18 (0.4)	11 (0.5)	**7** (0.6)
North Macedonia	100 (0.0)	89 (3.8)	**11** (3.8)	76 (5.0)	51 (7.7)	**25** (8.9)	26 (5.2)	16 (6.1)	10 (7.9)
Serbia[a]	100 (0.0)	92 (4.1)	8 (4.1)	87 (3.4)	81 (6.3)	6 (7.5)	9 (2.7)	2 (2.2)	6 (3.5)

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

Table 5 Amount of variance in student mathematics achievement by school location, the home resources for learning scale (HRL) and the school emphasis on academic success scale (SEAS)

Education system	Number of students (n)	Variance (R^2) explained by model	Standardized regression coefficients					
			Urbanization		SEAS		HLR	
Albania	3986	0.17	−0.03	(0.05)	**0.13**	(0.04)	**0.38**	(0.03)
Bosnia and Herzegovina	5260	0.12	0.00	(0.03)	−0.02	(0.03)	**0.35**	(0.02)
Croatia	3684	0.13	−0.01	(0.03)	0.01	(0.03)	**0.36**	(0.03)
Kosovo[a]	4256	0.09	0.04	(0.04)	**0.09**	(0.03)	**0.27**	(0.02)
Montenegro	4325	0.13	**−0.05**	(0.02)	−0.01	(0.02)	**0.37**	(0.01)
North Macedonia	2685	0.23	0.01	(0.05)	0.06	(0.05)	**0.45**	(0.02)
Serbia[a]	4184	0.27	**0.06**	(0.03)	0.05	(0.03)	**0.49**	(0.02)

Notes To assess the urbanization level of schools, we coded rural schools as 0 and urban as 1. R^2 = the proportion of variance in the outcome variable that is explained by the set of predictor variables. Statistically significant ($p < 0.05$) regression coefficients are shown in bold. Standard errors appear in parentheses

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

the urbanization level of schools, home resources for learning scale scores, and the school emphasis on academic success scale scores (where higher values mean more home resources were available and the school placed greater emphasis on academic success) (Tables 5 and 6).

The three predictors together explained between nine and 27% of variance in achievement across the Dinaric region, which is a remarkable amount given the many factors that potentially affect student achievement. Home resources for learning was a significant predictor for all participants after controlling for urbanization and school emphasis on academic success. While school emphasis on academic success was a significant predictor of grade four students' mathematics and science achievement in Kosovo and Albania, the urbanization level of the school was only significant for mathematics achievement and only in Montenegro and Serbia. Nevertheless, all these significant coefficients were rather low, and, after controlling for school emphasis on academic success and home resources for learning, the difference in achievement scores between urban and rural schools disappeared. In other words, differences in student achievement between urban and rural schools seem to be largely determined by the students' backgrounds, and these may vary considerably according to the urbanization of the area surrounding the school.

Table 6 Amount of variance in student science achievement by school location, the home resources for learning scale (HRL) and the school emphasis on academic success scale (SEAS)

Education system	Number of students (n)	Variance (R^2) explained by model	Standardized regression coefficients:					
			Urbanization		SEAS		HLR	
Albania	3986	0.16	−0.01	(0.05)	**0.14**	(0.04)	**0.36**	(0.03)
Bosnia and Herzegovina	5260	0.10	0.01	(0.03)	−0.01	(0.03)	**0.31**	(0.02)
Croatia	3684	0.13	−0.01	(0.03)	0.02	(0.03)	**0.37**	(0.02)
Kosovo[a]	4256	0.10	0.07	(0.04)	**0.11**	(0.03)	**0.26**	(0.03)
Montenegro	4325	0.14	−0.03	(0.02)	−0.01	(0.02)	**0.38**	(0.02)
North Macedonia	2685	0.25	0.04	(0.05)	0.08	(0.05)	**0.46**	(0.03)
Serbia[a]	4184	0.27	0.06	(0.03)	0.05	(0.03)	**0.49**	(0.02)

Notes To assess the urbanization level of schools, we coded rural schools as 0 and urban as 1. 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

4 Discussion

International studies have noted differences in educational achievement between urban and rural schools, generally in favor of the urban schools (see e.g., Mohammadpour & Abdul Ghafar, 2014; Piyaman et al., 2017; Wasley et al., 2000). We aimed to identify variables which could enhance understanding of differences between urban and rural schools. We analyzed any differences and similarities between these two groups of schools in Dinaric region and analyzed the type and quality of the scaffolding for learning that students received from both home and school.

Our comparisons confirmed that urban and rural schools tended to have different demographic structures. In all seven participating systems, there were more students in total and more grade four students enrolled in urban schools than rural schools. Not only were there fewer students enrolled in rural schools, but these schools are also smaller. We also analyzed principals' reports of the percentage of enrolled students that came from homes with different socioeconomic situations. The data revealed that, in general, the percentages of students enrolled in the schools categorized as more affluent tended to be higher in urban areas than in rural areas.

Students' TIMSS achievement scores can usually be attributed to a combination of factors, including factors related their family background, and other school- or teacher-related factors. We wanted to establish whether the support that comes with these factors differed between urban and rural areas. At the family level, we assessed variables related to student readiness for schooling and home resources for learning. In general, scaffolding in learning measured by scores on the schools where students enter the primary grades with literacy and numeracy skills scale did not appear to differ substantially between urban and rural schools; students in five out of the seven participating systems tended to achieve similar mean scores in both urban and rural schools. However, in Montenegro and Serbia, principals of students in urban areas tended to report that their children started school more prepared in comparison to the reports from principals of rural schools. While the analyses for most Dinaric participants showed no differences in principals' perceptions of the readiness of students for schooling between urban and rural schools, there were differences in home resources for learning. In all participating seven Dinaric systems, students from urban areas had better access to resources such as books in the home and home study supports, and tended to have parents with higher educational and occupational levels.

At the school level, we analyzed the factor school emphasis on academic success and the material resources for learning available in the school. School emphasis on academic success differed between urban and rural schools in only three of the education systems, while in other four there was no difference between urban and rural schools. In Croatia, Montenegro, and Serbia, school emphasis on academic success was lower in rural areas than in urban areas. This led us to investigate school education policies in these systems to discover the reasons underlying such differences. We also examined the material resources that were available to students in schools. In general, in most of the participating systems, urban and rural schools has similar levels of access to technology, libraries, and laboratories. There were a few exceptions to this, which may provide important lessons for improving learning environment in rural schools. For instance, students in urban schools in Albania had greater access to laboratories and to assistance in conducting science experiments than students in rural schools. In Kosovo and North Macedonia, the percentage of rural students that had access to libraries was significantly lower than percentage of students that such critical support in urban area. These findings provide a good basis for policymakers to discuss when considering the topic of rural schools. All Dinaric education systems are advised to devote more attention to equipping rural schools with the requisite technologies and resources to compensate students for the reduction in educational opportunities created by lack of such resources in the home.

Our analyses of the TIMSS 2019 data confirms that an achievement gap between urban and rural areas exists in all seven Dinaric systems. The achievement gap was substantial in Serbia and Kosovo (up to 40 points), both for science and mathematics achievement. Our regression analyses showed that, after controlling for school emphasis on academic success and home resources for learning, the difference in achievement scores between urban and rural schools disappeared. Note that, in our analyses, we simplified the distinction between these two groups of schools (urban and rural), but there may be additional differences between densely populated metropolitan capital cities and other districts.[2]

[2] National achievement testing (Baucal et al., 2007) and analysis of the human development index results (Vujnić, 2014) showed, for example, that treating the center of Belgrade (Serbia) as a separate region returned different perceptives and prediction models for achievement.

Analyses of the TIMSS 2019 results provide valuable evidence-based data for both policymakers and those professionally engaged in topics related to urbanization and education. We have identified several key points that are significant across the Dinaric region: (1) there needs to be increased awareness of the difference in achievement in students from different locations; (2) rural areas often lack resources for learning in the home, putting students from these areas at a disadvantage; and (3) all schools require the requisite technologies and equipment to support their students, while the demands may differ by location. The overarching message is that there are students who experience very different learning conditions created by location, and their achievement may thus differ. We suggest that families from rural areas require significant support in order to minimize the differences in learning outcomes among students. Schools may need additional support to provide the laboratory equipment, materials, computers, and software that can help in better developing students' competencies. Of course, the availability of school resources does not automatically mean that they will be used in the classroom; teachers also need to have the knowledge and skills to use the available resources successfully. Therefore, resources need to be accompanied by investment in the professional development of teachers' competencies so that educational resources are used most effectively. As well as equipping households with computer equipment and supplying books, families will need additional support to make optimal use of the materials. The learning process in rural schools needs to be constantly reviewed, to broaden understanding of the factors affecting student achievement. In future analyses, it would be interesting to compare this Dinaric data with similar research efforts in other European countries, or even a more global TIMSS context.

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