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Effects of computer usage to support 4th grader mathematics learning: Comparative study

Ahmet Oguz Akcay [1*]

[1] Elementary Education Department, Faculty of Education, Eskisehir Osmangazi University, Eskisehir, TURKEY
***Corresponding Author:** aoguzakcay@gmail.com

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ABSTRACT

The aim of this study was to examine the effect of using computers during mathematics lessons on the academic achievements of 4th-grade students. Additionally, this study aimed to determine the frequency of computer usage in selected countries. TIMSS 2019 4th-grade mathematics data were used in this study to determine the relationship between student mathematics achievement and the use of activities on computers during mathematics lessons, to support student learning by teachers in different countries. To identify the relationship between student mathematics achievement and the use of computers while teaching mathematics, a linear regression analysis was conducted. The results showed that the use of computers explained the high student achievements for the countries that ranked above average and the low student achievements for the countries that ranked below average. On the other hand, the relationship between computer usage in 4th-grade math education and test scores is likely to vary between the selected countries.

Keywords: mathematics achievement, computer usage, elementary education, elementary teachers, TIMSS

INTRODUCTION

The rapid growth of technology in the 21st century has brought about significant changes in the abilities expected from individuals who should access new information to fulfill their needs. For this purpose, all concepts of the teaching and learning processes, such as teaching materials, methods, and techniques, and teacher and student roles, have been changed and updated. One of the most important stakeholders affected by this change is the teacher. The use of technology has an important place among the competencies expected from the teachers of today. Teachers use numerous pedagogies in teaching mathematics, one of which is technology. Teachers in the 21st century should offer different learning opportunities for their students and arrange classroom environments based on technology (Larson & Miller, 2011). The use of technology in teaching and learning environments has increased over the recent decades in many countries (Comi et al., 2017; Falck et al., 2018); hence, the idea of teaching mathematics has been changed based on the developments and changes in technology (Zbiek et al., 2007).

The effect of using technology in education has been a focus of research for many years and the use of technology in educational settings provides significant advantages for both the teachers and students. Many mathematics education researchers and professional organizations support the use of technology in mathematics education, such as the National Council of Teachers of Mathematics (NCTM). The NCTM (2008, 2014) stated six principles of mathematics education, one of which is technology integration. The NCTM (2014) stated that teachers should "incorporate and support the effective use of appropriate tools and technology in mathematics curriculum standards across all grade levels" (NCTM, 2014, p. 111). The use of computers in mathematics education increases the achievements of the students and supports their understanding of mathematics (Mkomange et al., 2012). Keong et al. (2005) stated that one of the effective ways to support this understanding of mathematics is the integration of technology. The use of technology allows students to develop deep interpretations and focus on problem-solving and reasoning, and helps students develop mathematical thinking (Keong et al., 2005) and mathematical ideas (Wachira & Keengwe, 2011).

Computers have become a commonly used technology in mathematics education, and their use continues to increase. Computers are a tool for teaching and learning, and they provide a rich stimulating environment for children. Li and Mai (2010) reported that the integration of computer technology in teaching mathematics has significant effects on mathematics achievement, especially in elementary schools. Children who interact with computer technology not only develop achievement but also develop critical thinking and problem-solving skills. Bulman and Fairlie (2016) stated that the effectiveness of using computer-assisted instruction comprised of the followings:

Table 1. TIMSS 2019 4th grade mathematics scores of the selected countries

Countries	Mean score	Standard error	Ranking	Proficiency level
England	556	3.0	8th	Above average
Turkey	523	4.4	23rd	Above average
United Arab Emirates	481	1.7	43rd	Below average
North Macedonia	472	5.3	45th	Below average

1. more effective use of time,
2. individualized instruction,
3. better monitoring of student progress, and
4. improved access to worldwide information.

When the literature is examined, it is stated that there is a relationship between computer use and students' mathematics achievement. Bochniak (2014) mentioned that the use of computers is a long-standing approach to improving students' math performance and can be especially important for computations in mathematics. The use of computers in mathematics increased students' outcomes when comparing students who were taught traditional instructional methods (Barrow et al., 2009) Utilizing computer technology in mathematics education can enable students to acquire a positive attitude towards mathematics and increase the efficiency of mathematics education and students' permanence of mathematics education (Ozdemir et al., 2020).

Many policymakers want to learn what works in their education system and understand their performance and effectiveness. To achieve this goal, the International Association for the Evaluation of Educational Achievement (IEA) conducts cross-national comparisons of student math and science achievements to gain information about the education systems of various counties. Many countries around the world participate in large-scale international assessments (e.g., Trends in International Mathematics and Science Study [TIMSS], Programme for International Student Assessment [PISA], and Progress in International Reading Literacy Study [PIRLS]). TIMSS is a large-scale international assessment that is administered every four years to monitor the mathematics and science achievements of 4th and 8th graders and determine their ranks among other countries. TIMSS was first administered in 1995 and has provided 24 years of trends in mathematics and science achievement (Mullis & Martin, 2017). TIMSS data are applied by many policymakers, educators, and researchers to identify the effectiveness, weaknesses, and strengthens of their education system. TIMSS data provide information about five broad areas, which comprise community and national policies, home contexts, school contexts, classroom contexts, and student attitudes toward learning (Mullis & Martin, 2017).

The use of technological tools is suitable for mathematics teaching, and teachers should be provided with training on the use of technology for the effective integration of technology. The mathematics achievements of students could be affected by many factors, including the practices used by the teachers in the classroom. The main aim of this study was to examine the effect of using computers during mathematics lessons on the academic achievements of 4th grade students. Additionally, another aim of this study was to determine the prevalence of computer usage in different countries. It was thus attained answers to the following questions:

1. How often do teachers use computers in 4th-grade mathematics classrooms in selected countries?
2. Is there a relationship between the frequency of using computers by teachers in 4th-grade mathematics lessons and their student achievement?

METHOD

TIMSS 2019 4th grade mathematics data were used in this study to determine the relationship between student mathematics achievement and the use of activities on computers during mathematics lessons, to support student learning by teachers in different countries. The questionnaire method, which is one of the quantitative research method techniques, was used to identify the relationship between student mathematics achievement and activities on computers during mathematics lessons to support learning. The independent variable was the activities on the computers during mathematics lessons to support learning, which is a categorical variable, and the dependent variable was the student mathematics achievement scores. In 2019, a total of 58 countries participated in the TIMSS at the 4th grade level, and the national mathematics average scale scores ranged from 297 to 625. Four countries (a mix of high- and low-performing countries) were selected in this study based on their proficiency levels according to the TIMSS 2019 mathematics results. **Table 1** shows the TIMSS 2019 4th grade mathematics scores of the selected countries.

The center point of the scale considered as a reference in TIMSS assessments is 500 points. In this study, scores above 500 were defined as high-performing countries and below 500 were defined as low-performing countries. In this study, England and Turkey were selected as the high-performing countries, while the United Arab Emirates and North Macedonia performed below the center point of the TIMSS scale. Also, when selecting high and low-performance countries, it was considered that at least 500 teachers from selected countries participated in the TIMSS 2019 study. While there was another criterion during the country selections, the education systems of the selected countries emphasize the use of technology. The researcher especially is interested in Turkey, because Turkey has initiated the largest and most comprehensive education movement in the world regarding the use of technology in education.

Turkish Education policies were also affected by technology and new education projects started to be developed, and FATIH Project (Movement to Increase Opportunities and Attach Technology), which was implemented in Turkey in 2013 (MEB, 2018).

Table 2. Computers available for students to use during mathematics lessons

Countries	Mean score	Standard error	Percentage of students who use computers during mathematics lessons
England	566	5.6	32
Turkey	533	3.1	16
United Arab Emirates	512	2.5	45
North Macedonia	472	7.7	47

Table 3. The number of teacher participants in this study

Countries	Number of teachers
England	544
Turkey	599
North Macedonia	1,353
United Arab Emirates	9,894
Total	12,430

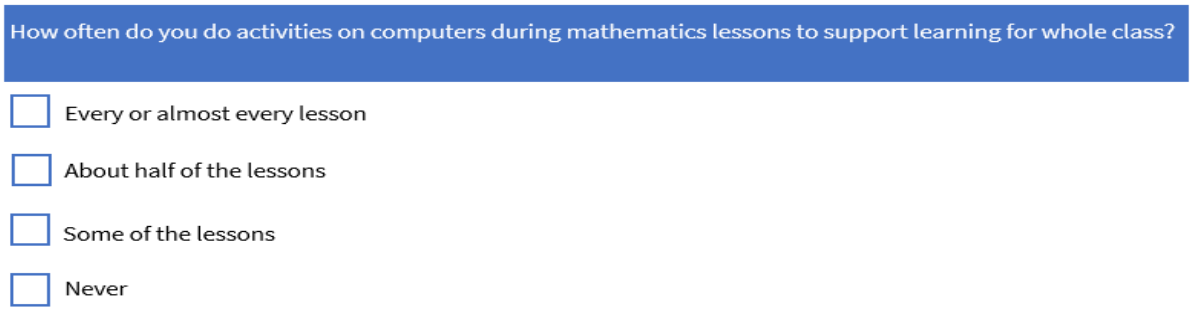

Figure 1. TIMSS teacher questionnaire on teaching mathematics in the class

England's education system focused on technology in education for teaching and learning over the last 25 years (Radović & Passey, 2014). The United Arab Emirates government sees technology as one of the cornerstones of education in the 2021 vision (UAE Vision, 2021). North Macedonia's education system has developed a curriculum to support teaching and learning with technology since 2002 (Selimi et al., 2020). Another reason for choosing these countries is that Asian countries are generally chosen in TIMMS studies, and the author wanted to choose different countries other than Asian countries.

Table 2 shows the results regarding the student usage of computers for mathematics lessons based on the reports of the teachers. **Table 2** shows that 32% of students in England, 32% of students in Turkey, 45% of students in the United Arab Emirates, and 47% of students in North Macedonia use computers during mathematics lessons. When the results in **Table 2** are compared with those of **Table 1**, it can be seen that the mean scores of the students who use computers in mathematics education in England (566), Turkey (533), and United Arab Emirates (512) have increased, while the score did not change in North Macedonia (472).

Study Sample

TIMSS 2019 4th-grade data were used in this study. To generalize the results for the countries of the participants, TIMSS uses a 2-stage random sampling design (Joncas & Foy, 2016). First, the schools are chosen and then the classrooms for each grade level are selected from the sampled schools. **Table 3** shows the number of teachers of each selected country for this study.

Data Collection

The study used the 4th grade teacher data of four countries to determine the relationship between the frequency of the teachers to use computers for the whole class and the mathematic achievements of the students. The teacher data, which were publicly available, were directly obtained from the TIMSS website. In the TIMSS, the teachers were asked about their use of computers while teaching mathematics for the whole class of students. The use of computers while teaching mathematics and the student math achievement scores from the TIMSS 4th-grade assessment were the main data source of this study. The 4th-Grade Teacher Questionnaire about doing the activities on computers during mathematics lessons to support learning for the whole class can be seen in **Figure 1**. The computer usage while teaching mathematics is coded as every or almost every lesson=4, about half of the lessons=3, some lessons=2, never=1.

Data Analysis

For this study, the Inter-American Development Bank *(*IADB) Analyzer Tool (developed by IEA for creating TIMSS and PIRLS datasets to be used in statistics tools) was used to analyze the data. To identify the relationship between student mathematics achievement and the use of computers while teaching mathematics, a linear regression analysis was conducted. Linear regression analysis provides the t-value, so to determine statistical significance, the at-value was used. The IADB (2016) highlighted that "if the absolute value of the group difference divided by the standard error of the difference exceeds the at-value of 1.96, the result can be regarded as statistically significant at the 95%-level" (p. 25).

Table 4. Descriptive results for England

Frequency	n	Percentage (%)
Every or almost every lesson	68	12.5
About half of the lessons	207	38.0
Some lessons	229	42.1
Never	40	7.4
Total	544	100.0

Table 5. Descriptive results for Turkey

Frequency	n	Percentage (%)
Every or almost every lesson	198	33.1
About half of the lessons	266	44.5
Some lessons	56	9.3
Never	79	13.1
Total	599	100.0

Table 6. Descriptive results for North Macedonia

Frequency	n	Percentage (%)
Every or almost every lesson	59	4.4
About half of the lessons	656	48.5
Some lessons	618	45.6
Never	20	1.5
Total	1,353	100.0

Table 7. Descriptive results for the United Arab Emirates

Frequency	n	Percentage (%)
Every or almost every lesson	3,227	32.6
About half of the lessons	5,214	52.7
Some lessons	1,227	12.4
Never	226	2.3
Total	9,894	100.0

To answer research question 1, the descriptive results were provided (mean, percentage, standard deviations), and to answer research question 2 the linear regression was run. The frequency of using computers every or almost every lesson while teaching mathematics was selected as a constreference category in a linear regression analysis. In this study, to identify the relationship between the use of computers while teaching mathematics and student mathematics achievement, the frequency of using computers for half of the lessons, some lessons, or never using computers while teaching mathematics were compared with the frequency of using them daily or almost daily.

RESULTS

Descriptive Results

Descriptive results were obtained from the regression analyses for each country. **Table 4** shows the descriptive results for England. **Table 4** shows that 12.5% of teachers (n=68) use computers while teaching mathematics in every or almost every lesson in England. On the other hand, 7.4% of teachers (n=40) never use computers while teaching mathematics in England.

Table 5 shows the descriptive results for Turkey. **Table 5** shows that 33.1% (n=198) of teachers use computers while teaching mathematics in every or almost every lesson in Turkey. On the other hand, 13.1% of teachers (n=79) never use computers while teaching mathematics in Turkey.

Table 6 shows the descriptive results for North Macedonia. **Table 6** shows that 4.4% (n=59) of teachers use computers while teaching mathematics in every or almost every lesson in North Macedonia. On the other hand, 1.5% of teachers (n=20) never use computers while teaching mathematics in North Macedonia.

Table 7 shows the descriptive results for the United Arab Emirates. **Table 7** shows that 32.6% (n=3,227) of teachers use computers while teaching mathematics in every or almost every lesson in the United Arab Emirates. On the other hand, 2.3% of teachers (n=226) never use computers while teaching mathematics in the United Arab Emirates.

Table 8 shows the mean scores and standard deviations of using interesting materials for each country. **Table 8** shows that computer usage is highest in England (mean=2.52) and least in Arab Emirates (mean=1.84). In other words, a high mean score that teachers usually use computers in their mathematics lessons, while a low mean scores that teachers use computers less in their teaching.

Table 8. Mean and standard deviations of computer usage while teaching mathematics

Countries	Mean	Standard deviation
England	2.52	0.84
Turkey	2.03	0.98
North Macedonia	2.44	0.60
United Arab Emirates	1.84	0.72

Table 9. R-square result of each country

Countries	R-square	R-square (se)
England	0.03	0.02
Turkey	0.06	0.04
North Macedonia	0.01	0.01
United Arab Emirates	0.01	0.01

Table 10. Relationship between computer usage and student achievement

	Frequency	B	SE B	β	t-value
England	Every or almost every lesson	586.85	9.98		
	About half of the lessons	577.64	19.95	-0.05	-0.47
	Some lessons	556.83	11.80	-0.18	-2.54*
	Never	543.14	15.53	-0.18	-2.82*
Turkey	Every or almost every lesson	530.70	17.92		
	About half of the lessons	516.08	24.03	-0.08	-0.61
	Some lessons	593.09	21.32	0.22	2.93*
	Never	536.55	26.96	0.02	0.22
North Macedonia	Every or almost every lesson	487.37	28.71		
	About half of the lessons	468.10	30.56	-0.09	-0.63
	Some lessons	476.26	29.47	-0.05	-0.38
	Never	405.95	89.99	-0.07	-1.14
United Arab Emirates	Every or almost every lesson	508.59	5.20		
	About half of the lessons	508.15	7.56	-0.00	-0.06
	Some lessons	531.48	9.89	0.08	2.32*
	Never	514.58	21.62	0.01	0.28

Regression Results

This study employed linear regression to analyze the relationship between the use of computers while teaching mathematics and student achievement in the 4th grade mathematics assessment.

Table 9 represents the R-squared result of each country. **Table 9** shows that the use of computers while teaching mathematics by teachers explained 6% of the mathematics achievement in Turkey and 3% of the mathematics achievement in England. On the other hand, the use of computers while teaching mathematics by teachers explained only 1% of the student achievement in North Macedonia and the United Arab Emirates.

The regression analysis results are presented in **Table 10**. **Table 10** indicates that the frequency of computer usage affects student math achievement in England, Turkey, North Macedonia, and the United Arab Emirates. The section below will discuss the findings on a country-by-country basis.

The frequency of computer usage in England positively affected student success. Student mathematics achievement increased as the frequency of computer use increased. Additionally, there was statistical significance with regards to using computers in some lessons (t=-2.54) and never using computers in the lessons (t=-2.82) in comparison with using them in every or almost every lesson; however, no statistical significance was found with regard to using them for about half of the lessons.

The frequency of computer usage in Turkey affected student success. Student mathematics achievement increased as the frequency of using computers in some lessons increased. Additionally, there was statistical significance with regards to using computers in some lessons (t=2.93) in comparison with using them in every or almost every lesson; however, no statistical significance was found with regard to using them for about half of the lessons or never using computers in the lessons.

The frequency of computer usage in North Macedonia positively affected student success. The average student achievement was about 487 when the teachers used computers in every or almost every lesson, and about 405 when the teachers never used computers to the classroom. On the other hand, the mean student achievement scores increased when the teachers used the computers frequently.

The frequency of computer usage in the United Arab Emirates affected student success. Student mathematics achievement increased as the frequency of using computers in some lessons increased. Additionally, there was statistical significance with regards to using computers in some lessons (t=2.32) in comparison with using them in every or almost every lesson; however, no statistical significance was found with regard to using them for about half of the lessons or never using computers in the lessons.

DISCUSSION, CONCLUSION, AND RECOMMENDATION

This study examined the relationship between computer use by teachers during mathematics instructions and student test scores in the TIMSS 2019 4th grade assessment. The results showed that the use of computers explained the high student achievements for the countries that ranked above average and the low student achievements for the countries that ranked below average. On the other hand, the relationship between computer usage in 4th grade math education and test scores is likely to vary between the selected countries, and the effect of computer usage in 4th grade mathematics was significant for Turkey and England, and somehow effective for North Macedonia and the United Arab Emirates. Several studies have reported that computer usage had positive effects on the achievements of the students (Li & Ma, 2010; Luu & Freeman 2011). In sum, the computer use is an important predictor of a high score of students in mathematics for high-performing countries. For example, as computer use increases in England, students' mathematics success increases.

The student test scores varied according to the frequency of computer use. This study revealed evidence that the student mathematics scores increased based on the frequency of computer use for England, North Macedonia, and the United Arab Emirates; however, there was little evidence of this for Turkey. The use of computers for some lessons or never using computers in the lessons was negatively associated the mathematics test scores for England, while the use of computers for some lessons was positively associated the mathematics test scores for Turkey. The frequency of computer uses negatively affected the math success of students in Turkey and the United Arab Emirates and positively affected the math success of students in England and North Macedonia. On the other hand, when the use of technology decreased, student achievement increased in Turkey and the United Arab Emirates, while the opposite was true for England and North Macedonia. When the results were examined, it was concluded that there was no direct relationship between computer usage and student mathematics achievement. This study's results were consistent with previous studies, such as those by Carter et al. (2017), Karlsson (2020), and Yanguas (2020). Bayraktar (2001) also concluded that computer-assisted education has a negligible effect on student achievement. While the use of technology in England, one of the high-performance countries, was effective on the student's mathematics success, while occasional use was true in Turkey. When considering low-performing countries, while the use of technology in North Macedonia was effective on the student's mathematics success, while occasional use was true in the United Arab Emirates.

It was seen that the frequency of computer usage was higher in Turkey and the United Arab Emirates, where 77.6% of teachers in Turkey use computers in about half of the mathematics lessons or more frequently. This was similar in the United Arab Emirates, where 85.3% of teachers use computers for about half of the mathematics lessons or more frequently. In England, 38% of teachers use computers for about half of the mathematics lessons and 42.1% of teachers use computers some mathematics lessons. In North Macedonia, 48.5% of teachers use computers for about half of the mathematics lessons and 45.6% of teachers use computers for some of the mathematics lessons. The results showed that developing countries are equipped with better technology infrastructure in schools and classrooms, so teachers in these countries are more eager to use computers. With the economic and technology development in Turkey, North Macedonia, and the United Arab Emirates, the frequency of computer use has increased. For example, North Macedonia has developed a curriculum that supports teaching with digital tools since 2002 (Selimi, Saracevic, & Useini, 2020). Similarly in Turkey, the Ministry of National Education initiated the FATIH Project in 2013 to provide equal opportunities for all students and to update the technologies used in educational environments (MEB, 2020). The process of technology integration in the United Arab Emirates is similar to other countries. Although Turkey has started the largest and most comprehensive education movement regarding the use of technology in education, the use of computers by teachers, which is the most basic technology, is at a low level. In addition, although technology has been in used nationwide for about 10 years in Turkey, the computer has little effect on students' mathematics achievement.

In the 4th-grade, computers are available for 39% of students to use during mathematics lessons according to TIMSS overall results (Mullis et al., 2020). Having computers available for instruction was associated with higher achievement in developing country (England). Falck et al. (2018) reported that the use of classroom computers and their effect on student achievement were mostly insignificant in less developed countries. Similarly, greater computer use does not guaranty better performance (OECD, 2016). This consistent result shows that students' mathematics achievement should be affected by other variables such as teachers' inability to use the computer, their perspectives on computer-assisted education, different purposes of computer use, or student backgrounds.

This study only investigated the relationship between computer usage by teachers and student mathematics achievement in different countries. The limitations of this study, analyzes were conducted only in selected four countries and the study only focused on 4th grade mathematics achievement. Future studies could focus on student achievement in different high and low-performing countries or developed and developing countries. It would also be interesting to determine the use of computers in science. Technology is mostly used while making presentations during mathematics lectures (Tatar, 2013), so elementary school teachers should be provided training for the effective use of computers during mathematics instructions because technology, when used effectively, can increase mathematical understanding.

It is important to allocate optimal computer use at the right frequencies. Based on the results, the researcher recommends that consistent use of computers in primary school mathematics teaching does not always increase the student's success and in this direction, teachers should use computers not all contents, but inappropriate lessons. Another factor to be considered is how teachers should use the computer in mathematics lessons and choose the technological content appropriate for the level of the student.

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