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Mathematics Education in The United States of America, Finland, and Singapore: A Comparative Study

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Cover Page Footnote

Thank you Kean University and Dr. Beaugris for allowing me to research an important topic and issue in this country and the world.

Mathematics Education in The United States of America, Finland, and Singapore: A Comparative Study

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Abstract

Education systems around the world must put quality instruction as a priority, even as society constantly changes. Countries have to put a bigger emphasis on the importance of science, technology, engineering, and mathematics (STEM) education in their schools as the years have progressed. Those who have a career in the STEM areas are an integral part of sustaining a country's economy. However, not every country does the best job in teaching STEM effectively and appropriately to students. Although countries around the world teach mathematics, each one has a different approach, as seen with scores from PISA and TIMMS regarding The United States of America, Finland, and Singapore. By taking part in these tests, countries can learn from each other and possibly enhance their education regarding mathematics in their schools.

Introduction

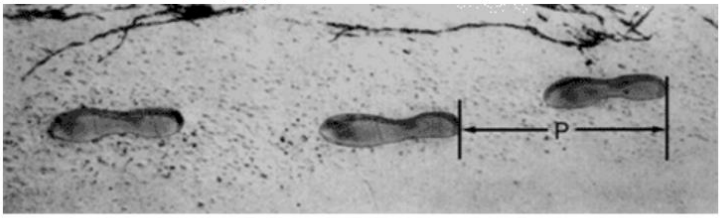
Comparing is one of the basic forms of intellectual activities that individuals take part in to test and measure understanding about an issue. Individuals in a school setting are often asked to compare and contrast two different items, concepts, or issues. However, it is also important to compare and contrast the different education systems around the world to see and understand how they are similar and how they differ from each other. Doing so creates a world of opportunities and ideas to better enhance the education system in a country. Maintaining quality education will bring changes in society and a country as a whole. In addition to quality education being a must for the enhancement of a country, STEM education has become an integral part of providing quality education to students around the world. STEM careers can have a positive impact on society, but the positive impact must begin with the education in schools and students must be taught effectively and appropriately. There are many different approaches to education around the world, as seen through worldwide test scores on The Organization for Economic Co-operation and Development's (OECD) Programme for International Student Assessment (PISA) and The Trends in International Mathematics and Science Study (TIMSS). Even though countries from around the world participate in these tests, they all score differently than each other, as seen with scores from The United States of America, Finland, and Singapore.

PISA and TIMSS

The OECD's PISA measures 15-year old's' abilities from countries around the world to use their reading, science, and mathematics skills and knowledge to meet real-life challenges and problems. This assessment is designed by education experts from around the world. The purpose of the test is to find out if students can apply what they learned in school to real life situations. Participation in this assessment is voluntary of countries. PISA is not just for ranking schools,

but for determining whether school systems are becoming more or less effective in their countries for further studies or work outside of the classroom. The goal of PISA is to help create a picture of what the most effective education systems look like for all types of students to have the best opportunities to learn and realize their greatest potential. This allows countries to better shape their education systems (PISA-PISA). The PISA test assessment includes a mixture of questions. Students are asked to answer a variety of questions regarding reading, science, and math and the combination of questions will be randomized for each student. Below, figure 1 is an example of a Mathematics question and answer, figure 2 is an example of a question regarding a Reading question, and figure 3 includes a question and answer for a Science question on the PISA test assessment.

Figure 1



The picture shows the footprints of a man walking. The pacelength *P* is the distance between the rear of two consecutive footprints.

For men, the formula, $\frac{n}{P} = 140$, gives an approximate relationship between *n* and *P* where,

n = number of steps per minute, and

P = pacelength in meters.

Mathematics Literacy Sample Items

Walking - Question #1

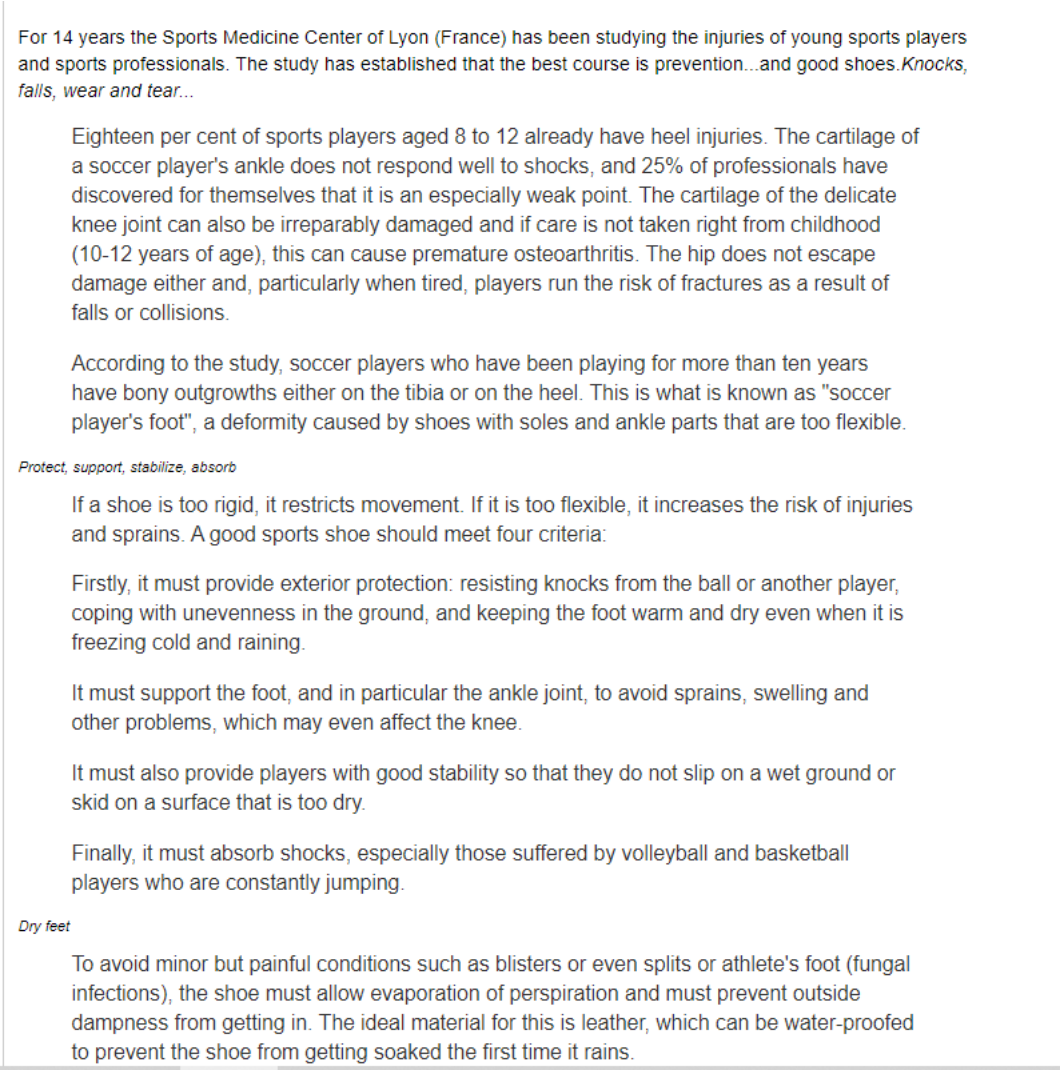
Question:

If the formula applies to Heiko's walking and Heiko takes 70 steps per minute, what is Heiko's pacelength? Show your work.

Answer:

The correct answer is :
0.5 m or 50 cm, ½ (unit not required).

- 70/ p = 140
  70 = 140 p
  p = 0.5.
- 70/140.



For 14 years the Sports Medicine Center of Lyon (France) has been studying the injuries of young sports players and sports professionals. The study has established that the best course is prevention...and good shoes.*Knocks, falls, wear and tear...*

Eighteen per cent of sports players aged 8 to 12 already have heel injuries. The cartilage of a soccer player's ankle does not respond well to shocks, and 25% of professionals have discovered for themselves that it is an especially weak point. The cartilage of the delicate knee joint can also be irreparably damaged and if care is not taken right from childhood (10-12 years of age), this can cause premature osteoarthritis. The hip does not escape damage either and, particularly when tired, players run the risk of fractures as a result of falls or collisions.

According to the study, soccer players who have been playing for more than ten years have bony outgrowths either on the tibia or on the heel. This is what is known as "soccer player's foot", a deformity caused by shoes with soles and ankle parts that are too flexible.

Protect, support, stabilize, absorb

If a shoe is too rigid, it restricts movement. If it is too flexible, it increases the risk of injuries and sprains. A good sports shoe should meet four criteria:

Firstly, it must provide exterior protection: resisting knocks from the ball or another player, coping with unevenness in the ground, and keeping the foot warm and dry even when it is freezing cold and raining.

It must support the foot, and in particular the ankle joint, to avoid sprains, swelling and other problems, which may even affect the knee.

It must also provide players with good stability so that they do not slip on a wet ground or skid on a surface that is too dry.

Finally, it must absorb shocks, especially those suffered by volleyball and basketball players who are constantly jumping.

Dry feet

To avoid minor but painful conditions such as blisters or even splits or athlete's foot (fungal infections), the shoe must allow evaporation of perspiration and must prevent outside dampness from getting in. The ideal material for this is leather, which can be water-proofed to prevent the shoe from getting soaked the first time it rains.

Figure 2

Question:	Answerable by scientific research?
Should the scientific uncertainties about the influence of CFCs on the ozone layer be a reason for governments to take no action?	Yes / No
What would the concentration of CFCs be in the atmosphere in the year 2002 if the release of CFCs into the atmosphere takes place at the same rate as it does now?	Yes / No

Read the following section of an article about the ozone layer.

The atmosphere is an ocean of air and a precious natural resource for sustaining life on the Earth. Unfortunately, human activities based on national/personal interests are causing harm to this common resource, notably by depleting the fragile ozone layer, which acts as a protective shield for life on the Earth.

Ozone molecules consist of three oxygen atoms, as opposed to oxygen molecules which consist of two oxygen atoms. Ozone molecules are exceedingly rare: fewer than ten in every million molecules of air. However, for nearly a billion years, their presence in the atmosphere has played a vital role in safeguarding life on Earth. Depending on where it is located, ozone can either protect or harm life on Earth. The ozone in the troposphere (up to 10 kilometers above the Earth's surface) is "bad" ozone which can damage lung tissues and plants. But about 90 percent of ozone found in the stratosphere (between 10 and 40 kilometers above the Earth's surface) is "good" ozone which plays a beneficial role by absorbing dangerous ultraviolet (UV-B) radiation from the Sun.

Without this beneficial ozone layer, humans would be more susceptible to certain diseases due to the increased incidence of ultra-violet rays from the Sun. In the last decades the amount of ozone has decreased. In 1974 it was hypothesized that chlorofluorocarbons (CFCs) could be a cause for this. Until 1987, scientific assessment of the cause-effect relationship was not convincing enough to implicate CFCs. However, in September 1987, diplomats from around the world met in Montreal (Canada) and agreed to set sharp limits to the use of CFCs.

What does the author intend to show in this text?

A. That the quality of many sports shoes has greatly improved.
B. That it is best not to play soccer if you are under 12 years of age.
C. That young people are suffering more and more injuries due to poor physical condition.
D. That it is very important for young sports players to wear good shoes.

Answer:

The correct answer is D.

Figure 3

Science Literacy Sample Items

Ozone - Question #1

Question:

Lines 14 and 15 state: "Without this beneficial ozone layer, humans would be more susceptible to certain diseases due to the increased incidence of ultra-violet rays from the Sun."

Name one of these specific diseases.

Answer:

To receive full credit, answers must refer to skin cancer or melanoma.

(*Program for International Student Assessment (PISA) - Sample Assessment Questions*)

The TIMSS provides reliable mathematics and science achievements of students from around the world and compares the average scores against each other. The TIMSS collects data from students in grade 4 and grade 8 and is sponsored by the International Association for the

Evaluation of Educational Achievement (IEA) (Trends in International Mathematics and Science Study). This test is to see if students in one country know as much about mathematics and science as students in another country. This test also allows countries to see the differences in curricula around the world, such as the structure and demand in them. The results from TIMMS suggest the degree to which students learned Math and Science concepts and skills that were likely taught in school. The TIMMS assessment has four different levels of student achievement that education systems can fall under: 1) Advanced with a score of 625, 2) High with a score of 550, 3) Intermediate with a score of 475, and 4) Low with a score of 400. These levels provide a way to understand how students' proficiency in Math varies at different points on a TIMMS scale. Figure 8 shows the knowledge and skills students at each level need to answer mathematics questions at that level and reach the cut off score (Trends in International Mathematics and Science Study (TIMSS) - Overview). Shown below in figures 4 and 5 are test questions from the 2011 TIMSS assessment for fourth grade mathematics and science and figures 6 and 7 show mathematics and science test questions for eight grade from the 2011 TIMSS assessment test.

Figure 4

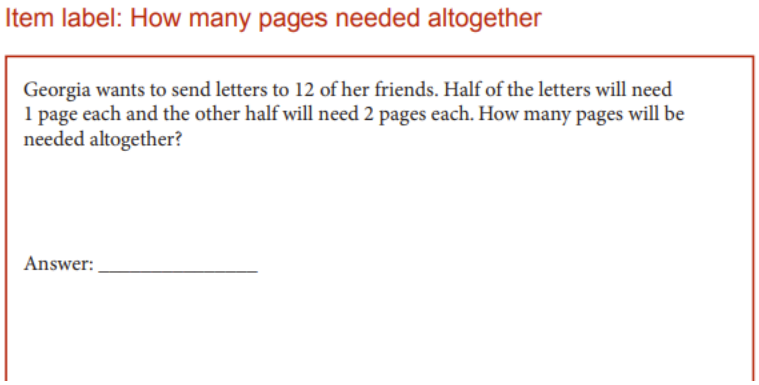
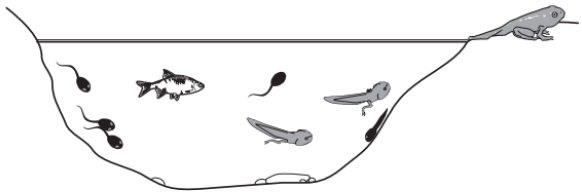


Figure 5

Item label: How tadpoles get in the pond



Melissa found some tadpoles and fish in a pond as shown above.
How did the tadpoles get there?

A. They hatched from eggs laid by fish in the pond.
B. They formed from mud at the bottom of the pond.
C. They were made from materials dissolved in pond water.
D. They developed from eggs laid by frogs in the pond.

Figure 6

Ann and Jenny divide 560 zeds

Ann and Jenny divide 560 zeds between them. If Jenny gets $\frac{3}{8}$ of the money, how many zeds will Ann get?

Answer: _____

Figure 7

One function of the uterus

The uterus (womb) is part of the reproductive system in mammals.
Name one function of the uterus.

(*Trends in International Mathematics and Science Study (TIMSS) - Assessment Questions*)

Figure 8

Benchmarks	4th grade	8th grade
Advanced (625)	***Students can apply their understanding and knowledge in a variety of relatively complex situations and explain their reasoning.*** They can solve a variety of multistep word problems involving whole numbers. Students at this level show an increasing understanding of fractions and decimals. They can apply knowledge of a range of two- and three-dimensional shapes in a variety of situations. They can interpret and represent data to solve multistep problems.	***Students can apply and reason in a variety of problem situations, solve linear equations, and make generalizations.*** They can solve a variety of fraction, proportion, and percent problems and justify their conclusions. Students can use their knowledge of geometric figures to solve a wide range of problems about area. They demonstrate understanding of the meaning of averages and can solve problems involving expected values.
High (550)	***Students can apply their knowledge and understanding to solve problems.*** They can solve word problems involving operations with whole numbers, simple fractions, and two-place decimals. Students demonstrate an understanding of geometric properties of shapes and angles that are less than or greater than a right angle. Students can interpret and use data in tables and a variety of graphs to solve problems.	***Students can apply their understanding and knowledge in a variety of relatively complex situations.*** They can use information to solve problems involving different types of numbers and operations. Students at this level show basic procedural knowledge related to algebraic expressions. They can solve a variety of problems with angles including those involving triangles, parallel lines, rectangles, and similar figures. Students can interpret data in a variety of graphs and solve simple problems involving outcomes and probabilities.
Intermediate (475)	***Students can apply basic mathematical knowledge in straightforward situations.*** They demonstrate an understanding of whole numbers and some understanding of fractions and decimals. Students can relate two- and three-dimensional shapes and identify and draw shapes with simple properties. They can read and interpret bar graphs and tables.	***Students can apply basic mathematics knowledge in straightforward situations.*** They can solve problems involving negative numbers, decimals, percentages, and proportions. Students have some knowledge of linear expressions and two- and three-dimensional shapes. They can read and interpret data in graphs and tables. They have some basic knowledge of chance.
Low (400)	***Students have some basic mathematical knowledge.*** They can add and subtract whole numbers, have some understanding of multiplication by one-digit numbers, and can solve simple word problems. They have some knowledge of simple fractions, geometric shapes, and measurement. Students can read and complete simple bar graphs and tables.	***Students have some knowledge of whole numbers and basic graphs.*** The few items at this level provide some evidence that students have an elementary understanding of whole numbers. They can match tables to bar graphs and pictographs.

Naturally, all countries that participate in these tests obtain different results. These different results allow the opportunity for lower scoring countries to look at what higher scoring countries are doing in their math education in school systems and can model after them to enhance the math education in their own country. Finland, The United States of America, and Singapore all take part in the PISA and TIMMS testing, but all end up with different scores and it could be due to the differing education systems in the countires.

The United States of America

According to the 2018 PISA results, students in America performed below the OECD's average score in math. The average score is 490 and students in America scored 478. There has been no significant improvement or decline in the performance in math of students in America

since 2003, which could be a reason for the lower score on PISA. Students in the United States of America reported more competition in class than cooperation among peers to a greater degree than reporting students in any other PISA participating countries. 64% of students in America reported that they compete in class. The average percentage is 50%. (Publications - PISA. (2019)). The average TIMMS score for The United States of America in 2015 was 539 for the fourth grade, which was higher than the average scores in 34 other education systems and lower than 10 education systems that participated in this test. The average eighth grade score was 518, which was higher than 24 other education systems and lower than 8 education systems. American students in fourth and eighth grade have, on average, shown long term improvement on TIMMS assessments. The 2015 scores were higher than any other prior assessment. In the fourth grade, 79% of students reached the Intermediate level of student achievement, while 70% of students in eighth grade reached the same level (TIMMS). As seen, both the average score and percentage of students reaching an Intermediate level of content knowledge is lower in the eighth grade compared to the fourth.

In The United States of America, public education is decentralized, meaning that each individual state governs its own school system. Education is the largest budget item in each state, but there are still severely low-income school districts in each state. Public education in this country refers to the system by which federal, state, and local governments provide the funding and oversight for free public schools for all children from kindergarten through Grade 12. There is no national curriculum for the school systems in America and individual states are responsible for the development of curriculum frameworks in core subject areas. However, as of 2016, 38 states, the District of Colombia, four U.S territories, and the Department of Defense Education Activity have adopted the Common Core State Standards Initiative’s mathematical standards to

help guide the curriculum frameworks. The Common Core State Standards for Mathematics (CCSSM) were developed to bring a greater focus to the teaching of mathematics in school systems. Not all states have adopted these standards and they are only guidelines for states. However, the CCSSM have greatly influenced mathematic education in The United States. Just as each state is in charge of the curriculum for each school system, states and school districts are in charge of professional development for teachers. There is currently no national policies regarding the content and methods of professional development programs. Teachers in America must be licensed from their state, hold a bachelor's degree, and demonstrate expertise in their field or content area (Malley, Neidorf, Arora, & Kroeger, 2016).

Finland

Students in Finland scored higher on the 2018 PISA than both students in The United States of America and the OECD average (490). Students in Finland had a score of 507. However, the average mathematics performance of students continues to decline. This decline started in 2006. 70% of students reported that classmates cooperate rather than have a competition with each other, but 59% reported that schoolmates compete with each other in class. Finland did not have any scores reported for the TIMMS assessment for eighth grade but did for fourth. Finland's average score for the TIMMS assessment for fourth grade was 535.

Education is considered a fundamental right of all citizens in Finland regardless of age, nationally, place of residence, financial situation, or language. The government determines the general educational objectives and instructional time between the different subjects. Before children go to school, usually the year they turn seven years old, children must participate in one year of pre-primary education. Education in Finland is mostly free; students must pay for materials. According to the National Core Curriculum for Basic Education, the purpose for

education in mathematics is to offer opportunities to develop mathematical thinking and problem-solving methods. The goal of mathematics instruction is to develop creative and precise thinking and to guide the student in finding, formulating, and solving problems. A master's degree is a pre-requisite for teacher qualification and the Ministry of Education and Culture started a teacher professional development program in 2014 where the goal was to train 50,000 in only two years (Vettenranta, Hiltunen, Kupari, & University of Jyväskylä, 2016).

Singapore

Singaporean students have consistently outscored students from other countries regarding the PISA and TIMMS assessments. In the 2015 TIMMS report, Singapore scored a 618 for fourth grade students and a 621 for eighth grade; both of these scores are significantly higher than American and Finland's scores (TIMMS). Singapore's mission of education (MOE) is to mold the future of the nation by nurturing its people. The public education system in Singapore is balanced and well rounded. It aims to help children develop passion and capabilities for learning throughout life, allowing them to realize their potential, live life to the fullest, and use their strengths for the good of themselves, their families, their society, and their country. Singapore's education system is characterized by flexibility, diversity, and school autonomy. This education system has a flat type of government with no middle levels between the MOE Headquarters and the schools themselves. The MOE Headquarters is responsible for: ensuring resources are equally distributed among schools, setting national policies that affect education and its access to all children, recruiting public school teachers, paying for training for teachers at the National Institute of Education (NIE), and deploying them to schools in the country. Schools in Singapore are given autonomy and are highly encouraged to customize the implementation of the national curriculum. (Chee et al., 2019).

Preschool education is not mandatory in Singapore, but it is available for children under the age of three, and pre-primary education programs are accessible for children over the age of three. Primary school is compulsory and formal schooling starts the year a child turns seven (Grade 1: Primary 1). At the end of Grade 6, students take an assessment test in English language, mother tongue, science, and mathematics. This assessment is called the Primary School Leaving Examination (PSLE) and is used as an academic merit in a secondary school system. Secondary school is not mandatory, but most Singaporean children complete it. In 2014, less than 1% of children who completed Primary 1 did not complete secondary education (Chee et al., 2019). Since it is not mandatory, the students in some sense want to be there to learn. Therefore, any academic scores and tests will be heightened or higher since the students have a higher sense of intrinsic motivation. Secondary schools in Singapore tend to be more specialized than primary schools, allowing students to find their strengths and focus and hone them. The education system as a whole in Singapore aims to equip students with basic numeracy skills, scientific knowledge, and skills necessary in daily life. Additionally, it allows students with specialized interests or strengths to study further to a higher level. The study of science is required through the eighth grade and mathematics is required through Grade 10, putting an immense focus on mathematics and science education (Chee et al., 2019).

Conclusion

Research shows that not every country tests the same in mathematics and some countries score better than others, as seen with Singapore, The United States of America, and Finland. The expectations of teachers and the education system of a country play a key part in how a country scores on the PISA and TIMMS. The importance of education, specifically in the field of Math and Science, is shown from these findings and research on education in these three countries.

Based on the research findings, countries from around the world can lead by example, as shown with Singapore, or begin to take the necessary steps and actions to put a higher importance on Mathematics education in the country by looking at higher scoring countries and their education system.

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