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The Effects of Bringing Interesting Materials into the Classroom on 4th Grade Students' Mathematics Achievement: A Comparative Study Using TIMSS Data

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Abstract
The aim of this study is examining the relationship between student achievement and bringing interesting materials to the classroom in 4th grade mathematics in Saudi Arabia, Qatar, Turkey, and Singapore. This study used TIMSS 2015 data to investigate the relationship between student achievement and bringing interesting materials to the classroom in 4th grade mathematics. The frequency of bringing interesting materials to the classroom is the independent variable and student achievement scores is the dependent variable of this study. The study selected four countries, each from different proficiency levels according to the TIMSS 2015 mathematics result, to see if bringing interesting materials to classrooms has different effects in different countries. SPSS in conjunction with the IDB analyzer tool, developed by International Association for the Evaluation of Educational Achievement (IEA), were used to analyze data. The result shows that a significant relationship between frequency of bringing interesting materials and student achievement in 4th grade. In addition, the study found that bringing interesting materials explains 3% of mathematics achievement in Qatar, Saudi Arabia, and Turkey; however it does not explain any portion of student achievement in Singapore.

Keywords: Interesting materials, Elementary education, Mathematics achievement, TIMSS

Introduction

Mathematics is an important subject from kindergarten through the high school curriculum. The aim of mathematics is to provide students with reasoning, problem-solving, communicating, and representing skills (NCTM, 2000). Mathematics includes abstract concepts so many students struggle to learn it.

Using physical and digital materials can help students to visualize abstract concepts. Thus, students can learn those concepts easily and deeply. Utilizing materials in mathematics not just helps students to learn, but also they help teachers to teach more effectively. However, it is not easy to bring materials to the classroom every day because they take time to make them. Using instructional materials also cost money for teachers. Teachers have an important role in the teaching-learning environment to increase the quality of education (Arends, Winnaar, &Mosimege, 2017). Different strategies and teaching styles are applied in the classroom by teachers to involve their students actively in the instruction to teach the mathematics concepts.

A variety of strategies to increase students' learning are used by teachers during instructional practices so that students can learn better by increasing their interest in the subject and engaging them during instructions. Teaching with materials is one of the strategies to increase student interest and engage them with subjects. Research showed the potential of using materials to supports teachers' classroom practices. NCTM (2014) highlights eight mathematics teaching practices, and one of them is "use and connect mathematical representations".

- Establish mathematical goals to focus learning
- Implement tasks that promote reasoning and problem solving
- Use and connect mathematical representations
- Facilitate meaningful mathematical discourse
- Build procedural fluency from conceptual understanding
- Support productive struggle in learning mathematics
- Elicit and use evidence of student thinking (p.10).

Teachers are constantly looking for new strategies to increase student understanding. There are known methods, such as using educational materials in classrooms to motivate students and engage them with instructions. Githua (2011) highlighted the importance of the use of educational materials that the poor mathematics performance was one of the results of the use of inadequacy of materials in teaching mathematics (cited in Githaiga, 2019). Including various tools in educational processes make teaching permanent, teaching environments more enjoyable and provide students with better learning experiences (ÇamAktaş, 2014). These tools are called teaching materials. Material is a visual and movable object designed to represent abstract mathematical concepts, stimulating students' various senses (Moyer, 2001). Instructional materials are the tools used by those who work in teaching environments to concretize abstract concepts and to realize teaching more effectively. On the other hand, material is a "physical objects that are used as teaching tools to engage students in the hands-on learning of mathematics" (Teacher Vision, 2009, p. 1) Effective use of materials is considered an important aspect of mathematics educational programs (Kaplan, Topan, & Erkan, 2013). The Turkish Ministry of National Education (MEB) stated the importance of materials used in mathematics teaching as;

> *Concrete materials should be used as much as possible in teaching new concepts and in evaluations to be made. Number cards, decimal blocks, fraction sets, various models from simple everyday materials, etc. It can be shown as an example of these materials (MEB, 2018, p.15).*

Educational processes supported by instructional materials provide students open and research-based learning environments, and the opportunity to work independently. One of the important roles of the instructional materials is to simplify abstract, complex and difficult terms, ideas, facts, and events and it makes them easier to understand (Fer, 2011). The instructional materials support students relate concrete ideas to abstract ideas (Uribe-Flórez& Wilkins, 2010). Teaching materials that can be used in the classroom environment are real objects, models, written materials (books, brochures), visual printed materials (pictures, photos, drawings, tables, graphics), various boards (chalkboard, whiteboard, electronic board), overhead projector and transparencies, computers, web pages, and software (Kaya,2006). Researchers stated the several benefits of educational materials for students as making meaningful learning, supporting active learning, hands-on-learning, improving reasoning, problem-solving and creative thinking skills, and providing real-life experience (Akçay, Tüysüz, Feyzioğlu, &Oğuz, 2008; Apperson, Laws, &Scepansky, 2006). Teaching with instructional materials makes mathematics easier to understand and learn by embodying abstract concepts and simplifying the content (Yalın, 2003). The use of teaching materials in learning environments puts the student at the center, provides richer learning opportunities, enables doing mathematics, and makes mathematics teaching enjoyable (Bozkurt &Akalın, 2010). In addition, the use of instructional materials helps students to understand better what mathematical concepts mean and associate them with daily life by concretizing mathematical concepts (Byoung, 2001). The other benefits of the use of teaching materials allows students to develop their mathematical thinking including problem-solving skills (Kamii, Lewis, &Kirkland, 2001).

It is important to examine the international measures because the researchers can use the information gathering from international exams (such as TIMMS) to make correct deison about their educational policies. The large-scale studies such as the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) resulted that multiple factors affect student achievement (Yetişir, 2014). These factors are associated with students, teachers, classroom, school and curriculum, and affect students' mathematics achievement. Researchers have concluded that mathematics` achievement is connected with student, family, and school. (e.g., Chen, Lin, Wang, Lin, & Kao, 2012; Kaya & Rice, 2010; Shen & Tam, 2008). The instructional practices used by teachers during learning and teaching environment have the potential for affecting student academic achievement. (Leithwood & Jantzi, 2006; Coe, Aloisi, Higgins & Major, 2014). Many TIMSS studies have identified the effectiveness of the use of materials on students achievement (e.g. Kaleli-Yılmaz & Hanci, 2016; Caponera & Losito, 2016; Wiberg, Rolfsman & Laukityte, 2013). The literature shows the effects of teacher practices on student achievement are mixed. (Dodeen, Abdelfattah, Shumrani, & Hilal, 2012). The aim of this study is examining the relationship between student achievement and bringing interesting materials by teachers to the classroom in 4th grade mathematics in Saudi Arabia, Qatar, Turkey, and Singapore. On the other hand, the researchers investigates how teachers' practices affect 4th students mathematics achievement between different TIMSS determined four proficiency levels countries.

Methodology

This study used TIMSS 2015 data to investigate the relationship between student achievement and bringing interesting materials by teachers to the classroom in 4th grade mathematics. The study used a questionnaire method, a technique of quantitative research method, to explore the relationship between student achievement and bringing interesting materials. The frequency of bringing interesting materials to the classroom is the independent variable and student achievement scores is the dependent variable of this study. The study selected four countries, each from different proficiency levels according to the TIMSS 2015 mathematics result, to see if bringing interesting materials to classrooms has different effects in different countries. TIMSS determined four proficiency levels: Advanced (625 and above), High (550-625), Intermediate (475-550), and Low (400-475) international benchmarks (Averett, et al. 2017). Four selected countries' TIMSS 2015 scores are presented in Table 1 (TIMSS and PIRLS International Study Center, 2019).

Table 1: Selected Countries' TIMSS 2015 Scores

Countries	Score	Ranking	Proficiency Level
Saudi Arabia	383	46th	Below low
Qatar	439	41st	Low
Turkey	483	36th	İntermediate
Singapore	618	1st	High

According to TIMSS 2015 4th grade mathematics result, none of the participating countries scored 625 and above points. Therefore, the study could not select a country from advanced proficiency level. As it is seen in Table 1, Singapore ranks at high proficiency level, Turkey ranks Intermediate, Qatar low, and Saudi Arabia ranks at below low proficiency levels.

Study Sample

TIMSS 2015 data was used in this study. TIMSS uses special methods to select students, teachers, and principals to take part in TIMSS exams. TIMSS uses two-stage random sampling design to ensure results can be generalized for the participant countries (Joncas& Foy, 2016). In the first stage, schools are drawn for each grade level. In the second phase, one or more intact classrooms are selected from sampled schools. TIMSS makes selections on classroom basis rather than individuals to avoid regular instructions in classrooms (Joncas&Foy, 2016). The goal is selecting about 150 schools for each country at different grade levels and two classrooms from selected schools to have at least 4500 student participants in TIMSS exams. Table 2 shows the number of student participants for this study. The study also used teacher data. While it is not possible to access the exact number of teacher participants,

it can be calculated by assuming the average class size as 20 students. Table 2 shows the number of students and teachers participated in this study

Table 2: Number of Student and Teachers Participants in this Study

Countries	Number of Students	Number of Teachers (Approximate)
Saudi Arabia	4273	213
Qatar	5362	268
Turkey	6440	322
Singapore	6393	319
Total	22468	1122

Data Collection

The study used four countries' 4th grade students and their teachers' data to analyze the relationship between teachers' frequency of bringing interesting materials and student achievement. These data were directly obtained from TIMSS publicly available website. TIMSS applies questionnaires to teachers to see what teacher related factors affect student learning. Grade 4 Teacher Questionnaire about instructional practices including "Relate the lesson to students' daily lives, Ask students to explain their answers, Bring interesting materials to class, ask students to complete challenging exercises that require them to go beyond the instruction, Encourage classroom discussions among students, Link new content to students' prior knowledge, ask students to decide their problem-solving procedures, and Encourage students to express their ideas in class". One of the questions is 'how often do you bring interesting materials in teaching this class?' It was asked to teachers as it is seen in Figure 1.

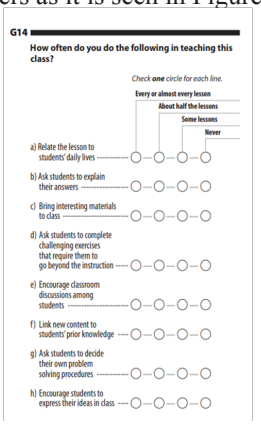

Figure 1: Teacher Questionnaire about Instructional Practices

Teachers' answer to the question was the main data source of this study. The study also obtained student exam results to analyze the relationship between using interesting materials and student achievement.

Data Analysis

For the purpose of analyzing the relationship between independent (bringing interesting materials) and dependent variables (student achievement scores) of this study, linear regression tests were used for each selected country. Since TIMSS data is structured as hierarchical data, SPSS alone is not enough to handle TIMSS data. Therefore the study used the IDB Analyzer tool (developed by IEA for creating TIMSS and PIRLS datasets to be used in statistics tools) along with SPSS to correctly analyze the TIMSS data. However, result tables that are presented in regression analyses do not include ANOVA tables and therefore p values (E.J. Gonzales, personal communication, October 27, 2016). However, results provide t-value which is used in this study to test for statistical significance. IADB (2016) says ' if the absolute value of the group difference divided by the standard error of the difference exceeds a t-value of 1.96, the result can be regarded as statistically significant on the 95% level' (p.25). Therefore, significance tests are conducted by t-value. Never bring interesting material frequency was selected as a constant/reference category in regression analyses. The other frequencies (half the lessons, some of the lessons, and every lesson) were compared with never frequency to see the relationship between bringing interesting materials and student achievement.

Findings

Descriptive Results

Descriptive results were obtained from regression analyses for each country. Table 3 shows descriptive results for Saudi Arabia.

Table 3: Descriptive Results for Saudi Arabia

Frequency	N	%
Every or almost every lesson	1296	30
About half the lessons	1490	35

Some lessons	1383	32.5
Never	104	2.5
Total	4273	100

Table 3 indicates that 97.5% of students see their teachers bring an interesting material at least once in Saudi Arabia. Only 25% of students' teachers never bring interesting materials in Saudi Arabia. On the other hand, 30% of students' teachers bring interesting material in every or almost every lesson. Table 4 shows descriptive results for Qatar.

Table 4: Descriptive Results for Qatar

Frequency	N	Percentage (%)
Every or almost every lesson	2086	39
About half the lessons	1750	32.5
Some lessons	1497	28
Never	29	0.5
Total	5362	100

Table 4 shows that almost every teacher brings an interesting material to the classroom in Qatar. Only 0.5% students (29) never see interesting material in their classroom. In Qatar, 39% of students see their teachers bring an interesting material to the class in every or almost every lesson. Table 5 shows descriptive results for Turkey.

Table 5: Descriptive Results for Turkey

Frequency	N	Percentage (%)
Every or almost every lesson	882	13.5
About half the lessons	1473	23
Some lessons	4030	62.5
Never	55	1
Total	6440	100

Table 5 shows that the majority of Turkish students (62.5%) see their teachers bring interesting material to the classroom in some lessons. While1% of Turkish students never see an interesting material, 13.5% of students see an interesting material in every or almost every lesson. Table 6 shows descriptive results for Singapore.

Table 6: Descriptive Results for Singapore

Frequency	N	Percentage (%)
Every or almost every lesson	506	8
About half the lessons	2809	44
Some lessons	3042	47.5
Never	36	0.5
Total	6393	100

Table 6 shows that almost every teacher brings an interesting material to the classroom in Singapore. Only 0.5% students (36) never see their teacher bring interesting material. 8% of Singaporean students see their teachers bring interesting material to the class in every or almost every lesson.

Table 7 shows mean scores and standard deviations of bringing interesting materials for each country.

Table 7: Mean and Standard Deviations of Bringing Interesting Materials

Countries	Mean	SD
Qatar	1.91	.84
Saudi Arabia	2.07	.85
Singapore	2.40	.64
Turkey	2.52	.73

Table 7 shows that Qatar teachers bring interesting materials most frequently while Turkish teachers bring the least frequently in comparison to the four selected countries. Lower mean score indicates bigger frequency due to coding mechanism in TIMSS teacher questionnaire.

Regression Results

The study employed linear regression tests to analyze the relationship between bringing interesting materials to the classroom and student achievement in 4th grade mathematics. Table 8 represents the R Square result of each country.

Table 8: R Square Result of Each Country

Countries	R Square	R Square (se)
Saudi Arabia	.03	.02
Qatar	.03	.02

Turkey	.03	.02
Singapore	.00	.00

R square table shows that bringing interesting materials explain 3% of mathematics achievement in Qatar, Saudi Arabia, and Turkey. On the other hand, bringing interesting materials to the classroom does not explain any portion of student achievement in Singapore. Regression analyses results are presented in Table 9.

Table 9: The Relationship between Bringing Interesting Materials and Student Achievement

	Frequencies	B	SE B	β	t-value
Saudi Arabia	Never	325.43	21.33		
	Some lessons	365.91	21.91	.21	1.84
	About half the lessons	388.71	22.80	.33	2.77*
	Every or every almost lesson	398.97	23.26	.37	3.18*
Qatar	Never	362.13	42.92		
	Some lessons	459	43.23	.46	2.25*
	About half the lessons	444.77	44.10	.39	1.87
	Every or every almost lesson	421.87	.	.	.
Turkey	Never	324.78	25.60		
	Some lessons	483.28	26.21	.80	6.17*
	About half the lessons	479.75	26.47	.68	5.72*
	Every or every almost lesson	499.36	27.25	.62	6.26*
Singapore	Never	570.89	18.64		
	Some lessons	617.09	19.56	.27	2.34*
	About half the lessons	619.38	18.76	.28	2.58*
	Every or every almost lesson	616.13	22.71	.14	1.91

Table 9 indicates that, in general, as frequency of bringing interesting materials increases, student achievement also increases in four selected countries. Section below will discuss findings on country bases.

Saudi Arabia: There is a linear relationship between bringing interesting material and student achievement in Saudi Arabia. Student achievement increases as the frequency of bringing interesting materials increases. These increases are significant at about half the lessons (t-value = 2.77) and every or almost every lesson (t-value =3.18) frequencies in comparison to never frequency. Even though student achievement increases at some lessons frequency, this increase is not a statistically significant (t-value= 1.84) increase.

Qatar: The average student achievement is 362 points among Qatari students whose teachers never bring interesting materials to their classroom. However, the average score rises up to 459 points among students whose teachers bring interesting materials to the classroom in some lessons. This 97 points increase is a statistically significant (t-value =2.25) increase in comparison to the never frequency of bringing interesting materials variables. There are increases in about the half lessons and every or almost every lesson frequencies in comparison to never frequency, too. But these increases are not statistically significant.

Turkey: The relationship between bringing interesting materials and student achievement is linearly correlated in Turkey. Table A shows that the average student achievement was about 324 in whose teachers never bring interesting materials to the classroom. However, student achievement greatly increased at some lessons frequency (t-value = 6.17), about half the lessons frequency (t-value = 5.72), and every or almost every lesson frequency (t-value = 6.26). All of these increases in student achievements are statistically significant increases.

Singapore: Singapore's finding also shows

significant relationships but these relations are not linear. Student achievement increased about 47 points (t-value = 2.34) at some lesson frequency and about 49 points (t-value = 2.58) at about the half frequency in comparison to never frequency level. These differences indicate statistically significant differences. Even though student achievement increased about 46 points (t-value = 2.91) at every or almost every lesson, it is not a significant increase despite being so close to the cut off t-value point of 1.96∓.

Conclusion and Suggestions

The purpose of this current study is to examine the relationship between student achievement and bringing interesting materials to the 4th grade mathematics classroom in Saudi Arabia, Qatar, Turkey, and Singapore. Linear regression analyses were conducted to determine the relationship between bringing interesting materials in classroom and student achievement for four countries that are at the four different proficiency levels based on their scores on TIMSS 2015 mathematics achievement. The results showed that there is a significant relationship between student achievement and using interesting materials in teaching mathematics. These results were observed in all of four selected countries despite being in four different achievement categories.

Descriptive results indicated that almost every teacher took an interesting material to their classroom at least once in the 2015 school year in four selected countries. While 39% of Qatari students see interesting material in every lesson, only %8 of Singaporean students see interesting material in every lesson. Students' rates that never see their teachers bring interesting materials to the classroom were 0.5% in Qatar and Singapore, 2.5% in Saudi Arabia and 1% in Turkey. Qatari students are most likely to see their teachers bring interesting materials to the classroom while Turkish students least likely to see those materials among four selected countries. The international average shows that teachers who reported bringing interesting materials to class in 2015 were 28 percent as in 2011 33 percent (Mullis, Martin, Foy, and Arora, 2012).

This study found a significant relationship between frequency of bringing interesting materials and student achievement in 4th grade. In Saudi Arabia and Turkey, it can be concluded that as the frequency of bringing interesting materials increases, the mathematics success of the students also increases. The relation between bringing interesting materials and student achievement is about linear in these countries. However, in Qatar and Singapore, the student achievement and bringing interesting material frequency is not linear. The optimal frequency of using interesting materials is some of the lessons in Qatar and about half the lessons in Singapore. In contrast, Arends, Winnaar and Mosimege (2017) found that teachers who spent more time bringing interesting materials to class were associated with lower average mathematics scores. The study concluded that it is important to bring the instructional materials in the classroom at the right frequencies. Using too many materials may overwhelm students and as a result their motivation for materials may decline. The current study found that using materials every day is most helpful in Turkey and Saudi Arabia but not in Qatar and Singapore. It means that there are some cultural differences toward using materials.

The study found that bringing interesting materials explains 3% of mathematics achievement in Qatar, Saudi Arabia, and Turkey, however it does not explain any portion of student achievement in Singapore. Three percent of student achievement may seem non-significant, but TIMSS supposes more than two hundred variables are associated with student success. Thus, 3% of student achievement related with just one variable, using interesting materials, is a significant portion. Interestingly, bringing interesting material to the classroom in Singapore, which is at a high proficiency level according to TIMSS 2015 results, is very unlikely to explain elementary students' mathematics achievement. Since Singapore is a high achieving country in almost all international assessment projects such as PISA, PIRLS, and TIMSS, studies should focus on Singaporean teachers' instructional practices to see what they are doing and look for the ways to adopt those teaching strategies to apply in other countries.

To conclude, the study found that using interesting materials increases student achievement in 4th grade mathematics. However, teachers cannot create materials for each standard or learning objective because creating materials requires a significant amount of time and money. In order to ease teachers' loads of creating materials, schools can provide materials for teachers. Schools can also work with teacher candidates in education faculties to create materials to be used in classrooms.

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