Introduction to Dinaric Perspectives on TIMSS 2019

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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 km², 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 km² and 13,810 km², respectively, while Serbia is geographically the largest at 88,360 km².

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 km² and 105 people per km², 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 study³ 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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