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Trends of Homework in Mathematics: Comparative Research Based on TIMSS Study

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Homework is a common instructional practice that is used to motivate students, develop students' studying skills and habits, inform parents about student learning, and increase student achievement. Homework provides an opportunity for students to revisit daily topics, and improve students' understanding of math concepts and problem-solving skills, helps students learn from their mistakes, and prepare for tests. One of the primary goals of this study was to find the trends of homework frequency. This study used TIMSS 2003, 2007, 2011, and 2015 data for Singapore, United States, Slovenia, and Turkey. The study used hierarchical multiple regression analyses to examine the relationship between homework frequency and student achievement in fourth- and eighth-grade mathematics in Slovenia, Singapore, Turkey, and US. The study also sought optimal homework frequencies in those countries. The study found that homework frequency significantly effects student achievement in 8th grade but not in 4th grade. The study also found that trend of the assigning homework from 2003 to 2015 is negative both in 4th and 8 grades in all selected countries, except in Turkey.

Keywords: homework, mathematics education, 4th grade, TIMSS, international comparasion

INTRODUCTION

Homework is a common instructional practice that is used to motivate students, develop students' studying skills and habits, inform parents about student learning, and increase student achievement (NEA, 2015). Homework is defined as "any task assigned to students by school teachers that is meant to be carried out during nonschool hours" (Cooper, 1989, p. 86) and "an important extension of in-school opportunities to learn" (Good & Brophy, 2003, p.393). Homework is an effective way to extend instruction and monitor student progress in different subject areas and homework practices have benefits for both students and teachers. Students refresh and improve their problems

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solving skills when they work on homework as well as help them to prepare for their tests (Kalchman, 2011). Moreover, teachers can use homework as feedback to see whether their instructional methods are effective or not by looking at students' work.

Homework provides an opportunity for students to revisit daily topics, and improve students' understanding of math concepts and problem-solving skills, helps students learn from their mistakes, and prepare for tests (Kaur, 2011). Even though assigning homework is perceived as a beneficial strategy to increase student learning, there is no consensus on its importance and relevance to student achievement (Zhu & Leung, 2012; Trautwein, 2007). Moreover, teachers have different opinions about the effect of homework. While some teachers frequently assign homework, some teachers rarely utilize homework, and even some teachers think that homework should be banned in primary schools because homework is waste of time for children, teachers, and parents (Paton, 2009).

Homework is used by teachers for a long time but the influence of the homework on students' achievement is very controversial (Cooper, Robinson & Patall, 2006; Gu & Kristoffers, 2015). Previous research about homework is not certain and inconclusive about positive effect of homework because some found that homework have positive effect on student achievement while some others found its negative effects (e.g., Dettmers, Trautwein, & Lüdtke, 2009; Boddison, 2015).

Earlier studies have investigated relationship between homework and students' achievement, especially in math education, and the results are inconsistent. For example, Keith (1982) investigated high school students' academic achievement and the amount of time spent on homework, and found a positive effects. However, some researchers found negative or low relationships students' academic achievement and time spent on homework in elementary, middle and high schools (e.g., Cooper, Robinson, and Patall, 2006; Rosário et al., 2009, 2011; Trautwein, U., Schnyder, Niggli, Neumann, and Lüdtke, 2009). Some researchers found significant and positive relationships between homework and math achievement (e.g., Areepattamanil & Kaur, 2013; Cheema & Sheridan, 2015;Fernandez-Alonso, Suarez-Alvarez, & Muniz, 2015; Ladson, 2012; Pelletier, 2005; Riley, 2007). For example, Ladson (2012) and Fernandez-Alonso, Suarez-Alvarez, Muniz, (2015) specifically investigated differences between math achievement and time spent on homework, and they found significant effects.

However, homework can improve students' academic success as well as their academic skills if homework is well-designed for students' life-long learning process skills, suitable for students' interests and needs, and their age (Bembenutty, 2011; Ramdass and Zimmerman, 2011; Rudman, 2014; Stoeger and Ziegler, 2008; Xu, 2005; Warton, 2001). When we consider homework frequency instead of time spent on homework, Dettmers, Trautwein, Lüdtke, Kunter, and Baumert (2010) and Fernández-Alonso, Suárez-Álvarez, and Muñiz (2015) found a positive relationship between homework frequency and academic achievement.

Studies also show that homework in the early age does not affect the success of the student, and it develops negative attitudes of students towards the education (Cooper,

Robinson and Patall, 2006; Eren and Henderson, 2011; Froiland, 2011; Rudman, 2014; Xu, 2005). For example Cooper, Robinson, and Patall (2006) found strong relationships between homework and achievement for students in grade 7-12 than for students in grade K-6. Kalenkoski nad Pabilonia (2017) found that homework time has positive effects on academic achievement for boys in high school.

A recent study of Spanish indicated that assigning homework that will take one hour per day to complete is the optimal amount of homework. Department of Education research results indicated that working on homework two-three hours per day could increase student achievement greatly in English, math, and science (Vasagar, 2012). However, another study conducted at Stanford University found that too much homework may cause more stress, physical health problems, imbalance and isolation from society (Boddison, 2015). As can be seen in above discussion, the optimal frequency of assigning homework is not clearly known or it changes from subject to subject and it may change from country to country.

Therefore, this study is conducted to determine the optimal frequency of assigning homework in mathematics in different countries through Trends in International Mathematics and Science Study (TIMSS) data as it provides data for many countries. TIMSS data also enables researchers to see the change of homework assigning frequency over the time. This study also investigated the teachers' homework assigning frequency trend from 2003 to 2015.

The importance of this study is beyond determining the relationship between homework frequency and student achievement in mathematics. The ideal homework frequency in mathematics is not known. Thus, this study investigated the relationship between homework frequency and eight-grade mathematics achievement in selected countries (Singapore, U.S., Slovenia, and Turkey) through TIMSS data in order to determine the ideal homework frequency in mathematics. The study also explored the trends of homework frequency. This study also compared four countries' (Slovenia, Singapore, Turkey, and United States) homework frequency to see the differences from country to country.

Despite the presumable benefits of homework, there is no consensus among teachers about homework frequency. Previous TIMSS survey results showed that frequency of assigning homework and the amount of time to do homework for mathematics varies from country to country and even teacher to teacher. Homework practices vary from teacher to teacher because teachers have different opinions about homework's benefits. There are also policies about assigning homework in different countries that also results different applications of assigning homework (TIMSS, 2011). Beside, homework causes problems for teachers, students, and parents because teachers complain about students' lack of effort on completing assignments while students complain about spending time on homework rather on entertainment (Trautwein, 2007). Parents are also not happy about doing homework because they are not agreed on when, whether, and how to complete assignment (Trautwein, 2007).

The first aim of this research study is examining the relationships between homework frequency student achievement in mathematics in fourth and eighth grade in selected countries. The second aim of the study is finding the trend of the homework frequency in selected countries. The final goal of this study is determining the optimal homework frequency in selected countries.

METHOD

Country Selection

This study used TIMSS 2003, 2007, 2011, and 2015 data for Singapore, United States, Slovenia, and Turkey. The study includes a mix of high performing and low performing countries. TIMSS defines countries as high performing and low performing countries based on their score on TIMSS assessments. Countries that have score of 500 and above are defined as high performing and 500 and below are defined as low performing countries. Singapore, United States, and Slovenia are high-performing countries while Turkey performed well below TIMSS Scale centerpoint average in all TIMSS administrations at both 4th and 8th grades. Researchers especially are interested in Turkey and United States because Turkey is their home country and they studied in United States. Singapore is usually the top performer country in TIMSS and Slovenia is performing similarly with United States. Thus, these countries were selected to compare Turkey and America's performance with a top performer and a similar performer country.

While Slovenia, Singapore, and United States participated all of the TIMSS sessions at fourth and eighth-grade, Turkey did not participate TIMSS in 2003 and 2007 at fourth grade, and TIMSS 2007 at eighth grade. Some students are also excluded in TIMSS studies if school sizes are extremely small, accessibility is difficult to schools because of their remote location, schools offer an education that is radically different from the mainstream educational system, or if schools only provide education to special needs students (reference needed). Students with functional and intellectual disabilities as well as students whose language is different than the test language were also excluded from the TIMSS.

Sample

Data for this study were retrieved from the four most recent TIMSS administrations (2003, 2007, 2011, and 2015). Table represents sample students that participated TIMSS exams in each TIMSS administration. The TIMSS employs a two-stage stratified cluster design to select students from each country to ensure all students are represented ın the exams. In the first sampling phase, schools were selected based on their probabilities proportional size (PPS) from a list of nationally representative schools and two additional schools were randomly selected for each school in case initially selected schools refused to participate. Around 150 schools and two classrooms from each school were selected in most countries so that representation of a sample size of at least 4,500 students was obtained for each country (Mullis, Martin, Foy, & Arora, 2012). Table 1 shows number of students participated to TIMSS exams each year.

Table 1
Student samples for selected countries

Grades	4th Grade				8th Grade			
Years	2003	2007	2011	2015	2003	2007	2011	2015
Slovenia	3126	4351	4492	4445	3578	4043	4415	4527
Singapore	6668	5041	6368	6517	6018	4599	5927	6116
Turkey	.	.	7479	6456	.	4498	6928	6079
US	9829	7896	12,569	10,029	8912	7377	10,477	10,221

The present study had two variables; homework frequency was the independent variable and student scores (1st to 5th Mathematics plausible values) was the dependent variable of the study. Homework frequency variable was derived from math teacher questionnaire. It is stated as How often do you usually assign mathematics homework to the students? Teachers needed to respond to this question as in Table 2.

Table 2
Homework frequency in 2003 and 2007 teacher survey

Homework Frequency	Codes
Every day or almost every day	1
About half the lessons	2
Some lessons	3

Above question format was used in TIMSS 2003 and 2007. TIMSS modified homework frequency question in TIMSS 2011 and 2015. The question was stated as How often do you usually assign mathematics homework to the students in this class? Teachers needed to respond to this question as in Table 3.

Table 3
Homework frequency in 2011 and 2015 teacher survey

Homework Frequency	Codes
I do not assign mathematics homework	1
Less than once a week	2
1 or 2 times a week	3
3 or 4 times a week	4
Every day	5

Teachers' responses to this question in TIMSS 2011 and 2015 were recoded through SPSS to match with 2003 and 2007 versions.

Data Analyses

Hierarchical multiple regression analyses were conducted to measure the relationship between homework frequency and student achievement for each country for TIMSS 2003, 2007, 2011, and 2015 administrations. Some Lessons homework frequency was selected as constant/reference category in regression analyses for all TIMSS exams. TIMSS data cannot be handled without IDB analyzer tool that is developed by International Association for the Evaluation of Educational Achievement (IEA). IDB analyzer take hierarchical structure of TIMSS data into consideration and prepares data set for statistical analyzing tools. SPSS used for data analyzing in this study. However,

SPSS in conjunction with IDB Analyzer do not provide ANOVA table (E.J. Gonzales, personal communication, October 27, 2016), but provides t-value in regression analyses. IADB (2016) says ' if the absolute value of the group difference divided by the standard error of the difference exceed 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.

FINDINGS

The results are presented in following sections year by year under 4th grade and 8th grade results headlines.

Relationship between Homework Frequency and Student Achievement

4th Grade Results

4th grade regression results for 2003 are not included here to avoid repetition but 2003 results were similar to 2007 results. No significant relationship was found between student achievement and homework frequency in any selected countries.

2007

Table 4
Hierarchical multiple regression analyses predicting 4th grade mathematics achievement from homework frequency

Countries	R-Square (s.e.)	Category name	B	SE B	β	t-value
		Constant	5000.92	17.04		
		Half of the lessons	19.88	.	.	.
Slovenia	.00	Every lesson	16.59	19.22	.04	.84
		Constant	593.56	15.23		
		Half of the lessons	8.96	15.37	.07	.73
Singapore	.00	Every lesson	-5.47	17.24	.08	-.36
Turkey	Did not participate					
		Constant	519.29	17.04		
		Half of the lessons	10.96	17.33	.07	1.27
US	.00	Every lesson	12.04	21.10	.07	1.24

Table 4 shows the results of the hierarchical linear regression analyses. Homework frequency explained none of the variance (R^2= .00) in student achievement in any of the selected countries. As seen in Table 4, student achievement increased by increase in homework frequency but none of those increases were statistically significant.

2011

Table 5
Hierarchical multiple regression analyses predicting 4th grade mathematics achievement from homework frequency

Countries	R-Square (s.e.)	Category name	B	SE B	β	t-value
		Constant	512.94	2.15		
		Half of the lessons	-7.63	17.66	.02	-.45
Slovenia	.00	Every lesson	.	.	.	.
		Constant	485.11	19.82		
		Half of the lessons	124.07	20.43	.11	5.66*
Singapore	.03	Every lesson	117.07	21.57	.11	4.98*
Turkey	.00	Constant	438.17	26.00		
		Half of the lessons	33.85	26.40	.13	1.28
		Every lesson	28.79	27.06	.13	1.06
		Constant	539.53	5.29		
		Half of the lessons	3.36	6.12	.03	.55
US	.00	Every lesson	2.83	8.78	.04	.32

* indicates statistically significant differences

Table 5 indicates the results of the hierarchical linear regression analyses. Homework frequency explained 3% of the variance (R^2= .03) in student achievement in Singapore, but none in Slovenia, Turkey, and the US (R^2= .00). Table 5 also shows that student achievement increased by increasing the homework frequency. Student achievement greatly increased by increasing homework frequency in Singapore but not in other countries.

2015

Table 6
Hierarchical multiple regression analyses predicting 4th grade mathematics achievement from homework frequency

Countries	R-Square (s.e.)	Category name	B	SE B	β	t-value
		Constant	500.92	18.94		
		Half of the lessons	19.88	.	.	.
Slovenia	.00	Every lesson	16.59	19.22	.04	.84
		Constant	636.13	19.69		
		Half of the lessons	-17.43	20.04	.10	-.87
Singapore	.01	Every lesson	-27.12	20.71	.10	-1.30
Turkey	.01	Constant	506.05	17.04		
		Half of the lessons	-20.84	18.51	.09	-1.14
		Every lesson	-29.34	18.39	.09	-1.60
		Constant	543.72	8.81		
		Half of the lessons	-5.19	9.22	.05	-.56
US	.01	Every lesson	-9.33	11.81	.05	-.79

Table 6 shows the results of the hierarchical linear regression analyses. Homework frequency explained 1% of the variance (R^2= .01) in student achievement in Singapore, Turkey, and the US, but none in Slovenia (R^2= .00). Table 6 also indicates that student achievement decreased by increasing homework frequency in all countries except in Slovenia. However, none of those changes were statistically significant.

8th Grade Results

8th grade regression results for 2003 are not included here to avoid repetition but 2003 results were similar to 2007 results. Significant relationships were found between student achievement and homework frequency in Singapore and US but not in Slovenia. Turkey did not participate to TIMSS in 2003 at 8th grade.

2007

Table 7
Hierarchical multiple regression analyses predicting 8th grade mathematics achievement from homework frequency

Countries	R-Square (s.e.)	Category name	B	SE B	β	t-value
		Constant	467.31	26.41		
		Half of the lessons	35.61	26.99	.09	1.33
Slovenia	.01	Every lesson	10.81	27.78	.09	.39
		Constant	544.53	19.06		
		Half of the lessons	40.58	22.71	.10	1.81
Singapore	.05	Every lesson	62.69	19.98	.10	3.24*
		Constant	422.74	10.82		
		Half of the lessons	1.88	16.45	.06	.11
Turkey	.00	Every lesson	11.29	14.15	.07	.80
		Constant	466.54	6.34		
		Half of the lessons	13.53	8.32	.03	1.72
US	.03	Every lesson	46.90	7.20	.04	3.34*

* indicates statistically significant differences

Table 7 shows the results of the hierarchical linear regression analyses. Homework frequency explained 1% of the variance (R^2= .01) in student achievement in Slovenia and 5% (R^2= .05) in Singapore, and 3% (R^2= .03) in the US, but none in Turkey (R^2= .00). Table 7 also indicates that student achievement increased by homework frequency in all of the selected countries. However, statistically significant increases are observed in only Singapore and United States.

2011

Table 8
Hierarchical multiple regression analyses predicting 8th grade mathematics achievement from homework frequency

Countries	R-Square (s.e.)	Category name	B	SE B	β	t-value
Slovenia	.01	Constant	444.26	34.30	.	.
		Half of the lessons	61.97	34.28	.11	1.87
		Every Lesson	45.21	35.92	.11	1.27
		Constant	526.33	15.06		
		Half of the lessons	91.59	14.95	.07	6.42*
Singapore	.09	Every lesson	93.44	17.15	.07	5.76*
		Constant	423.17	10.67		
		Half of the lessons	37.71	12.12	.04	3.20*
Turkey	.02	Every lesson	-12.02	21.35	.04	-.57
		Constant	480.15	9.39		
		Half of the lessons	30.61	10.41	.07	2.95*
US	.03	Every lesson	41.81	10.05	.06	4.12*

* indicates statistically significant differences

Table 8 shows the results of the hierarchical linear regression analyses. Homework frequency explained 1% of the variance (R^2= .01) in student achievement in Slovenia and 9% (R^2= .09) in Singapore, 2% (R^2= .02) in Turkey, and 3% (R^2= .03) in the US. Table 8 also indicates that there was significant relationship between homework frequency and student achievement in Turkey, Singapore, and United States but not in Slovenia. The table also show that student achievement increased in all selected countries by homework frequency.

2015

Table 9
Hierarchical multiple regression analyses predicting 8th grade mathematics achievement from homework frequency

Countries	R-Square (s.e.)	Category name	B	SE B	β	t-value
		Constant	516.09	2.81	.	.
Slovenia	.00	Half of the lessons	-14.09	5.25	.02	-2.6*
		Every lesson	3.28	4.06	.03	.81
		Constant	541.66	56.19		
		Half of the lessons	81.11	56.83	.21	1.46
Singapore	.03	Every lesson	68.76	60.86	.20	1.15
		Constant	442.54	11.57		
		Half of the lessons	18.87	13.48	.05	1.42
Turkey	.01	Every lesson	1.65	21.52	.04	.08
		Constant	484.31	8.09		
		Half of the lessons	25.84	8.77	.05	2.93*
US	.05	Every lesson	58.40	9.44	.05	6.33*

* indicates statistically significant differences

Table 9 shows the results of the hierarchical linear regression analyses. Homework frequency explained 3% of the variance (R^2= .03) in student achievement in Singapore and 1% (R^2= .01) in Turkey, and 5% (R^2= .05) in the US, but none in Slovenia (R^2= .00). Table 9 indicates that student achievement increased by homework frequency in

Singapore, Turkey, and United States but decreased in Slovenia. Changes in United States and Slovenia were statistically significant.

Trend of Homework Frequency

Table 10
Trend of homework frequency for 4th grade from 2003 to 2015

Countries/Years	2003	2007	2011	2015
Slovenia	1.12	1.11	1.33	1.36
Singapore	1.40	1.39	1.52	1.62
Turkey	NA	NA	1.89	1.71
U.S.	1.35	1.32	1.56	1.61

Mean scores of homework frequency in last four TIMSS exams are presented in Table 10. It can be seen that mean scores increased in general from 2003 to 2015. Mean scores was closer to 1 (almost every day) in 2003 but it was closer to 2 (half of the lessons). It means that teachers are now assigning less frequent homework than before.

Table 11
Trend of homework frequency for 8th grade from 2003 to 2015

Countries/Years	2003	2007	2011	2015
Slovenia	1.04	1.07	1.38	1.43
Singapore	1.26	1.39	1.84	1.86
Turkey	NA	1.73	2.23	2.25
U.S.	1.15	1.17	1.59	1.63

Table 11 shows the trend of assigning homework in eighth-grade mathematics courses. It indicates that teachers in all of the selected countries assigned less and less homework between each TIMSS exams. Even though there was significant relationship between homework frequency and student achievement in every TIMSS exam in US and in most of TIMSS exams in Singapore, teachers in those countries also assigning less homework in comparison to previous TIMSS administrations.

Optimal Homework Frequency

4th Grade

Tables 4-6 indicate no relationship between homework frequency and student achievement in all the selected countries except in Singapore. In general, student achievement increased by the increase of homework frequency in Singapore. It can be concluded that while there is no optimal homework frequency for Slovenia, Turkey, and United States at fourth grade, half the lesson homework frequency is the optimal frequency for Singapore, the top performer country in the most TIMSS exams.

8th Grade

Tables 7-9 indicate that there is significant relationship between homework frequency and student achievement in all selected countries except in Slovenia. In general, student achievement significantly increased by the increase in homework frequency in Singapore and the United States. However, such pattern was not observed in Slovenia

and Turkey. It can be concluded that optimal homework frequency is almost every day in Singapore and US, but there is no optimal homework frequency for Slovenia and Turkey since no relationship was found between student achievement and homework frequency in these countries, in general.

DISCUSSION

The study found that homework frequency significantly effects student achievement in 8th grade but not in fourth grade. Trautwein's (2007) experimental study found that homework frequency significantly affects student achievement. Trautwein (2007) also found that time spent on completing the homework is negatively correlated with student achievement. Previous studies found that homework is more effective in middle school than primary school (Şirin, 2014). It is possible that primary school students spend so much time on doing homework, while middle school students spend enough time to complete their homework. It might be one of the reasons of significant relationship in 8th graders but non-significant relationship in 4th graders.

Even though this study found no relationship between homework frequency and student achievement in 4th grade and there are grumbles about assigning and completing homework, the majority of stakeholders in education agreed on benefits of homework as a valuable instructional strategy (Xu, 2005). Even though different opinions and policies exist about assigning homework, Patnam (2013) suggests that teachers need to assign a balanced amount of homework regularly but it needs to be aligned with students' needs so that they are not so easy for some students while it is too hard for some other students. Challenging guided exercises might be better for students because students will derive satisfaction and improve self-confidence by answering practice questions (Patnam, 2013).

The study found that Slovenian teachers are assigning homework most frequently and Turkish teachers least frequently. Despite the high frequency of assigning homework, student achievement do not benefit in both 4th and 4th grades in Slovenia. Even though Turkish teachers are giving less frequent homework, it has been increasing since 2007.

Trend of the giving homework from 2003 to 2015 is negative in all selected countries expect in Turkey both in 4th and 8 grades. Even though homework frequency positively affects student achievement in Singapore and US, teachers in Singapore and US are giving homework less frequently. But, homework frequency is higher in 4th grade than 8th grade in all of the selected countries even though it is more effective in 8th grade.

CONCLUSION

This study investigated the relationship between homework frequency and student achievement in fourth- and eighth-grade mathematics in Slovenia, Singapore, Turkey, and US. While there was not statistically significant relationship among three homework frequencies in Slovenia and Turkey, significant relationship was detected in Singapore and the United States. Even though homework frequency do not have significant effect on student achievement in every country, teachers should continue to assign homework because homework also teaches responsibility, planning, time management, and working

independently. However, it is important to assign optimal amount of homework at right frequencies. General idea about assigning homework is that teachers should assign homework everyday but time that it takes to complete homework should change by grade levels (Cooper, 2006; Bodisson, 2015). Time to work on homework should be 10 minutes in 1st grade and should increase 10 minutes at each grade. 6th graders should spend one hour to complete homework per day but 3rd graders should spend half an hour. Table 12 can be used as guidance for teachers in assigning homework (Cooper, 2006).

Table 12
Homework completion time for grades

Grades	1st-2nd Graders	3rd-6th Graders	7th-8th Graders	9th-12th Graders
Homework Time	10-20 min.	30-60 min	90 min	1.5-2.5 hours

While it is surprising to see the decreasing trend of homework frequency even though it increases student achievement in Singapore and US, it is even more surprising to find that homework frequency is a significant predictor of student achievement in 8th grade but not in 4th grade. Further studies are needed to deliberately analyze the homework practices in different countries to find out why it improves student achievement in some countries but not in others. This study only focused on homework frequency but further studies can focus on time that needed to complete assignments, homework types, tracking homework, and other aspects of homework practices to see what aspects of homework lead to higher student achievement.

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