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COMPETENCE OF MATHEMATICS OF 4th GRADE STUDENTS OF LATVIA IN INTERNATIONAL COMPARISON

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ABSTRACT

Education in Latvia currently is facing major changes. Learning content is based on a competences-based approach. The competences approach is wide spreading in the curricula of other countries, but each country has a different approach to implementing the competences. Not only in the context of the competences-based approach, but also in the education processes in general, the quality of education is emphasised. The quality of education receives increased attention, including of analyse various aspects – the students' level of knowledge and skills, the professional competence of teachers and principals, the school infrastructure, the evaluation of the education system, etc. In Latvia, the Education Law defines the quality of education, which is similar to the other definitions and explanations of the quality of education that also focuses on the learner acquiring the knowledge and skills, which are required to succeed in life.

In countries where the content of the competences-based approach is implemented learning areas are identified. The breakdown of the learning areas varies from country to country, but the core areas are the same: languages, science, maths and arts. This article will analyse students' mathematics competence to find out which of the skills are better developed, and which of them need further improvement. For that Trends in International Mathematics and Science Study (TIMSS) 2019 data are used, which shows that 4th grade students in Latvia are the 10th best mathematicians in the world, however that does not mean that there are no areas for more development. To become one of the best education systems in the world, it is needed to look for weaknesses and try to reduce them. This article highlights these areas. The aim of this article is to identify the weaknesses of students in Latvia in mathematics competences in TIMSS 2019 and give recommendations what could improve the mathematics competences of students in Latvia and their chances to become better mathematicians.

Keywords: *Competence, Mathematics, Mathematical skills, TIMSS, 4th graders*

Introduction

Today, as automated jobs are on the rise and technology becomes more important in all areas of work and life and also in business sector, social and civic competences

become increasingly important to ensure resilience and adaptability to change, competence requirements have changed (European Union, 2018). In the past it was assumed that a person's life skills were fully acquired at school, but today's rapid developments have led to a change in previous education policies, as students are leaving secondary education with a lack of skills needed for a life of achievement in the world of work and society. As one of the pillars of Sustainable Development, the modern education based on a competence approach was promoted. In the UNESCO Education 2030 Incheon Declaration and Framework for Action the main objective is to set the establishment of a sustainable and inclusive education process in schools which is based on competences approach (UNESCO, 2016). In Latvia a competences-based approach to the curriculum also has been gradually introduced from 2019 until 2023 (Cabinet of Ministers Regulation No. 747, 2018).

The skills needed to succeed in life in the world are changing, and there is a gap between the skills learned in school and the skills needed to function in the workplace and society. Learning, communicating, collaborating and problem-solving in a digital environment requires a wide range of skills. The Skills of 21st Century have been identified by UNESCO, OECD and others as competences required for a sustainable future of the knowledge society (European Commission, 2019; UNESCO, 2012; Ananiadou & Claro, 2009; OECD, 2019; González-Salamanca et al., 2020).

The competences-based approach to learning in the European Union has developed over the last 20 years as a result of policy orientations when it was realised that the skills needed today in the world of work and in society at large were insufficient to achieve the desired goals, because the knowledge we learn at school is insufficient in terms of certain skills that are needed in order to be successful in life. Competences are needed to equip students and adults with the skills they need in a world where change is happening every day, including changes in the society, economics, the world of work and employment, climate change, interculturality and interdependence (UNESCO, 2015). The most important basic competences person needs to learn at the age when person is attending school to succeed in life.

Key competences are a set of knowledge, skills and attitudes that are needed for personal fulfilment and development, employability, social inclusion and active citizenship (European Union, 2018). The 2018 Council recommendation on key competences for lifelong learning defines eight key competences that all learners should acquire: literacy; multilingual; mathematics, science, technology, and engineering; digital; personal, social and learning to learn; citizenship; entrepreneurship; cultural awareness and expression (European Union, 2018).

This article will focus on one of these competences, mathematics competence, which is important not only to be successful in different subjects but also to be able to integrate successfully in today's society by being able to deal with different problem-solving situations. Mathematics competence is the ability to develop and apply mathematical thinking and insight in order to solve a range of problems in everyday situations. Necessary knowledge in mathematics includes a sound knowledge of numbers, measures

and structures, basic operations and basic mathematical presentations, an understanding of mathematical terms and concepts and an awareness of the questions to which mathematics can offer answers (The Council of the European Union, 2018). Possessing the mathematics competence means having the knowledge of, understanding, doing, and using mathematics and having a well-founded opinion about it, in a variety of situations and contexts where mathematics plays or can play a role (Niss & Højgaard, 2019, p. 49).

In accordance with the UNESCO goals – better educational development, skills development, and acquisition, requires the integration of the related disciplines of Science, Technology Engineering, and Mathematics into a single competency-based education, defined as STEM (Educación, U.O. & Ng, 2019). STEM brings together and integrates all these sectors offering opportunities and contributions to the development of each competence but given that the above fields are based on mathematics, not only for doing calculations but also for making estimations, it is necessary to mention that the basis for the development of STEM competences in students is mathematics knowledge at school. A student learns numbers in pre-primary education, numerals and counting in the early stages of primary education but as the numbers increase and the precision required to handle them increases, it is assumed that a solid foundation is laid to develop more complex mathematical problem-solving skills (Gersten, Jordan, & Flojo, 2005).

The main goal of mathematics education today is to develop the knowledge and skills necessary for adult life. Two essential subdomains are the arithmetic fluency (i.e., the ability to add, subtract, multiply, and divide with basic number combinations accurately and quickly) and the mathematical problem-solving (i.e., the ability to apply mathematical knowledge and skills to solve actual or imagined "real life" problems using mathematical notation, text, and/or pictures) (Kaskens et al., 2020). For example, The Programme for International Student Assessment (PISA) is a worldwide study by the Organisation for Economic Co-operation and Development (OECD PISA) defines mathematics competence as an individual's ability to formulate, apply and interpret mathematical problems in a variety of mathematics in various situations in life; an individual's ability to mathematically discover causal relationships, apply mathematical concepts, operations, facts to describe, explain and predict phenomena and their the process; the individual's ability to see the role of mathematics in the world and to make well-founded decisions necessary to be a constructive, engaged and responsible citizen (Geske et al., 2015). The OECD PISA study more focuses on the ability of 15-year-olds to apply their mathematics competences in their lives, in different life situations, while the IEA TIMSS study for 4th grade students focuses more on the curriculum – what students should be able to do (Mullis & Martin, 2017). It is important to stress that the mathematics competence at the primary stage is a key predictor of mathematical and academic achievement (Duncan et al., 2007). Mathematics competence therefore is one of the key factors for a students' success in later school life. Therefore, **the aim** of this article is to identify the weaknesses of students in Latvia in mathematics competences in TIMSS 2019, as well as to find out what could improve the mathematics competences of students in Latvia and their chances to become better mathematicians.

Methodology

TIMSS 2019 data on mathematics are used in the research. TIMSS 2019 is a good border point to analyse the old curriculum and it might be possible to contrast these outcomes with the ones obtained by students, who are schooling of new curriculum some years later. As a mathematics and science assessment, TIMSS is a valuable resource for monitoring educational effectiveness because science, technology, engineering, and mathematics, often known as STEM, are key curriculum areas (Mullis & Martin, 2017). So here is the comparison between TIMSS framework and Curriculum in Latvia – the old standards and education program (Cabinet of Ministers Regulation No. 468, 2014), which was valid until 2020, and the new standards and education program (Cabinet of Ministers Regulation No. 747, 2018), which entered into force in 2020 (see in table 1.2). TIMSS framework and Curriculum comparison lets us see what our students should know and what not yet and what could change in the future.

For mathematics TIMSS 2019 is organized around two dimensions:

- Content dimension, specifying the subject matter to be assessed;
- Cognitive dimension, specifying the thinking processes to be assessed.

In this research we concentrated on the content dimension. There are 3 content domains (see in Table 1).

Number. Numeracy includes calculating integers, calculating unknowns in simple equations and understanding ratios of quantities. To solve problems students, need to compare, add and subtract common fractions and decimals. **Measurement and geometry.** Measurement – using a ruler to measure length, calculate areas and perimeters for simple polygons, using cubes to measure volume and measuring the properties of lines, angles, and various two-dimensional shapes. Geometry – signing and drawing different geometric shapes and using geometric relationships to solve problems. **Data.** The study uses two types of data tasks – one that involves reading, interpreting and displaying data, and one that involves solving problems using the data. Students are required to read and recognize different forms of data representations – to collect, organize and represent data in graphs and charts to answer simple questions, and to use data from one or more resources to solve problems (Mullis & Martin, 2017; Mihno & Geske, 2020).

The data in the research represented the data of 20013 4th grade students in Latvia who are from different schools. Table 2 shows the percentage of students by type of school, learning language and location of the school.

Table 1 TIMSS 2019 Content Domains in Mathematics for 4th Grade

Content Domains	Percentages of tasks
Number	50%
Measurement and Geometry	30%
Data	20%

Table 2 Distribution of students in Latvia by location of the school, learning language and type of school in the TIMSS 2019 study

Learning language	Precentages of students	School location	Precentages of students	School type	Precentages of students
Latvian	70.13	**Rural**	24.24	**Basic**	24.47
Russian	25.72	**Cities**	43.22	**Elementary**	9.05
Mixed	4.15	**Riga**	32.54	**Secondary**	66.48

The aim of this research was to understand what kind of content tasks are a problem for students in Latvia. In this research tasks are detected, which are less completely answered. For that, were used human-coded items, split them by content. Student answers to these items were recoded – correct, partially correct, and incorrect answers. In the end results were calculated on how many students in Latvia did these tasks correctly and incorrectly.

Results

Table 3 shows a comparison of the old curriculum in Latvia valid from 2014–2020, the new curriculum in Latvia valid from 2020, and the TIMSS framework by topic area in the mathematics content domains.

Table 3 Comparison of the old curriculum in Latvia valid from 2014–2020, the new curriculum in Latvia valid from 2020 and the TIMSS 2019 framework

Topic areas	Timss 2019	Curriculum in Latvia valid from 2014–2020	Differences from previous curriculum in new curriculum in latvia valid from 2020
Mathematics content domains: Number 50%			
Whole numbers (25%)	Calculates with whole numbers of reasonable size, uses calculations to solve problems. Representing whole numbers with words, diagrams, number lines, symbols. Adds, subtracts, multiplies and divides (certain digit numbers). Determines even and odd numbers, knows how to round and combine numbers.	Until the beginning of the 2nd semester of the 4th grade calculates with whole numbers of reasonable size (up to four-digit numbers), uses calculations to solve problems. Represents whole numbers with words, diagrams, number lines, symbols. Adds, subtracts, multiplies and divides (certain digit numbers). Determines even and odd numbers. Only in the 5th grade learns how to round whole numbers.	In the 3rd grade rounds measurements to the nearest tens of centimetres, but do not yet learn the formal rules of rounding. Only in the 5th grade learns how to round whole numbers.
Expressions, simple equations, and relationships (15%)	Understands the concept of variables (unknowns) in simple equations.	Understands the concept of variables (unknowns) in simple equations as $15 + t = 70$.	

Topic areas	Timss 2019	Curriculum in Latvia valid from 2014–2020	Differences from previous curriculum in new curriculum in latvia valid from 2020
Fractions and decimals (10%)	Compares, adds, and subtracts fractions and decimals (with denominators – 2, 3, 4, 5, 6, 8, 10, 12, 100)	Compares unit fractions (with numerator – 1). Calculates unit fraction of whole numbers. Using decimals can read a price written in decimal form. Only in 5th grade learns how to add, subtract fractions with other numerators than 1 and decimals.	In the 2nd grade: Reads and compares amount of money using decimals. In the 3rd grade: Determines (shows, marks, separates) a certain fraction of a geometric figure. Determines (shows in the model, draws) the whole, if a fraction of it is given. Determines what fraction of the whole is given. Can read and write the fraction (the denominator has a single digit number or 10). Uses number line to show the fraction. Reads tenths and hundredths written in decimal form. In the second semester of the 4th grade: Compares fractions (denominators up to 10), adds, and subtracts fractions with the same denominators). In the 5th grade compares, adds, and subtracts decimals.
Mathematics content domains: Measurement and Geometry 30%			
Measurement (15%)	Measure with a ruler, estimate the lengths. Calculations with mass, volume and time, determine types and sizes of units, read weights. Calculates the perimeter of polygons, the area of rectangles, determines the shape of areas.	Measure with a ruler, estimate the lengths. Calculations with mass, volume and time, determine types and sizes of units, read weights. Calculates the perimeter of polygons. In the second semester of the 4th grade calculates the area of rectangles.	In the 2nd grade starts to use concept “area”, in the 3rd grade calculates the area of rectangles using squares and boxes. Only at the end of 4th grade uses area units such as square centimetres, meters and others.
Geometry (15%)	Determines and draws parallel and perpendicular lines, draws right angles and compares them. Describes and compares circles, triangles, quadrilaterals and other polygons. Describes and compares cubes, cones, rectangular solids, cylinders, and spheres.	Draws right angles and compares them. Recognizes, draws and makes measurements to calculate perimeter of triangles, quadrilaterals and other polygons. Recognizes and draws circles. Recognizes cubes, cylinders, and spheres. Only in the 6th grade determines and draws parallel and perpendicular lines, in 5th grade recognizes rectangular parallelepiped, in 9th grade – cone.	In the first semester of the 4th grade determines and draws parallel and perpendicular lines on checkered sheet, recognizes rectangular parallelepiped. In the 3rd grade recognizes and makes cones.

Topic areas	Timss 2019	Curriculum in Latvia valid from 2014–2020	Differences from previous curriculum in new curriculum in latvia valid from 2020
Mathematics content domains: Data 20%			
Reading, interpreting, and representing data (15%)	Reads, organizes and displays data from tables and certain charts.	Reads, organises and displays data from tables and certain charts. Only in the 5th grade draws charts.	In the 2nd grade draws simple charts. Draws bar charts in the 4th grade, pie charts in the 5th grade.
Using data to solve problems (5%)	Solves problems and performs calculations using data, combines data, draws conclusions based on existing data.	Solves problems and performs calculations using data, combines data, draws conclusions based on existing data.	

The table above shows that the TIMSS measure is broadly in line with the content of the curriculum in Latvia, but there are some topics and skills that students in Latvia learn later than TIMSS research takes place, such as operations with fractions and decimals, calculation of the area of a rectangle using area units, rounding whole numbers, etc. And that does not change in the new curriculum. However new curriculum provides that students will sooner learn how to draw bar charts, parallel and perpendicular lines and determine fractions, which is being tested in TIMSS.

Following the methodology described above, calculations were carried out and frequency tables were created which further allowed the creation of the corresponding diagrams to be discussed in this chapter.

In total, 3 charts were created – Numbers, Measurements and Geometry and Data.

In the diagrams each bar represents a sub-domain group of tasks. In all diagrams the proportion of students who were able to complete the sub-domain tasks correctly, that were allocated to that specific student, is coloured green. The grey shading represents the proportion of students who were only partially able to complete the tasks, and the red shading represents the proportion of students who were not able to complete the tasks according to the task conditions.

As can be seen (see Figure 1), problems involving integers and their computation are those that more than 50% of students in Latvia were able to solve correctly. The most difficult problems are tasks with fractions which only 18% of students in Latvia could solve correctly.

In Measurement and Geometry the most challenging problems were related to measurement and length problems (36% of students solved correctly). In Geometrics the most challenging problems were those related to parallelism, perpendicularity and angles (solved correctly by 33% of students) (see Figure 2).

In the Data tasks, the tasks that involved using data to solve problems (36% of students correctly solved) and reading data to answer questions (35% of students correctly solved) were the least likely to be solved correctly (see Figure 3).

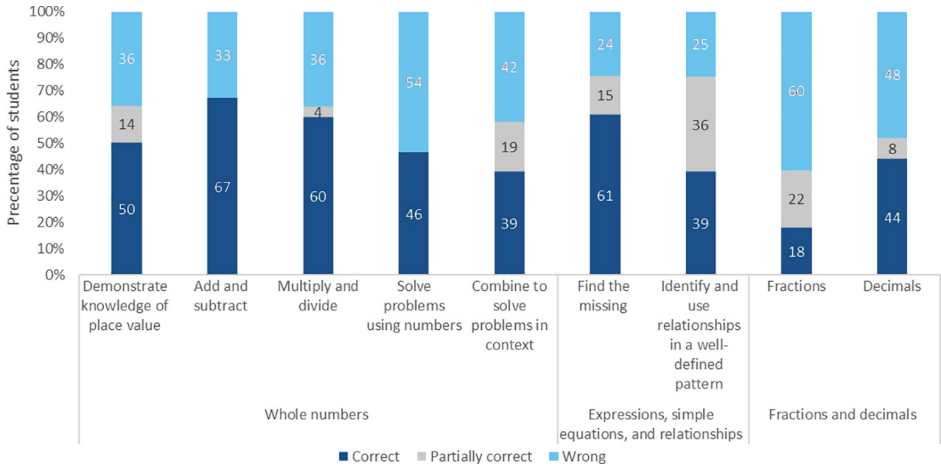

Figure 1 Numbers

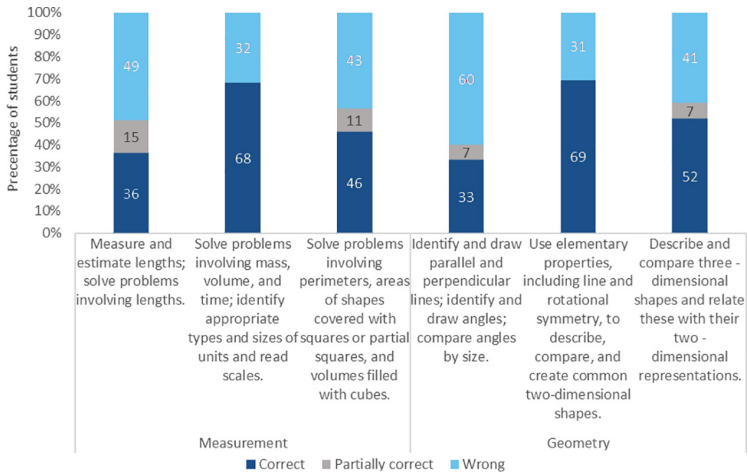

Figure 2 Measurements and Geometry

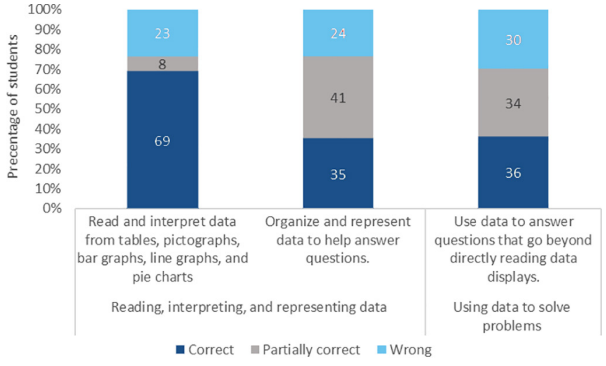

Figure 3 Data

Discussion

Before the data analysis it was important to find other possible factors, that could influence results. Data show that students from schools with Russian learning language have higher results in all domains than students from schools with Latvian learning language and these results are statistically significant at the 95% confidence level. Students from schools in Riga showed higher results than other students, and students from Basic schools had lower results than students from Elementary schools and Secondary schools and these results are statistically significant at the 95% confidence level. The percentage of students with Russian as their language of instruction is much higher in urban schools – 65% – and lowest in rural schools – 15%. The highest percentage of students with Latvian as their language of instruction (48%) is in urban schools, while the lowest percentage is in Riga – 23%, which could explain the differences.

Number

As shown in Figure 1, Fractions and Decimals are the one of the hardest tasks for students in Latvia. One reason could be the fact that selected students learn fractions and decimals later – in the next grades. As it can be seen, the new curriculum in Latvia introduces decimals and fractions earlier than they were taught in the previous curriculum, although the most operations with fractions and decimals will still be taught later than TIMSS research takes place. That provides us with a small evidence-based optimism for the future that kids in future could be better in tasks related to fractions and decimals, but still there is a gap between TIMSS framework and curriculum in Latvia.

Other tasks where students in Latvia have problems are problem-solving tasks. One of the reasons could be the fact that the old curriculum was more based on standard problem solving. Teachers showed examples of how to solve a task, and students mostly demonstrated skills to use this exact algorithm to solve similar tasks. The new curriculum is based on the problem solving, where students need to use and develop these skills in all subjects. For problem solving we need students to develop their reading skills. Students need to be able to read to solve problem-solving tasks, and they also need to have a deep understanding of text and language to solve more complex tasks, so mathematics competence is also closely linked to reading and literacy (Pagani et al., 2010; Blair & Raver, 2014; Duncan et al., 2007). Reading is an essential skill that is needed to solve problem solving tasks, if the student does not understand what is written there, he could not solve this task. The other thing that students need is to do more unfamiliar tasks, like tasks, where they need to use their skills, but what is different from what the teacher has shown before. But before starting to use this, there is a need to show students different strategies and algorithms, that could help them to solve a wide range of complex problems.

Measurements and Geometry

There are problems related to tasks, where students should use measurements for problem solving, or tasks where they need to use knowledge in geometry, such as angles, perpendicular and parallel lines. The reason for this could be the fact, that most of

the students till the fourth grade did not use geometry so much, mostly it was related to some figures and their perimeter. According to the old curriculum students got to know perpendicular and parallel lines only in 6th grade, but the new curriculum provides, that students determine and draw parallel and perpendicular lines on checkered sheet in the first semester of the 4th grade – before TIMSS takes place. Therefore, it is possible to also have better results in this area in future.

Data

As it can be seen, reading and interpretating data is not such a huge problem for students in Latvia, however the biggest problem is using these data for problem solving. As mentioned above, reading literacy is essential for success in problem-solving tasks. Reading literacy is an important basic life skill that influences much of students' achievement in other areas, such as financial literacy (Mihno, 2022; Jappelli & Padula, 2013; Kalmi & Ruuskanen, 2018; OECD, 2014; Riitsalu & Poder, 2016). It is therefore essential to develop it to promote achievement in other areas.

So, to improve mathematics competence of students in Latvia, teachers and parents need to cooperate to improve students' reading skills. That means that reading should take an important part in the everyday learning process in every school, every class, and every lesson (Yang et al., 2021), reading skills are also closely linked to literacy and learning in general (Gutierrez de Blume et al., 2021). It is not just language teachers' responsibility, but also schools, families and all of society are responsible for enhancing students reading habits. We can start just with reading activities, just a few minutes per day, and eventually give them more and more. It is important to show students that they can read different kinds of books, not just what teachers give (Yang et al., 2021). We need to make our libraries more interesting for teenagers and youngsters (Balan et al., 2019), not just for kids and adults. It is so important that after reading students can talk about books, stories, or articles, to see what students are reading and how they are understanding it. That could help to improve problem solving skills – to listen to others, to let to hear out other opinions and to discuss that (Yang et al., 2021). In addition, skilled readers are able to create a text that expresses a deeper understanding of what they have read, not just a retelling of the text (Gutierrez de Blume et al., 2021). And the third thing is basic skills in each subject, which is so important not only for that subject, but for other subject problem solving as well. So, we need our kids to be the best in math basics and to do easy tasks very fast that will help them use their knowledges to solve huge problems faster.

Conclusions

The biggest problem areas for students in Latvia are tasks, which include fractions, decimals, angles, parallel and perpendicular lines, which can be explained by the fact that these subjects were taught later (mostly at the end of 4th grade or even in 5th or 6th grade), because of the old curriculum these students studied. Based on the new curriculum there is hope, that after some years our students will do these kinds of tasks better than students

in 2019, because they will at least have some basic knowledge and skills in those subjects. The next problem area for students in Latvia is problem solving, that probably is the most important thing to improve. It is more than necessary to use knowledge in different situations rather than just knowing something. Often students do not even try to understand the problem what needs solving. They see more than two sentences and they do not have the necessary skills to understand the given problem. Sometimes there is no desire to solve it or, as the research shows, they feel anxiety while doing complicated tasks, because of the length of the task. It is particularly important to improve reading skills and to encourage students to read, so they can not only start, but successfully finish given tasks.

Hence to improve mathematics competencies of students in Latvia the first need is to make reading as a trend, what everyone wants to do, and show how interesting that is. Second, we need to make reading as a live activity, meaning that we do not just read, but discuss and reflect reading. The third need is to teach basics in every subject, so students know them very well to quickly use them in different situations.

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