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# Comparison of the content of Data display domain (TIMSS 2015) in Slovak and Singapore primary mathematics curriculum

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**Abstract**. International benchmark assessments have been a measure of a success of an education system for several decades [1]. They provide data for evaluating the knowledge of students of different ages in the given subjects, and offer us a unique opportunity to compare the performance of students in the Slovak Republic with the performance of students in other countries of the world. The TIMSS (Trends in International Mathematics and Science Study) has monitored trends in mathematics and science achievement at the fourth and eighth grades since 1995. The latest released results of the study are from 2015. Each of assessment frameworks for TIMSS 2015 was organized around two dimensions: Content dimension (the subject matter) and Cognitive dimension (the thinking processes). In the Content dimension of mathematics, three content domains were assessed: Numbers, Geometric shapes and measures, and *Data display*. Slovak 10-year-old students achieved 492 points in TIMSS 2015 – *Data display* domain, which is incomparable with 600 points of Singapore 4$^{th}$ grade students [3]. In Slovakia, in addition to international testings, since 2015 the National Institute of Certified Educational Measurements (NICEM) [2] has also been organizing nationwide testings of 5$^{th}$ grade students – T5. In T5 from mathematics, five thematic units are represented, including *The solution of application tasks and tasks developing specific mathematical thinking* – which is comparable to the domain of the *Data display* in TIMSS. From the results (52,06 % in 2019), it is clear that statistical literacy is a major problem for Slovak 5$^{th}$ grade students. These facts led us to review the Singapore and Slovak curricula focusing on the display of the *Data display* domain, and to compare the content of education in the domain in Slovakia and Singapore with TIMSS 2015 mathematical framework.

**Keywords**. Data display, Mathematics, Primary education, Singapore, Slovak republic, TIMSS, T5

## Introduction

International benchmark assessments have been a measure of a success of an education system for several decades [1]. They provide data for evaluating the knowledge of students of different ages in the given subjects, and offer us a unique opportunity to compare the performance of students in the Slovak Republic with the performance of students in other countries of the world.

The TIMSS (Trends in International Mathematics and Science Study) has monitored trends in mathematics and science achievement at the fourth and eighth grades since 1995. It is carried

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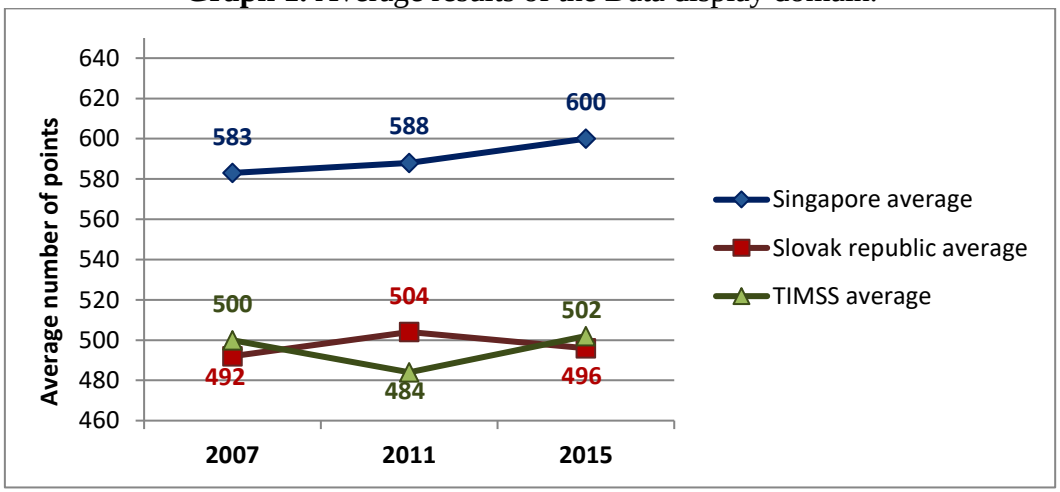
out under the auspices of the IEA (International Association for the Evaluation of Educational Achievement), regularly in four-year cycles. Slovak eighth grade students have been involved in the research since 1995 and fourth graders since 2007 [2].

The latest released results of the study are from 2015. Each of assessment frameworks for TIMSS 2015 was organized around two dimensions: Content dimension (the subject matter) and Cognitive dimension (the thinking processes). In the Content dimension of mathematics, three content domains were assessed: *Numbers*, *Geometric shapes and measures*, and *Data display* [3]. The *Numbers* domain is focused on numbers and basic arithmetic operations, the *Geometric shapes and measures* domain examines the level of geometric literacy of students and the *Data display* domain determines students' ability to work with data shown mainly in graphical form (tables, graphs, diagrams and pictograms). The last area, *Data display*, examines precisely those areas of mathematics that belong to statistical literacy [4]. In the case of primary school students, it is statistical literacy at the basal level.

Slovak 10-year-old students achieved 498 points in TIMSS 2015, which is a result comparable to the average of the TIMSS scale (500 points), but statistically significantly lower than the average of participating EU countries (527 points) and OECD countries (528 points). According to *Achievement in mathematics content domains*, the second most problematic area for Slovak students is the *Data display* domain [5] [6].

On the contrary, students from Singapore ranked highest on the TIMSS 2015 [6] scale. In the *Data display* domain, they achieved 600 points, which is incomparable with 496 points of Slovak students. The average results of the *Data display* domain of Slovakia and Singapore compared to the TIMSS scale average of the given domain are shown in Graph 1.

**Graph 1.** Average results of the Data display domain.




In Slovakia, in addition to international testings, since 2015 the National Institute of Certified Educational Measurements (NICEM) has also been organizing nationwide testings of 5th grade students – T5. Students of 5th grade are tested in their mother tongue and mathematics at the beginning of the school year [2].

The aim of T5 of mathematics is to objectively determine the level of mathematical literacy of students and to compare the performance of individual students when entering the first year of lower secondary education [7]. The tests are aimed at verifying the permanence, depth and scope of knowledge and the ability of students to use the acquired knowledge meaningfully. In T5 from mathematics, five thematic units are represented, including *The solution of application tasks and tasks developing specific mathematical thinking* [2] – which is comparable to the domain of the *Data display* in TIMSS.

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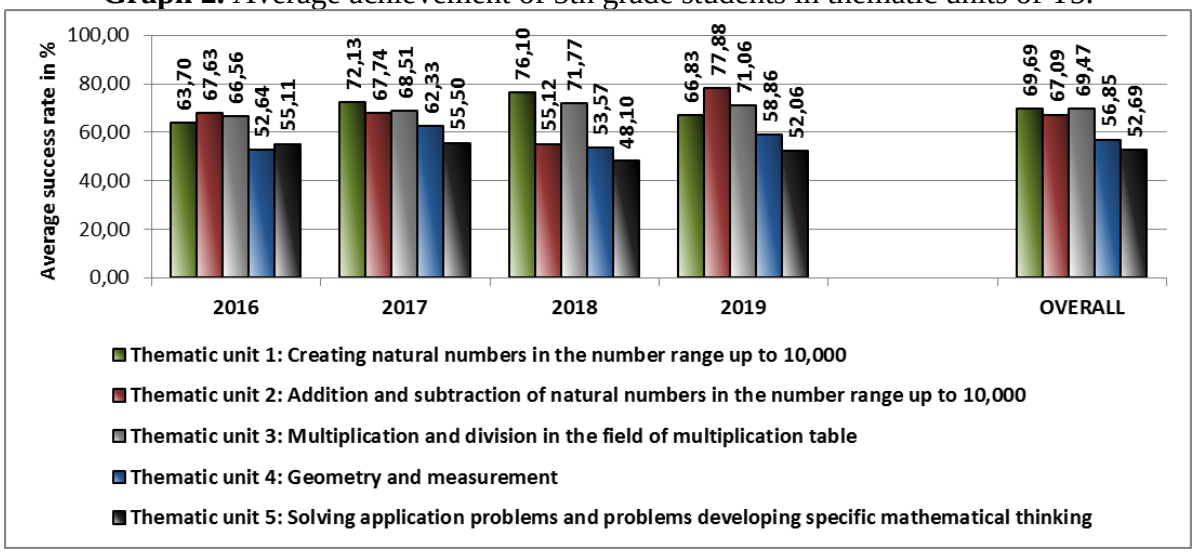
**Graph 2.** Average achievement of 5th grade students in thematic units of T5.




As can be seen in Graph 2, Slovak 5th grade students have achieved the worst results in the Thematic unit 5: *Solving application problems and problems developing specific mathematical thinking* repeatedly. On the contrary, they achieve the most favorable results in the Thematic unit 1: *Creating natural numbers in the number range up to 10,000*. The data are processed on the basis of the results from T5 in the years 2016 – 2019, which were attended by 185 269 5th grade students. The number of students in each year of T5 is shown in Table 1.

**Table 1.** Number of students in individual years

| Count | Year | | | | Total |
|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2019 | |
| **Girls** | 22 119 | 22 120 | 22 890 | 23 726 | 90 855 |
| **Boys** | 23 167 | 22 942 | 23 461 | 24 844 | 94 414 |
| **Total** | 45 286 | 45 062 | 46 351 | 48 570 | 185 269 |

These facts led us to review the Singapore and Slovak curricula focusing on the display of the *Data display* domain, and to compare the content of education in the domain in Slovakia and Singapore with TIMSS 2015 mathematical framework.

## 1. Mathematics at the primary level of education in Slovakia

Mathematics is included among the compulsory subjects throughout primary education. Students spend four 45 minutes periods per week on mathematics form 1st till 4th grade, but the Ministry of Education within the Framework Curriculum offers a total of 8 hours (for the whole primary education cycle) left to the school head's discretion, which can be used according to the school's own focus or as needed. In total, primary school students spend about 18% of school time on mathematics lessons [8].

Mathematical education in Slovakia is guided by an effort to enable students to acquire new knowledge in a spiral [9]. The aim of mathematical education at the primary level of education

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is to develop students' mathematical thinking, which is necessary for solving various problems in everyday situations; prepares them for individual acquisition and application of knowledge. Mathematical education develops logical and critical thinking, students' ability to analyze and synthesize, seek appropriate strategies for solving problem tasks (including group cooperation) and verify them in practice [10]. One of the aims of mathematical education is also to strengthen positive moral and will qualities (independence, determination, perseverance, tenacity, criticism, self-criticism, self-confidence, skills and possibilities, systematicness in solving problems) [9].

The mathematics syllabus [9] for each grade is divided according to the areas of mathematics: natural numbers, operations with natural numbers (addition, subtraction, multiplication and division), geometry and measurement and solving application problems and problems developing specific mathematical thinking.

## 2. Mathematics at the primary level of education in Singapore

Mathematics is a compulsory subject throughout the primary level of education. The Ministry of Education provides guidelines for mathematics curriculum at primary level. For 1st grade those are seven and for 2nd grade nine periods of 30 minutes each per week. Students of 3rd to 4th grade should attend eleven 30-minute mathematics lessons per week. This means that about 20% of the school teaching time in the early grades is devoted to mathematics [11].

The mathematics curriculum, centrally planned by the Ministry of Education, respects the hierarchical nature of mathematics, and a spiral approach is used in its conception and design. Mathematical education at primary level aims to enable all students to: “acquire mathematical concepts and skills for everyday use and continuous learning in mathematics; develop thinking, reasoning, communication, application and metacognitive skills through a mathematical approach to problem-solving; build confidence and foster interest in mathematics” [12].

The syllabi developed by the Ministry of Education [12] are arranged along three content areas with a list of mathematical processes that relate to the given areas. The content areas consist of: number and algebra, measurement and geometry and statistics.

## 3. Comparison of Data display domain in Slovak and Singapore primary school mathematics curriculum and TIMSS 2015 mathematics framework

As mentioned above, the aim of this paper is to review Singapore and Slovak curricula focusing on the display of the *Data display* domain, and to compare the content of education in the domain in Slovakia and Singapore. Our research questions are therefore formulated as follows:

1. *What is the content of the Data display domain for grades 1 – 4 in primary education in Slovakia and Singapore?*
2. *What is the difference between the content of the Data display domain for grades 1 – 4 in primary education in Slovakia and Singapore?*
3. *What are the similarities between the Data display domain in the curriculum of the chosen countries and the TIMSS 2015 Mathematics Framework?*

In order to be able to answer our research questions we needed to make curricula more transparent and demonstrate the links between elements in different curricula correctly. Therefore we used a method for creating and using the curriculum map – visual representation of components and characteristics of a curriculum so that the constituent parts are visible, thus allowing for easier review and potential comparison [13].

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**Table 2.** Curriculum mapping

| Key stage | Description |
|---|---|
| **Aim and purpose** | To review and compare content of the *Data display* domain in Singapore and Slovak primary mathematics curricula. |
| **Curricula** | Mathematics curricula for primary education issued by the Ministry of Education of the Slovak Republic and the Ministry of Education of the Republic of Singapore. |
| **Key features of comparison** | Content of *Data display* domain (according to TIMSS 2015 – Content dimension). |
| **Data** | Slovakia: Štátny vzdelávací program pre primárne vzdelávanie – 1. stupeň základnej školy – Matematika – primárne vzdelávanie.<br><br>Singapore: Mathematics Syllabus. Primary One to Six.<br><br>International studies such as Trends in International Mathematics and Science Study (TIMSS). |
| **Instrument** | Hypothetical standard instrument: Comparison of Slovak and Singapore mathematics curricula based on TIMSS 2015 mathematics framework. |
| **Visualization** | Tables. |

In Slovakia, the *Data display* domain is located in the thematic area entitled *Solving application problems and problems developing specific mathematical thinking*. We include work with tables and bar graphs there. In Singapore, the content of education from the given area is a part of the Statistic section – *Data representation and interpretation* sub-strand. It includes picture graphs with and without scales, bar graphs, tables and line graphs. The content of the *Data display* domain in the mathematics curriculum of chosen countries is summarized in Table 3.

**Table 3.** Content of *Data display* domain in Slovakia and Singapore according to grades

| Grades | Slovakia | Singapore |
|---|---|---|
| **1. grade** | Tables | Picture graphs |
| **2. grade** | Tables | Picture graphs<br>with scales |
| **3. grade** | Tables<br>Bar graphs | Bar graphs |
| **4. grade** | Tables<br>Bar graphs | Tables<br>Line graphs |

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Throughout their studies, Slovak primary school students work only with tables and bar graphs. During the 1st and 2nd year of primary school, students devote themselves to work with tables only. They learn to distinguish rows and columns, write data to a table, create their own tables and use tables as a tool for solving problems. In the 3rd year, students continue to work with tables and also get acquainted with bar graphs – learn to work with them, draw them and use them as a tool for solving problems. In the 4th year, students improve their work with tables and bar graphs [9].

*Data display* domain in the 1st and 2nd grade in Singapore is focused on picture graphs. First graders should learn how to read and interpret data from picture graphs, and second graders are required to read and interpret data from picture graphs with scales and solve 1-step problems using data from picture graphs. The task of third-year students is to be able to read and interpret data from bar graphs, use different scales on axis and solve 1-step problems using data from bar graphs. 4th grade students complete tables from the given data, read and interpret data from tables/line graphs, and solve 1-step problems using data from tables or graphs [6]. As can be seen in Table 3 Slovak and Singapore mathematics curricula have only 2 topics in common.

The content dimension of the *Data display* domain in the TIMSS 2015 [3] consists of one topic area: *Reading, interpreting, and representing*. Students of 4th grade should be able to: read, compare, and represent data from tables, pictographs, bar graphs, line graphs and pie charts; and use information from *Data display*s to answer questions that go beyond directly reading the data displayed (e.g., solve problems and perform computations using the data, combine data from two or more sources, make inferences, and draw conclusions based on the data).

**Table 4.** Topics included in the mathematics curricula for 1st – 4th grade in chosen countries

| **Are the following topics included in the curricula?** | **Curriculum 1 (Slovakia)** | **Curriculum 2 (Singapore)** |
|---|---|---|
| ***1. Tables*** | Yes | Yes |
| ***2. Pictographs*** | No | Yes |
| ***3. Bar graphs*** | Yes | Yes |
| ***4. Line graphs*** | No | Yes |
| ***5. Pie charts*** | No | No |
| **Number of correspondent topics overall** | **2**/5 | **4**/5 |

Based on the statistical analysis of TIMSS, the difference between the level of knowledge in the *Data display* domain of Slovak and Singaporean primary school students is supremely obvious. The low level of statistical literacy in Slovakia is also confirmed by the results of T5.

The difference between Slovak and Singapore mathematics curriculum and TIMSS 2015 mathematics framework can be found already in its content. While Slovak students can meet only with tables and bar graphs at their mathematics lessons, students from Singapore work with tables and almost all kinds of graphs/charts included in TIMSS assessments during their primary school (1 – 4 grade) studies. Slovak primary school students do not spend enough time by learning statistical literacy. Even in studying material (textbooks) from math there are not

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enough tasks using information in tables or graphs. That could also be the reason why Slovak students do not achieve as good results as students in Singapore.

## 4. Conclusion

The importance of statistical literacy today is constantly growing. We are surrounded by information and data that needs to be organized, analysed and evaluated in order to make sense of them. The IEA [3] states that "students need to understand that graphs and charts help organize information or categories and provide a way to compare data" and so "at the fourth grade, students should be able to read and recognize various forms of *Data display*s. Given a simple problem situation and the data that has been collected, students should be able to organize and represent the data in graphs and charts that address the questions that prompted the data collection. Students should be able to compare characteristics of data and to draw conclusions based on *Data display*s". The importance of statistical literacy is not only linked to good results in national or international testings, the ability to understand information provided in the form of tables or graphs is also very important for solving problems in everyday life. As part of the findings in our research, we identify with the arguments of Jurečková and Csachová [4] who claim that statistical literacy is a gradual and long-term developing skill, which develops to different levels and at different rates in individuals. Achieving a certain level depends not only on computational skills, which is dominant in school mathematics, but is also significantly affected by the level of context knowledge and the ability to interpret and evaluate statistical information. The research findings show that there is not enough attention paid to statistical literacy in mathematics lessons in Slovakia. For this reason, we consider it appropriate to be inspired by the mathematics curriculum in Singapore, which is structured in such a way, that students learn to work with one of the simplest types of graphs (picture graphs) and gradually move to more complex graphical representations of data. Results of both researches indicate that increased attention needs to be paid to this field of education in Slovakia [4].

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