Analysis of the Factors Affecting Student Achievement in TIMSS Mathematics Test for the Eighth Grade in Saudi Arabia at the Student and School Levels Using Hierarchical Linear Modeling

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Abstract

This study aims to investigate the most contributing factors at student-level and school-level in explaining variance in students' achievement in mathematics, using data obtained from Trends in International Mathematics and Science Study (TIMSS) 2019 test, and questionnaires accompanied by it. The study sample included (56,800) students from eighth-grader nested within (209) schools in Saudi Arabia, participated in TIMSS 2019. Hierarchical Linear Modeling (HLM) was used with two (student and school) levels. The results indicated that student and school variables were able to explain (42%) of the total variance. The school level variables accounted for the majority of explained variance (78.59%), compared to student variables which accounted for (21.41%), indicating that the differences in student math achievement is more due to school characteristics. When the variables were controlled at the student and school levels, the statistically significant predictors of students' achievement in mathematics at the student level, were related to potential source of education inequity, including student's background variables related to availability of educational resources at home and the student's characteristics variables related to student's attitudes towards mathematics and school. As for the statistically significant predictors at school level, they included teacher's background variable that relates to his/her specialization in mathematics, and school's climate variables related to percentage of students speaking the language of test, and the school socio-economic status (SES), that is represented by percentage of economically affluent students in the school. Thus, it is important to take these variables into consideration when planning to improve students' education and achievement in mathematics.

Keywords: HLM; TIMSS; Student characteristics; School Characteristics; Mathematics Achievement.

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تحليل العوامل المؤثرة على تحصيل الطلاب في اختبار تيمس للرياضيات للصف الثامن في المملكة العربية السعودية على مستوى الطالب والمدرسة باستخدام النمذجة الخطية الهرمية

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الملخص باللغة العربية

تهدف هذه الدراسة إلى استكشاف أهم العوامل المساهمة، على مستوى الطالب ومستوى المدرسة، في تفسير التباين في تحصيل الطلاب في الرياضيات، وذلك باستخدام البيانات المستمدة من اختبار *الاتّجاهات* في *الدراسات* العالمية للرّياضيات *والعلوم* (تيمس TIMSS 2019) والاستبيانات المصاحبة له. شملت عينة الدراسة (56800) طالباً وطالبة من الصف الثامن موزعين على (209) مدرسة في المملكة العربية السعودية شاركوا في الدراسة. تم استخدام النمذجة الخطية الهرمية HLM بمستويي الطالب والمدرسة. وأشارت النتائج إلى أن متغيرات الطالب والمدرسة كانت قادرة على تفسير (42%) من التباين الكلي. شكلت المتغيرات على مستوى المدرسة غالبية التباين المفسر (78.59%)، مقارنة بمتغيرات الطالب التي شكلت (21.41%)، مما يدل على أن التباين في تحصيل الطلاب في الرياضيات يرجع بشكل أكبر إلى خصائص المدرسة. وعندما تم التحكم في المتغيرات على مستوى الطالب والمدرسة، كانت المنبئات الدالة إحصائيا بتحصيل الطلاب في الرياضيات على مستوى الطالب، متعلقة بالمصادر المحتملة لعدم المساواة في التعليم، وتضمنت متغيرات خلفية الطالب المرتبطة بتوفر الموارد التعليمية في المنزل ومتغيرات خصائص الطالب المتعلقة باتجاه الطالب نحو الرياضيات والمدرسة. أما المنبئات الدالة إحصائيا على مستوى المدرسة، فشملت متغير خلفية المدرِّس/ة المرتبط بتخصصه/ها في الرياضيات، ومتغيريّ بيئة المدرسة المتعلقين بنسبة الطلاب الذين يتحدثون لغة الاختبار، والمستوى الاقتصادي الاجتماعي للمدرسة المتمثل في نسبة الطلاب الميسورين اقتصاديًا فيها. لذا، من المهم أخذ هذه المتغيرات في الاعتبار عند التخطيط لتحسين تعلم وتحصيل الطلاب في الرياضيات.

الكلمات المفتاحية: النمذجة الخطية الهرمية؛ *الاتّجاهات* في *الدراسات* العالمية للرّياضيات *والعلوم* *تيمس*؛ خصائص الطالب؛ خصائص المدرسة؛ التحصيل في الرياضيات.

1.Introduction

Over the past few decades, researchers have been interested in identifying the reasons for variation in the level of learning among students, and the variation in effectiveness level among schools, which can be explained by educational context in order to use results in educational reforms. As a result, various models and theories have been developed to study factors affecting student achievement across countries, particularly math and science using comprehensive databases (Shavelosn et al., 1987), such as the Trends in International Mathematics and Science (TIMSS), which provides reliable and valuable data about student achievement for a large number of participating countries. TIMSS was first administered in 1995 by the International Association for the Evaluation of Educational Achievement (IEA), and has been administered every four years. TIMSS collects a lot of information about the elements of the educational systems and process (including curriculum, student, teacher, and school), and the teaching and learning practices, which allows studying the reasons for the higher or lower performance of each country on achievement tests, based on their context, to plan improvement (Education and Training Evaluation Commission, 2021). A large number of studies across countries identified several factors at the different levels related to student achievement in science and mathematics using TIMSS data. Mathematics is considered one of the most important fields of human knowledge, which is a measure of the development and progress of nations (Mullis et al., 2020).

***For the student level variables related to mathematics achievement level*,** several TIMSS studies have confirmed the existence of a positive relationship between the variables of the first (student) level and students' mathematic achievement, including: the level of education of the parents (Kodippili, 2011; Tavsancil & Yalcin, 2015; Antonijevic, 2017; Doust, et al., 2022); the number of books in the house at home (Reinikainen, 2007; Jafari, 2010; Kareshki & Hajinezhad, 2014; Ababneh, 2019; Mutairi& Bennour, 2022); providing educational resources (computer or tablet, shared computer or tablet with others, desk or study table, room, and internet connection) (Chepete, 2008; Akyuz & Berberoglu, 2010; Kareshki & Hajinezhad, 2014; Tavsancil & Yalcin, 2015; Olmez, 2020); student's attitudes towards mathematics (enjoyment of learning mathematics, love of mathematics, and preference for mathematics) (House, 2006; Abu Aish, 2008; Geesa et al., 2019; Mutairi & Bennour, 2022); the student's attitudes towards the school (feeling safe at school, treating teachers fairly, being proud of attending school, and learning a lot at school) (Mohammadpour et al., 2009; Chen, 2013; Monroe, et al., 2024); and student's aspirations towards higher education (Jafari, 2010; Antonijevic, 2017). Several studies (such as: Laya & Chandrasegaranb, 2016) reported that student-level variables, including home possessions and books at home, are very important when determining student achievement in rich countries, but less important in poor developing countries. Regarding the effect of gender, some studies (such as: Qiu & Leung, 2022) showed that boys performed better in mathematics than girls, while others (such as: Wiberg, 2019) reported no strong association with gender.

For the school level variables related to mathematics achievement level, several TIMSS studies confirmed the existence of a positive relationship between the second (school) level variables and the student's mathematic achievement, including: the teacher's experience (Chepete, 2008; Kupari & Nissinen, 2013); educational qualification (Chepete, 2008; Alshunnaq et al., 2013); specialization (Ramirez, 2006; Alshunnaq et al., 2013); the teacher's attitudes towards school (feeling safe at school, student's respect for teachers, and applying school rules in a fair and consistent manner) (Chepete, 2008; Mohammadpour, 2013); the teaching method used (listening to the teacher while explaining new content, assigning students to memorize the rules and steps, working in groups of varying abilities, and working within groups of equal abilities) (House, 2008; Naghsh et al., 2013; Mutairi& Bennour, 2022); assigning homework (repetition of homework, time spent on homework) (Akyuz & Berberoglu, 2010); providing educational resources within the school (education resources, school buildings and playgrounds, specialized technical staff, audiovisual resources for teaching, computer technology, and resources for students with special needs) (Stanco, 2012; Ker, 2016; Geesa et al., 2019; Wiberg, 2019; Chatri et al., 2021; Qiu & Leung, 2022); principal's experience, and students' behavioral problems and their magnitude (delayed arrival at school, absence, cheating, theft, threats or verbal abuse of students, and physical abuse of students) (Neuschmidt et al., 2008; Stanco, 2012; Badri et al., 2014; Olmez, 2020); and school climate (Mullis et al., 2020; Mutairi& Bennour, 2022).

In addition, Several studies indicated that school climate, school socio-economic status (SES), and inequality (that are related to the possession of materials (e.g., desks, books, computers and internet connection) had positive and significant effects on mathematics achievement for students across grades, and that students from advantaged schools performed better (Wiberg et al., 2013; Caponera & Losito, 2016; Berkowitz, 2017; Geesa et al., 2019; Wiberg, 2019; Qiu & Leung, 2022; Wardat, et al. 2022). Schools SES is characterized by percentages of economically disadvantaged and economically affluent students in the school, where more affluent schools are the ones having more than 25 percent of students from economically affluent homes. Other researchers (Laya & Chandrasegaranb, 2016; Wiberg, 2019; Ersan & Rodriguez, 2020; Simonelis, 2022) indicated that SES at both school and student levels is a dominant factor related to mathematics achievement and a much stronger predictor at the school level, and that most successful schools tend to have students that are relatively economically affluent and speak the language of the instruction. Effect of variables such as SES vary across countries (Laya & Chandrasegaranb, 2016; Wiberg, 2019; Ersan & Rodriguez, 2020). Thus, it is important to investigate the school and student variables for TIMSS 2019 data, to determine the factors that could predict student achievement in mathematics, particularly for the countries that are lower than international average, in order to use them to improve student achievement and education.

Saudi Arabia is one of the countries participated in TIMSS since 2011, and across all three periods (2011, 2015, and 2019), and math scores were (394; 368; and 394, respectively). This is below the international average (500) and lower (more than 100 points) than average performance of Arab countries, and was placed on 37th position out of 39 participating countries(Mullis et al., 2020). A few studies conducted on Saudi data, and used limited variables, or did not consider multilevel models to deal with the nature of data at different levels (such the studies of Abu Aish, 2008; Jafari, 2010; Ababneh, 2019; and Mutairi& Bennour, 2022). Since the nature of data is structured at country, school, and student levels, the impact of the different educational system components at each level need to be examined through multi-level model (Shavelosn et al., 1987).

Since the analysis with simple statistical models consists of either students or schools as units of study, it determines the effect of independent variables on the dependent variable at one level, without taking into account the hierarchy of data and common variance, and therefore the standard errors and confidence intervals that are reached may be unrealistic, and thus does not provide a complete picture for educators and decision makers. While HLM statistical models take into account the levels of data, and determine the effect of variables at each level on student achievement, as well as the interaction between variables across their multiple levels. This gives a comprehensive picture of the factors affecting student achievement and their interaction instead of focusing on the effect of factors at one level only (Woltman et al., 2012; Huta, 2024) and for this reason the current study came to shed light on the hierarchical linear analysis of the factors affecting the eighth grade students' achievement in mathematics in TIMSS 2019 in Saudi Arabia.

A few studies conducted used multilevel models to study mathematics achievement of TIMSS, such as Kareshki & Hajinezhad (2014) study that compared UAE, Syria, Qatar, Iran, Saudi Arabia, Oman, Lebanon, Jordan, and Bahrain countries on math TIMSS 2011 using Hierarchical Linear Modeling (HLM) analysis. The results showed that school is a more important factor in explaining the variance of students' mathematics achievement in all countries, excluding Syria. In most of the studied countries, school resources, educational climate, and the number of enrolments of school showed more effect. Additionally, Aljunaydil (2020) study used HLM analysis to study factors affecting students' achievement TIMSS 2015 in math and science of eighth grade students in Saudi Arabia and Singapore. The results showed that at the student and school levels, the availability of a private room and being proud of attending school were the variables explained most the variance in students' academic achievement in Saudi in both mathematics and science.

Furthermore, Simonelis (2022) study applied two-levels HLM and found that SES of schools, school location, and school emphasis on success variables were significant and explained a large amount of variance of achievement at school level. In addition, Coşkun & Karadag (2023) investigated the effect of some student and school variables on TIMSS 2015 mathematics achievement of eighth grade students in Turkey, using two-levels HLM. The findings showed that school variables accounted for 35% of the variability and student variables 65%. School resources and teacher qualifications did not have a significant effect on student achievement; while home educational resources were important variables affected mathematics.

Therefore, this study aims to investigate the student and school factors that affect the mathematics achievement of eighth grade students in Saudi Arabia by using HLM analysis of TIMSS 2019 mathematics data. This study questions examine the following: 1) How do eighth-grade Students' mathematics achievement vary among students within and across schools? 2) What factors at the student level significantly influence students' mathematics achievement? 3) What factors at the school level significantly influence students' mathematics achievement, controlling for student variables?

2.Method

2.1 *Study Sample*

The study sample consisted of eighth-grade schools and students in Saudi Arabia, who participated in TIMSS 2019, and they were randomly selected by TIMSS team (LaRoche & Foy, 2016; Martin et al., 2020). TIMSS implements a two-stage random sample design. The sample selection process went through three stages: the first stage was the selection of a sample of schools, the second stage was the selection of two classes in large schools with more than (215) students and one class in small schools, and then the third stage, was the selection of students from within the classrooms. The total number of students was N=5,680 nested within (209) schools.

2.2 *Measures*

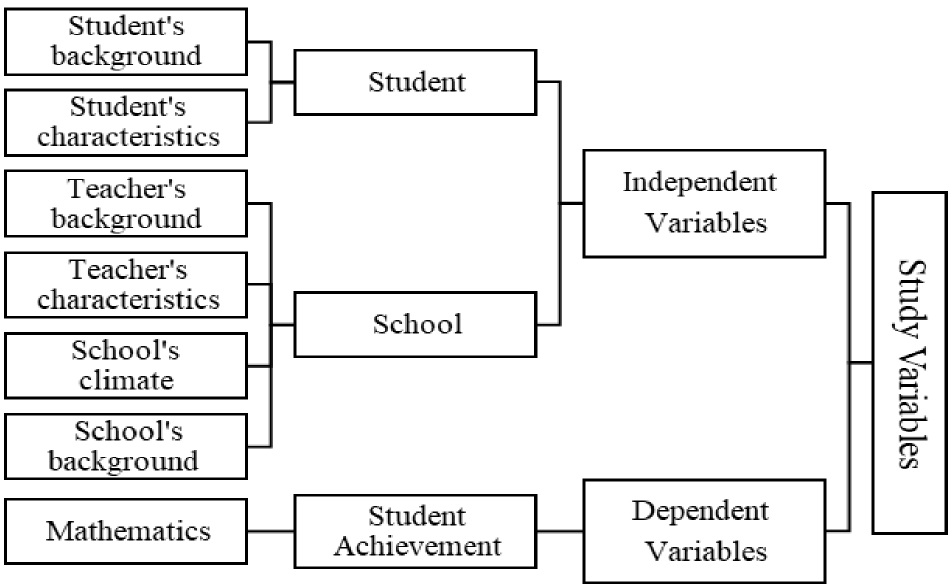
This study was conducted using the tools that TIMSS 2019 depends on, which are two types as follows:

- First: The responses to the test booklets: The total score of Saudi eighth grade students' responses to mathematics test booklets, with (five Plausible Values-PV) that are calculated for each student that represents outcome variable (Martin et al., 2020).

- Second: TMSS 2019 questionnaires: The items related to the study variables were selected, and they included the students, teachers, and school questionnaires (Martin et al., 2020).

The current study included (53) independent variables that are related to mathematics, and they are distributed over six factors: the student's background, and the student's characteristics at the first level (student level); and the teacher's background, the teacher's characteristics, the school's background, and the school climate, at the second level (school level). Figure 1 shows the study factors that included the study variables.

Figure 1. The study variables



Level 1 predicators

1-1-The student's background factor was measured with seven variables: Parents' education level, number of books at home, availability of educational resources (computer tablet, own room, internet connection, own mobile phone).

1-2-The student's characteristics factor was measured with ten variables: Sex of student, student's attitudes towards mathematics (enjoy learning mathematics, like mathematics, look forward to math class), student’s attitudes towards school (feel safe at school, belong at school, fair teachers, proud to go to school, learning interesting things) student’s aspirations towards higher education.

Level 2 predicators

2-1-The teacher’s background factor was measured with eleven variables: Teacher’s specialization in mathematics and other areas; teacher years of experience, educational qualification.

2-2-The teacher’s characteristics factor was measured with nine variables: Teacher’s attitudes towards school (feeling safe, student respect, rules enforcement), teaching methods used (explain new content, memorize rules, mixed ability groups, same ability groups), the imposition of homework (how often homework assigned, time spent on homework).

2-3-The school's background factor was measured with seven variables: Availability of educational resources within the school (books with different titles, school buildings, technological staff, computer technology, resources for students with disability, audio visual resources), and experience of the school principal.

2-4- The school climate factor was measured with nine variables: Behavioral problems of students (arriving late at school, absenteeism, cheating, theft, intimidation among students, physical injury), socioeconomic status of school (percentage of economically disadvantaged and economically affluent students in the school), percentage of students speaking the language of test.

2.3 *Data Analysis*

The data of mathematics achievement of eighth-grade students in Saudi Arabia, who participated in TIMSS 2019, and the responses of students, their teachers and school principals to the questionnaires that accompanied the application of these tests, were obtained from the official website of (IEA) (https://timssandpirls.bc.edu/timss-landing.html). The hypotheses of study method were verified (Foy, 2017; Raudenbush et al., 2019). The correlation matrix of coefficients between the independent variables at student level, and independent variables at school level was examined. In addition, multicollinearity in data was examined too.

Two-Level Hierarchical Linear Model Analysis (student level and school level) with HLM8 program, was used because of the nested structure of data and sample design, to study the impact of independent variables on student achievement at each level, simultaneously (Hox, 2017; Raudenbush et al., 2019; Huta, 2024).

The analyses in the current study followed a four-step process: First, the proportions of variance of student mathematics achievement at student and school levels were examined (testing the unconditional model-0), which is the basic model that does not contain any variables at either at the first level (student level) or the second level (school level), and centered grand mean was used. Model-0 aims to divide the variance into two parts: variance within schools, and variance between schools using the intra-class correlation coefficient (ICC), which shows the amount of variance in student achievement scores between schools, and how it is related to student achievement scores within schools. The larger the size of the intra-class correlation coefficient (ICC), the more important the higher level (group), which means that there is a large amount of variance between groups, and they should be dealt with separately, either by allowing for random constants or random slopes. Thus, Model-0 provided an estimation of the predicted value for the average score on outcome measure across all levels, and it investigates the necessity of two-level analyses (Peugh, 2010; Huta, 2024; Raudenbush et al., 2019).

Second, the random coefficients model was tested by adding only the student (level-1) variables to the model, and non-significant variables were removed in Model-2. Third, school variables were added in Model-3. Several HLM models were tested, and the ones that explained most of the variance were considered in Model-3. The relative influence of each of level-1 and level-2 predictors on the outcome variable (mathematics achievement) was assessed in the final model. The fully specified model (3), provides information on the remaining variance explained at both levels (Hox, 2017; Huta, 2024; Raudenbush et al., 2019).

The steps involved several statistical models, and the final one was random slopes and intercepts model, that allows for estimation of both the mean differences in the dependent variable and the mean differences in the slopes across the ranges. It is used to test interactions between independent variables at the first and second levels, and the first-level coefficients for both the constants and the slopes are predicted based on information about the ranges to which the second-level units belong. Level-1 equation describes the relationship between variables at the student level, and level-2 equations describe the relationship at the school level (Raudenbush et al., 2019).

•**Level – 1 (student level)**:

$$Y_{ij} = \beta_{0j} + \beta_{1j}X_{1ij} + \beta_{2j}X_{2ij} + \cdots + r_{ij,} \quad (1)$$

•**Level – 2 (school level)**:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}W_{1j} + \gamma_{02}W_{2j} + \cdots + u_{0j,} \quad (2)$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}W_{1j} + \gamma_{12}W_{2j} + \cdots + u_{1j.}$$

Where;

Y_{ij} = is the dependent variable measured for level one unit (*i*) nested within level two unit (*j*), which is the outcome for student (*i*) in school (*j*),

β_{0j} = is the constant for level two unit.

β_{1j} ،β_{2j} ،β_{3j} ,…. = are regression coefficients (slopes) associated with (X_{ij}) for level two unit (*j*).

X_{1ij} ،X_{2ij} ،X_{3ij}, … = are independent variables at level one, which represent the student-level predictors.

r_{ij}= is the random error associated with level one unit (*i*) nested within level two unit (*j*)

γ_{00}= is the overall arithmetic mean of the dependent variable across groups.

γ_{01} ‘γ_{02} ‘γ_{03}, …= are the regression coefficients (slopes) associated with (W_{ij}) relative to the level one constant.

W_{1ij} ‘W_{2ij} ‘W_{3ij}, … = are the independent variables at level 2, which represent the school-level predictors.

γ_{10}= overall mean of slopes across groups.

γ_{11} ‘γ_{12} ‘γ_{13}, …= are the regression coefficients (slopes) associated with (W_{ij}) relative to the level 1 slope.

u_{0j}= is the random effects of level 2 unit (j) on the constant (variance between groups).

u_{1j}= is the random effects of level 2 unit (j) on the slopes (variance in the slopes).

3 Results

In order to answer the study questions: 1) how do eighth-grade Students' mathematics achievement vary among students within and across schools?, 2) what factors at the student level significantly influence students' mathematics achievement? 3) what factors at the school level significantly influence students' mathematics achievement, controlling for student variables? two-levels HLM models were conducted gradually (unconditional model-0, then Model -1 with student variables, then Model -2 with school variables, and Model -3 with significant student and school variables). The variances explained by each model, within and across schools are reported, in addition to b coefficient values for each predictor at each level with their level of significance and other HLM modeling statistics are displayed in Table 1 (from Model 0 to Model 3).

Table 1. Hierarchical Linear Modeling Results for Eighth-Grade Students' Mathematics Achievement of TIMSS 2019 in Saudi Arabia.

		Unconditional model (M0)				**Model 1**				**Model 2**				**Model 3**			
		b	S. E	*p*-value		b	S. E	*p*-value		b	S. E	*p*-value		b	S. E	*p*-value	
Fixed effects																	
Intercept		421**	8.57	<0.001		421.25**	6.92	<0.001		421.9**	6.0	<0.001		421.64**	4.58	<0.001	
Student's level																	
1-SEX OF STUDENT						-15.28	14.37	0.288									
2-HIGHEST LVL OF EDU OF 2-PARENT/ GUARDIAN A Father						1.41	1.42	0.319									

		Unconditional model (M0)				**Model 1**				**Model 2**				**Model 3**			
3-HIGHEST LVL OF EDU OF PARENT/ GUARDIAN B Mother						2.32	1.79	0.197									
4-AMOUNT OF BOOKS IN YOUR HOME						5.21*	2.04	0.011						6.19**	1.99	0.002	
5-HOME COMPUTER TABLET						-36.95**	5.68	<0.001						-44.53**	5.25	<0.001	
6-HOME OWN ROOM						15.67**	4.00	<0.001						4.53**	1.41	<0.001	
7-HOME INTERNET CONNECTION						-2.54	11.86	0.83									
8-HOME OWN MOBILE PHONE						13.03*	5.30	0.014						17.71**	4.19	<0.001	
9-ENJOY LEARNING MATHEMATICS						-6.20	3.99	0.121									
10-LIKE MATHEMATICS						-15.09**	3.52	<0.001									
11-LOOK FORWARD TO MATH CLASS						6.85**	2.66	0.01						-15.67**	2.44	<0.001	
12-SAFE AT SCHOOL						1.01	2.63	0.7									
13-BELONG AT SCHOOL						-2.98	3.06	0.331									
14-FAIR TEACHERS						-4.28	2.50	0.088									
15-PROUD TO GO TO THIS SCHOOL						12.52**	3.26	<0.001						-6.82*	2.88	0.018	
16-LEARN INTERESTING THINGS						4.76	2.24	0.034									
17-HOW FAR IN EDU DO YOU EXPECT TO GO						10.85**	1.64	<0.001						10.37**	3.48	0.003	
School level																	
Intercept										b	S. E	*p*-value		b	S. E	*p*-value	
1-MAJOR AREA OF STUDY\MATHEMATICS										62.46*	25.0	0.025		23.32*	10.21	0.027	
2-MAJOR AREA OF STUDY\BIOLO										-56.98	77.0	0.471					

		Unconditional model (M0)				Model 1				Model 2				Model 3			
GY																	
3-MAJOR AREA OF STUDY\PHYSICS										38.88	67.8	0.575					
4-MAJOR AREA OF STUDY\CHEMISTRY										-63.63	74.3	0.405					
5-MAJOR AREA OF STUDY\<EARTH SCIENCE>										-87.05	78.8	0.286					
6-MAJOR AREA OF STUDY\EDU MATHEMATICS										14.96	28.8	0.611					
7-MAJOR AREA OF STUDY\EDU SCIENCE										3.32	82.5	0.968					
8-MAJOR AREA OF STUDY\EDU GENERAL										-30.25	37.1	0.427					
9-MAJOR AREA OF STUDY\OTHER										8.85	32.6	0.79					
10-YEARS BEEN TEACHING										-0.05	1.5	0.971					
11-LEVEL OF FORMAL EDUCATION COMPLETED										2.29	76.8	0.977					
12-THINKING ABT CURR SCH\FEEL SAFE										-0.37	16.0	0.982					
13-THINKING ABT CURR SCH\STUD RESPECT										28.60	18.8	0.148					
14-THINKING ABT CURR SCH\RULES ENFORCEMENT										-28.66	17.9	0.129					
15--ASK										3.04	14.3	0.835					

		Unconditional model (M0)				**Model 1**				**Model 2**				**Model 3**			
STUDENTS\EXPLAIN NEW CONTENT																	
16-ASK STUDENTS\MEMORIZE RULES										-10.14	14.7	0.502					
17-ASK STUDENTS\MIXED ABILITY GROUPS										8.35	10.7	0.448					
18-ASK STUDENTS\SAME ABILITY GROUPS										-6.72	9.4	0.487					
19-HOW OFTEN MATH HOMEWORK ASSIGNED										-9.91	14.9	0.517					
20-TIME SPENT ON HOMEWORK										-4.47	22.0	0.842					
21-BOOKS WITH DIFFERENT TITLES										21.57	26.8	0.433					
22-SHORTAGE\GEN\SCHOOL BUILDINGS										-15.91	10.5	0.151					
23-TECHNOLOGICAL STAFF										27.55	18.1	0.149					
24-COMP TECHNOLOGY										-9.74	21.5	0.657					
25-RESOURCES STD WITH DISAB										4.55	9.3	0.631					
26-AUDIO VISUAL RESOURCES										-14.07	19.8	0.489					
27-YEARS PRINCIPAL AT THIS SCHOOL										-1.85	1.9	0.357					
28-DEGREE PROBS\ARRIVING LATE AT SCHOOL										22.42	18.1	0.236					
29-DEGREE PROBS\ABSEN										2.76	18.5	0.883					

		Unconditional model (M0)				Model 1				Model 2				Model 3			
TEEISM																	
30-DEGREE PROBS\CHEATING										48.48	34.3	0.178					
31-DEGREE PROBS\THEFT										-34.90	34.1	0.322					
32-DEGREE PROBS\INTIMIDATION AMONG STUD										-28.54	16.5	0.104					
33-DEGREE PROBS\PHYSICAL INJURY										0.35	9.0	0.46					
34-STUDENTS BACKGROUND\ECONOMIC DISADVA										0.20	15.0	0.99					
35-STUDENTS BACKGROUND\ECONOMIC AFFLUEN										19.75	10.0	0.067		10.96*	4.42	0.017	
36-PERCENT OF STUDENTS LANG OF TEST										20.25	10.3	0.068		22.30**	3.00	<0.001	
Random effects		Variance Component	SD	*p*-value	χ^2	Variance Component	SD	*p*-value	χ^2	Variance Component	SD	*p*-value	χ^2	Variance Component	SD	*p*-value	χ^2
Student-level variance *r* *(within schools)*		3336.3	57.8	<0.001	496.4	2184.21	46.7	<0.001	436.9	1512.7	38.89	<0.001	83.2	916.83	30.28	<0.001	221
School-level variance u_0 (between schools)		4041.5	63.6	<0.001		3083.1	55.5	<0.001		4033	63.51	<0.001		3365.23	58.01	<0.001	
% of variance explained by model		7377.8				5267.3				5445.1				4282.06			
Student-level variance σ2		45.22%				41.47%				25.95%				21.41%			
School-level variance τ00		54.78%				58.53%				74.05%				78.59%			
Change in total variance						-28.61%				-26.20%				42%			

In Model-0, the unconditional model was tested to determine the variation in mathematics achievement of eighth grade students and the results are displayed in

Table 1. The value of the variance component between schools was 4041.5 (SD = 63.6), while the variance component among students was 3336.3 (SD = 57.8), and all of them were statistically significant (*p* <.001), indicating the possibility of conducting multi-level analysis on the data of the current study. The results of the Chi-square test showed statistically significant results ($\chi 2$ = 496.4; *p* <.001), indicating that mathematics achievement scores at the same school are more similar than students' mathematics achievement scores in different schools. In addition, ICC, which is ($\tau 00$/ ($\tau 00$+ $\sigma 2$), provided the percentage of total variance of the dependent variable (mathematics), that is attributed to the second (school) level (Raudenbush et al., 2019). The ICC value was (54.78) which is (4041.5/ (4041.5+ 3336.3), indicating that there was (54.78%) of the total variation in mathematics achievement at the student level that was due to the variance between schools, and (45.22%) was due to the discrepancy between students within schools.

In Model -1, the student variables (at level-1) were added to the model, without adding any of the school variables (at level-2). The variables at student level were: Sex of student; highest level of education of guardian/parents-father; highest level of education of guardian/parents-mother; number of books at home; availability of computer tablet at home; availability of own room at home; availability of internet connection at home; availability of own mobile phone; the student enjoy learning mathematics; like learning mathematics; look forward to math class; feels safe at school; feels belonging to school; feels teachers are fair; is proud to go to school; feels learning interesting things at school; and the student's aspirations towards higher education.

For model (1), table 1 shows that the value of variance (in students' mathematics achievement) within schools (among students) after adding student variables was (2184.21) (SD = 46.7). This represents a decrease by (34.53%), that is (1152.09) from (3336.3), in (model-0). Therefore, the explained variance in students' mathematics achievement at first level by this model (1) using the first level predictors was equal to (34.53%) of the total variance in achievement among students. In addition, the total variance decreased by (28.61%).

The variables at the student level that showed statistically significant effects on mathematics achievement of eighth-grade students, are ordered as follows: availability of computer tablet at home; availability of own room at home; the student likes mathematics; availability of own mobile phone; the student is proud to go to school; the student's aspirations towards higher education; number of books at home; learning interesting things. Moreover, the results indicated that "availability of computer tablet at home" was the independent variable that most explained the variance in this model (βx coefficient = -36.95, SE = .568, *p* <.001), which indicates that Saudi students who do not have their own computer tablet, tend to score (36.95) points lower in mathematics achievement than their peers with their own computer tablet, adjusting for other variables.

In Model (2), the variables of the second (school) level were added without adding any variables at first (student) level; in order to assess the effect of variables at school level on students' mathematics achievement. The school level variables were: major area of teacher specialization (mathematics, biology, physics, chemistry, earth science, education math, education science, education general, and other); teacher experience; teacher level of qualification; teacher thinks school is safe; teacher thinks student respect; teacher thinks rules enforcement; teacher asks students to explain new content; teacher asks students to memorize rules; working within mixed ability groups; working within same ability groups; frequency of math homework assigned; time spent on homework; number of books with different titles at school; availability of computer technology; availability of resources for students with disability; availability of audio visual resources; school principal's experience; student behavioral problems: arriving late at school, absenteeism, cheating, theft, intimidation among students, physical injury; Student background: economically disadvantaged, economic affluent; percentage of students speak language of test.

Table 1 shows that the explained variance between schools (in students' mathematics achievement) using school level predictors decreased from 4041.5 (SD = 63.6), in the unconditional model, to 4033 (SD = 63.5), in model (2), which represents a decrease by (8.5) from (model-0). Therefore, the amount of explained variance in students' mathematics achievement at the second level by this model (2), using the school level predictors was (0.2%) of the amount of total variance in mathematics achievement between schools. In addition, the total variance decreased by (26.20%) from model -0.

The variable at the school level that showed statistically significant effects on mathematics achievement of eighth-grade students is "the major area of teacher specialization: mathematics", which explained a large amount of variance in model (2) (γW coefficient= 62.46, SE = 25, p <.05). This indicates that students who have teachers with specialization in mathematics, tend to achieve (62.46) points higher than students who have teachers with specialization not in mathematics, with other variables controlled for.

In Model (3), the variables at the first (student) level and the variables at the second (school) level were added to the model, then significant predictors (p <.05) of the eighth grade students' mathematics achievement at student and school levels were retained. Table 1 shows the variables at the student level that had positive and significant effect in order: availability of own mobile phone; the student's aspirations towards higher education; number of books at home; availability of own room at home. The variables at the student level that had negative and significant effect were:

availability of computer tablet at home; the student looks forward to math class; the student is proud to go to school.

The results indicated that “availability of computer tablet at home” was the student variable that explained most of the variance in model (3); with a statistically significant effect on students' mathematics achievement (βx coefficient = -44.53, SE = 5.25, p <.001), indicating that students who do not have their own computer tablet, tend to score (-44.53) points lower in mathematics achievement than their peers with their own computer tablet, adjusting for other variables.

The variables at the school level that showed statistically significant effects on mathematics achievement of eighth-grade students are “the major area of teacher specialization: mathematic”, which explained a large amount of variance in model (3) (γW coefficient = 23.32, SE = 10.21, p <.05); followed by percentage of students speaking the language of test, and percentage of economically affluent students in the school.

Using student and school level predictors in Model (3), compared to the unconditional model, it is noticed that the explained variance among students within schools decreased by (73%) from (3336.3, to 916.83); the explained variance among schools decreased by (17%) from (4041.5, to 3365.23); and the total variance decreased by (42%) from (7377.8 to 4282.06). The school level variables accounted for the majority of explained variance (78.59%), compared to the explained variance by student variables (21.41%).

4. Discussion

The current study aimed to identify the variation in the achievement of Saudi eighth-grade students in mathematics (outcome) based on TIMSS 2019 dataset, and the most important predictors (at student and school levels) that contributed to explain variation in student achievement in math, using two level HLM.

The results showed that before adding any predictor at student and school levels (the unconditional model), the largest proportion (54.78%) of the total variation in the students' achievement in mathematics was due to variation between schools; while smaller proportion (45.22%) was due to variance among students within schools. When student and school variables were added to the final model (Model3), they were able to explain (42%) of the total variance. The school level variables accounted for the majority of explained variance (78.59%), compared to student variables which accounted for (21.41%), indicating that the differences in student math achievement is more due to school characteristics and climate. The explained variance among students within schools decreased by (73%), while the explained variance between schools decreased by (17%), indicating the importance of student variables in explaining student achievement in math.

In the final model (3), when the variables were controlled for at the student and school levels, the statistically significant predictors of students' achievement in mathematics at student level were the ones involved potential source of education inequity (student's background variables related to availability of educational resources at home such as availability of computer tablet at home; availability of own mobile phone; availability of own room at home, number of books at home; and the student's characteristics variables related to student's attitudes towards mathematics and school, such as the student looks forward to math class, the student is proud to go to school, and the student’s aspirations towards higher education).

The variable at school level that showed large effect, and was statistically significant, was teacher specialization in math, indicating the importance of this **teacher’s background** variable in increasing student achievement in math. Other school variables with significant effect were the ones related to school SES as characterized by percentages of economically affluent students in the school, in addition to percentage of students speaking the language of test. This indicates the importance of school SES and that the student speaks the language of test, as **school climate**, in increasing student achievement in math.

This result is consistent with studies conducted by Mohammadpour et al. (2009), Kareshki & Hajinezhad (2014) and Qiu & Leung (2022) that showed significant variances between schools in mathematics achievement for eighth grade students, and that the largest proportion of variation in mathematics was due to variation between schools. However, the result differs from the study by Chepete (2008), Ghagar et al. (2011), Ababneh (2019), Chatri et al., (2021), and Coşkun & Karadag (2023), which found that the largest proportion of total variation in students' mathematics achievement was due to the variance within schools. This variation in results may be attributed to the different characteristics of students and schools across countries.

S**tudent predictors** that influenced student mathematics achievement significantly, and explained most of the variance with **positive** and statistically significant impact, in this study, included the following, ordered based on their impact:

1. Educational resources variables, including: availability of own mobile phone; availability of own room at home; and number of books at home. This result is consistent with other studies (Reinikainen, 2007; Chepete, 2008; Akyuz & Berberoglu, 2010; Jafari, 2010; Kareshki & Hajinezhad, 2014; Tavsancil & Yalcin, 2015; Ababneh, 2019; Aljunaydil, 2020; Olmez, 2020; Chatri et al., 2021; and Mutairi& Bennour, 2022) that reported positive effect on math scores when students were provided with educational resources such as: desk or study table, own room, and books.

2. Student's aspirations towards higher education, including: the student's aspirations towards higher education, which is consistent with studies of (Jafari, 2010; Antonijevic, 2017).

These results confirmed the importance of student background variables (educational resources) and student characteristic variables (student attitudes towards math and school) for student mathematics achievement.

S**tudent predictors** that influenced student mathematics achievement significantly, and explained most of the variance with **negative** and significant impact, in this study, included the following:

1. **The student's background** variables, including: the availability of computer tablet at home; which have the largest explained variance; in addition to the student looking forward to math class, and the student is proud to go to school. These results support other studies (House, 2006; Abu Aish, 2008; Chepete, 2008; Mohammadpour et al., 2009; Akyuz & Berberoglu, 2010; Chen, 2013; Wiberg et al., 2013; Kareshki & Hajinezhad, 2014; Tavsancil & Yalcin, 2015; Caponera & Losito, 2016; Berkowitz, 2017; Geesa et al., 2019; Wiberg, 2019; Olmez, 2020; Chatri et al., 2021; Qiu & Leung, 2022; Mutairi& Bennour, 2022; Wardat, et al. 2022; and Coşkun & Karadag (2023), regarding inequality variables (that are related to the possession of materials, e.g., desks, books, computers and internet connection) that affect mathematics achievement for students, where students from advantaged schools performed better. Several studies (such as: Laya & Chandrasegaranb, 2016) reported that student-level variables including home possessions, books at home are very important when determining student achievement in rich countries, but less important in poor developing countries.
2. **The student's characteristics** variables, including: student's attitudes towards mathematics, (student looking forward to math class), which is in agreement with the studies of (House, 2006; Abu Aish, 2008; Mutairi& Bennour, 2022); and the student's attitudes towards the school (being proud of attending school), which is consistent with the studies of (Mohammadpour et al., 2009; and Chen, 2013; Aljunaydil, 2020).

The strong impact of home educational resources (e.g., availability of computer tablet at home; availability of own room at home; availability of own mobile phone; number of books at home) on students' mathematic achievement may be attributed to its effective contribution to afford opportunities for students to learn at home. In addition, aspirations towards higher education and preference for mathematics could elevate student motivation and achievement. Qiu & Leung (2022) indicated that home-level factors are an important source of inequity.

School predictors that influenced student mathematics achievement **positively** and significantly, and explained most of the variance, in this study, included the following:

1. **The teacher’s background** variable: teacher’s specialization in mathematics. This result is consistent with the study of (Ramirez, 2006; Alshunnaq et al., 2013) regarding the effect of teacher speciation in math and with the studies of (Chepete, 2008; Olmez, 2020; Mutairi& Bennour, 2022), which showed positive impact of school climate, and beliefs on students' achievement. This result disagreed partially with other studies such as the study of Ababneh (2019), and Coşkun & Karadag (2023), which did not find any significant effect of (teacher’s educational level, and specialization) on the variation in achievement among students, and the study of (Akyuz & Berberoglu, 2010), which did not find statistically significant correlations between educational qualification, and student achievement.
2. T**he school climate** variables: socioeconomic status of school (percentage of economically affluent students in the school), and percentage of students speaking the language of test. This result agreed partially with the research of (Laya & Chandrasegaranb, 2016; Wiberg, 2019; Ersan & Rodriguez, 2020; Simonelis, 2022), which indicated that SES at both school and student levels is a dominant factor related to mathematics achievement, and that most successful schools tend to have students that are relatively economically affluent and speak the language of the instruction. In fact, the effect of SES varies across countries (Laya & Chandrasegaranb, 2016; Wiberg, 2019; Ersan & Rodriguez, 2020). This may be due to cultural differences among countries. In addition, the presence of other more important variables influencing students' mathematics achievement may have affected the results.

One of the study limitations is the limited factors that could be considered at each level, in the analysis, and that the data is for one TIMSS cycle. Considering more variables and other TIMSS cycles could give much broader picture.

5-Conclusion

In this study we investigated several student and school-related factors that may explain achievement differences between students and schools in achievement in mathematics, using TIMSS 2019 math test data for Saudi Arabia. The purpose was to identify effective variables to inform educators, school leaders, researchers, and policymakers to improve level of achievement through controlling them.

When student and school variables were added to the final HLM model (Model3), they were able to explain (42%) of the total variance. The school level variables accounted for the majority of explained variance (78.59%), compared to student variables which accounted for (21.41%), indicating that the differences in student math achievement is more due to school characteristics.

The statistically significant predictors of students' achievement in mathematics, when the variables were controlled at the student and school levels, were student variables that involved potential source of education inequity including student's background variables related to availability of educational resources at home (including availability of computer tablet at home; availability of own mobile phone; availability of own room at home; and number of books at home); and the student's characteristics variables related to student's attitudes towards mathematics and school (including: the student looks forward to math class; the student’s aspirations towards higher education; and the student is proud to go to school). The availability of computer tablet at home was the student variable that explained most of the variance.

The variables at the school level that showed statistically significant effects on mathematics achievement of eighth-grade students are the teacher’s background variable: teacher’s specialization in mathematics that explained a large amount of variance in math scores, followed by school's climate variables: percentage of students speaking the language of test, and percentage of economically affluent students in the school.

Based on the results of this study, the researchers recommend working on enhancing factors that positively affect mathematic achievement of students in Saudi Arabia, and addressing the factors that negatively affect mathematics achievement (particularly availability of educational resources at home and student's attitudes towards mathematics and school) in order to minimize their effects, and to ensure efficiency of the educational system. Furthermore, it is important to provide students with specialized teachers in math because of its high impact on their achievement in math. Additionally, it is important to provide equal opportunities for children, regardless of their socioeconomic status. It is also recommended to conduct longitudinal studies on TIMSS to assess the effect of improvements on students’ mathematics achievement. Other countries with similar context could repeat the same study on previous and current TIMSS databases. Although the study is conducted within the national context of Saudi Arabia, the results might be of interest to other similar countries.

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