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Exploring Educational Equity: New Insights from TIMSS and National Achievement Metrics in Tunisia

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ABSTRACT

Purpose of the study: This paper investigates the relationship between mathematics achievement in the Trends in Mathematics and Science Study (TIMSS) and two key school achievement measures—grades and national test results—in Tunisia. Going beyond previous studies, this research also explores how these relationships differ across diverse student subgroups, providing a nuanced understanding of educational equity.

Methodology: Give name, Employing robust statistical analyses, the study uncovers a strong positive correlation between TIMSS mathematics scores and both grade 6 and grade 9 achievement measures, underscoring TIMSS's reliability as an indicator of student performance in the national context. Notably, students from more educated households consistently outperformed their peers from less-educated backgrounds on TIMSS, and the association between TIMSS scores and school achievement measures was significantly stronger for students from advantaged home environments.

Main Findings: These findings suggest that socioeconomic factors and school contexts critically shape TIMSS performance, highlighting disparities in educational outcomes. Furthermore, the results call for a re-evaluation of how TIMSS data is interpreted and utilized in national education policies, especially in addressing inequities. By illuminating the complex interplay between individual backgrounds, school contexts, and standardized assessments, this study contributes to a deeper understanding of TIMSS as both a tool for measuring student achievement and a reflection of systemic challenges.

Novelty/Originality of this study: These insights have profound implications for policymakers, educators, and researchers seeking to leverage TIMSS data for meaningful educational improvements while ensuring equity across diverse student populations.

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1. INTRODUCTION

The 2013 Trends in Mathematics and Science Study (TIMSS) assessment revealed a decline in mathematics achievement in Tunisia, raising concerns about the state of mathematics education [1]. However, this negative trend shifted with the 2015 TIMSS results, which indicated an improvement in Tunisia students'

mathematics performance [2]. This reversal has sparked debates about the alignment between TIMSS assessments, Tunisia national tests in mathematics, and school mathematics grades. TIMSS provides a relevant framework for measuring mathematics skills in Tunisia, it does not fully capture all elements of the national mathematics curriculum [3]-[5]. Moreover, the relationship between TIMSS results, national test scores, and school grades remains unclear, highlighting the need for deeper investigation.

Understanding the relationship between international assessments like TIMSS and national education measures is crucial for policy-making. If these assessments align closely, TIMSS results could serve as a reliable foundation for educational reforms. Conversely, discrepancies between international and national assessments might prompt policymakers to reconsider national curricula or introduce new education policies. For instance, international assessments have influenced education policies globally, finding that such assessments often drive substantial reforms [6]-[8]. Examples include the influence of TIMSS and PISA on the U.S. No Child Left Behind Act and the restructuring of Israel's middle school mathematics curriculum following TIMSS 1999 [9] Similarly, Japan's declining results in international assessments motivated a shift from a relaxed curriculum to one emphasizing academic rigor [10]. These cases underline the importance of assessing the extent to which TIMSS reflects national education systems. Research has shown that results from international and national assessments do not always align. Such divergences suggest a need to examine the relationship between TIMSS and national assessments within individual countries to understand their implications for education policy.

Role of Socioeconomic and Student Background Variables A critical factor influencing assessment outcomes is students' socioeconomic background. Studies consistently demonstrate that students from higher socioeconomic backgrounds perform better academically across nations and subjects [11]-[14]. This association extends to TIMSS mathematics achievement, where home educational resources, parental education, and school socioeconomic context have shown significant effects [15]-[17]. For Tunisia, both individual and school-level socioeconomic variables have been linked to TIMSS outcomes. However, the interaction between socioeconomic factors, TIMSS results, and national assessments warrants further exploration to determine how these variables jointly influence student achievement.

Research Gap While extensive research has examined the contextual and socioeconomic factors influencing TIMSS results, key gaps remain. Most TIMSS studies rely solely on data from the TIMSS international database, often overlooking national measures like school grades and national test results [18-[20]. Few studies have attempted to link TIMSS results directly with national assessments or explored how socioeconomic factors mediate this relationship. Additionally, while some analyses have modeled TIMSS achievement using multilevel approaches, these have yielded inconsistent conclusions across countries, underscoring the importance of country-specific research [21], [22]. In Tunisia, studies linking TIMSS with national achievement measures are limited. Preliminary analyses by the Tunisia National Agency for Education (2017) focused on grade 9 mathematics and science but lacked a comprehensive examination of grade 6 outcomes or other relevant student background variables. Moreover, international research linking TIMSS with large-scale assessments has primarily focused on aggregate patterns rather than individual-level connections between achievement measures.

Objectives and Contributions of the Study This study addresses these gaps by examining the relationship between TIMSS mathematics achievement and Tunisia national school achievement measures, including grades and national test results, with a specific focus on grade 6. Additionally, we investigate how student background variables, such as socioeconomic status, gender, and immigrant background, influence TIMSS performance and its alignment with national assessments. By incorporating multilevel analyses that account for both student-level and school-context variables, this study provides a nuanced understanding of the factors shaping mathematics achievement in Tunisia.

2. RESEARCH METHOD

This study analyzed mathematics achievement data from the TIMSS 2015 eighth-grade cohort in Tunisia. The TIMSS sampling procedure employed a two-stage random selection method, ensuring that the participating students were representative of the entire eighth-grade population in Tunisia. Data were collected from 4,090 students across 150 schools. The sample included 52% boys, 20% students with non-native backgrounds (either foreign-born or with foreign-born parents), 46% whose mothers had education beyond high school, and 37% from households with over 100 books. The response rate was high, with only 5% of students not participating due to absence during testing. Although students were informed that the test was significant, the low-stakes nature of TIMSS (results not used for grading) might have influenced their effort levels. Unique to this study, Tunisia social security numbers were collected, enabling linkage of TIMSS data to national registers containing information on school grades, national test results, immigrant status, and parental education.

Tunisia national tests in mathematics are administered in grades 3, 6, and 9, assessing core curriculum competencies. Designed to ensure fair and consistent grading across schools, these tests comprise multiple subtests, including an oral component and several written tests. The oral tests are conducted in small groups, while the written subtests require individual responses in multiple-choice, short-answer, or solution formats. Each subtest

is time-bound, ranging from 40 to 100 minutes depending on the grade level. In this study, national test results in mathematics from grades 6 and 9 were used. These tests serve as high-stakes evaluations, influencing grades and public discourse about academic achievement. Although national tests measure select aspects of the curriculum on specific test days, they are complemented by teachers' continuous assessments for grading.

Grading System, Tunisia employs a criterion-referenced grading system with a six-step scale from A to F (A = highest, F = fail). Numeric values are assigned to these letter grades (A = 20 to F = 0), allowing for the computation of a cumulative "merit value" based on 16 subject grades. The maximum merit value of 320 corresponds to a student achieving straight A grades. This cumulative measure serves as an indicator of overall academic performance. TIMSS 2015, TIMSS (Trends in International Mathematics and Science Study) is a large-scale assessment conducted every four years to evaluate student achievement and contextual factors in grades 4 and 8. TIMSS 2015 data included five plausible values for mathematics achievement, which are recommended for use in statistical analyses to account for measurement uncertainty. Achievement levels were categorized into four benchmarks: elementary (400–474 points), average (475–549 points), high (550–624 points), and advanced (625+ points).

To explore the consistency of academic measures, TIMSS mathematics achievement results were compared to national test scores and grades in mathematics from grades 6 and 9, as well as the cumulative merit value from grade 9. While the TIMSS assessment occurred in grade 8, school achievement data from grades 6 and 9 provided insights into trends over time. Although grade 9 measures may reflect students' maturation and learning between grades 8 and 9, their inclusion was justified due to methodological similarities between TIMSS and national tests, including their role in public discussions and policy evaluations.

Descriptive analyses included averages, standard errors, and correlations between TIMSS 2015 mathematics achievement and school performance measures. Student weights were applied to ensure representative results, and all five plausible values for mathematics achievement were incorporated. Linear regression models were employed to examine the association between TIMSS mathematics achievement and students' home background variables. Socioeconomic status (SES) was represented by mothers' educational levels due to data completeness. Variables such as gender, migration status, and home book quantity were also included, consistent with prior studies. These variables were coded as follows: Gender: 0 = female, 1 = male; Migration: 0 = native-born student with native-born parents, 1 = non-native background; Mother's education: 0 = no post-high school education, 1 = at least one year of post-high school education; Books at home: 0 = fewer than 100 books, 1 = 100+ books. Listwise deletion was applied for missing data, which ranged from 0.3% (gender) to 7% (grade 6 national test results). Although imputation could be advantageous, the low proportion of missing cases justified the chosen approach.

To account for TIMSS's two-stage sampling design, multilevel modelling was employed. These analyses enabled simultaneous exploration of student-level and school-level factors influencing mathematics achievement. Variables were entered hierarchically to assess their contribution to explaining variance in outcomes. Linear regression and multilevel analyses were also used to assess the relationship between TIMSS mathematics achievement and school measures. Given the significant gender differences observed in prior studies, gender was included as a variable, though its impact on mathematics achievement was expected to be minimal. Migration status was considered due to its documented influence on mathematics outcomes.

3. RESULTS AND DISCUSSION

The results in Table 1–3 are related to the first research question. In Table 1, the average scores and standard errors on TIMSS 2015 in mathematics for students receiving different grade levels in grade 6 and grade 9 are displayed. From Table 1 it is evident that regardless of year, the higher the grades the students had, the higher the student's average TIMSS achievement. Although this was true in both grade 6 and grade 9, the TIMSS results were in general higher for the different grade groups in grade 9. This is not surprising because there are more criteria that need to be met by the end of grade 9 in comparison to grade 6. Thus, this means that a smaller proportion of students might not have managed to get the highest mathematics grade in grade 9 (10%) in comparison to grade 6 (16%) because there are fewer goals to achieve in grade 6. This was similar for the students scoring highest on the national test for grade 9 (6%) compared to grade 6 (20%). Next, we examined the proportions of students who received each grade in grade 6 and grade 9 distributed on the TIMSS achievement levels (Table 2). By merging the two last TIMSS categories of 550–624 points and 625 or more points, we could conduct chi- square tests that showed that grades and TIMSS achievement levels cannot be seen as independent either in grade 6 ($X2(15) = 442$, $p < 0.001$) or in grade 9 ($X2(15) = 594$, $p < 0.001$). Noticeable is the consistency of the overall results regardless of whether we

Table 1. The proportions of students (%) in grades 6 and 9 receiving grades on the national mathematics assessments and the TIMSS mathematics assessment.

	Mathematics Grade				National test in Mathematics			
Grade	%	Grade 6	%	Grade 9	%	Grade 6	%	Grade 9
A	16	580 (2.8)	10	596 (3.2)	20	575 (2.9)	6	607 (3.8)
B	18	543 (3.4)	13	562 (3.2)	16	535 (2.9)	10	578 (3.1)
C	20	508 (2.8)	20	526 (2.4)	16	507 (3.3)	20	542 (2.6)
D	20	476 (3.0)	20	492 (2.4)	21	473 (3.3)	22	498 (2.5)
E	17	442 (3.0)	29	449 (3.0)	15	443 (3.0)	28	458 (2.4)
F	5	404 (6.0)	4	388 (6.3)	5	413 (5.4)	7	405 (6.0)

Table 2. Proportions of students within each of the grades in grade 6 and grade 9 depending on TIMSS achievement levels.

TIMSS	%	Grade 6	%	Grade 9	%	Grade 6
Grade 6 (625<	16	3	0	0	0	0
(551, 624)	20	44	21	5	1	0
(476,550)	22	45	54	49	25	82
401,475)	1	8	22	38	54	45
<400	0	1	3	7	19	46
Grade 9 (625<	24	5	1	0	0	0
(551, 624)	63	59	32	9	2	0
(476,550)	12	34	56	58	30	3
401,475)	0	2	11	29	52	38
<400	0	0	1	0	16	59

Table 3. Correlations between TIMSS mathematics achievement and the different school measures of mathematics achievement.

Variables	TIMSS	G6	NT6	G9	NT9
G6	.67				
NT6	.66	.89			
G9	.73	.69	.70		
NT9	.72	.66	.65	.86	
Mvalue G9	.65	.61	.59	.80	.73

G6 = Mathematics grade 6, G9 = Mathematics grade 9, NT = National test in Mathematics, and Mvalue G9 = Merit value in grade 9.

Use data from grade 6 or grade 9. It is also interesting to note that no student with a grade of A got fewer than 400 points on the TIMSS achievement scale. Likewise, no student with a grade lower than C reached the TIMSS advanced level.

The overall correlations, which were used to examine the relationships between grades, national tests, and TIMSS achievement can be seen in Table 3 in general and in Table 4 for different subgroups of students. The correlations between grades and national tests for both grade 6 (0.89) and grade 9 (0.86) were strong and positive. This indicates that the national test helps the teachers in their grading exactly as it is supposed to do. Recall that the aim of the national tests is to support an equal and fair grading process and to give information about how the knowledge demands are fulfilled on a school level and on a national level. From Table 3 it is evident that the highest correlation with TIMSS was for mathematics grade 9 (.73), followed by national test grade 9 (.72). This is not surprising if we believe that these achievement measure- ments measure similar things and because these were collected only one year after (grades and national tests in grade 9) or two years before (grades and national tests in grade 6) the TIMSS assessment was conducted. The correlations are quite high and in line with our expectations, although we thought they would be closer to the correlation between grades and national test results. It is interesting to note that the correlation between merit value and TIMSS was quite high, even though the merit value is a combined measure of 16 subject grades in grade 9. The merit value indicates what is usually seen in school studies – that students who perform well in one subject area also tend to perform well in other subject areas.

Table 4. Correlations between TIMSS mathematics achievement and the different mathematics achievement measures according to the students' background variables.

Variables	Girls	Boys	Tns	Imm	Lmed	Hmed	Lbook	Hbook
G6	.69	.69	.67	.66	.63*	.67*	.64*	.68*
NT6	.68	.67	.67	.67	.63	.63	.64	.67
G9	.74	.74	.74	.71	.67*	.74*	.68*	.74*
NT9	.66	.66	.73	.71	.67*	.74*	.69*	.73*
Mvalue G9	.68	.68	.67*	.61*	.60*	.64*	.60	.63

* p-value < 0.05.

G6 = Mathematics grade 6, G9 = Mathematics grade 9, NT6 = National test grade 6, NT9 = National test grade 9. Mvalue = Merit value. Tns = parents or student born in Tunisia, Imm = Nonnative students or nonnative parents. Lmed = Student's mother has at most high school education, Hmed = Student's mother has higher education than high school education, Lbook = Student's home has 100 or fewer books, Hbook = Student's home has more than 100 books.

The results in Tables 4 and 5 were used to answer the second research question. When examining the sub correlations of the measures in Table 3, no significant differences in the relationships were found between girls and boys, as seen in Table 4. If the student was nonnative or had nonnative parents only gave a significant correlation difference in the merit value. This is not surprising because the merit value contains all subject areas and thus it is possible that language issues will have a stronger effect on that measure. The relationship was significantly different for most achievement measures if the mother had a high educational level or if the student lived in a home with more than 100 books. The exceptions were for national test score in grade 6 and students from homes with high number of books and the merit value. The latter result is probably due to the diversity among school subjects, which the merit value captures.

Correlation can only give us a measure of the linear relationship between two variables. To answer the second and third research questions, and to be able to examine the impact of several variables on both student and school levels, we used linear regressions and multilevel analyses. In the left part of Table 5 linear regressions and

Table 5. Regression and multilevel analyses with TIMSS mathematics achievement as the dependent variable and student background variables and different types of grades as the independent variables.

Variables	G6	G6	G6	NT6	NT6	NT6
Student Intercept	501.27 (2.09)	502.26 (1.88)	502.80 (1.74)	503.77 (1.94)	504.67 (1.74)	504.46 (1.59)
Achieve*	9.75 (0.30)	9.06 (0.29)	9.04 (0.29)	9.24 (0.31)	8.51 (0.30)	8.47 (0.30)
Sex		10.78 (1.96)	10.87 (1.97)		10.36 (2.16)	10.45 (2.16)
Imm		−6.33 (2.82)	−5.58 (2.73)		−8.19 (3.05)	−5.78 (2.96)
Book		16.96 (1.81)	15.88 (1.84)		16.46 (1.92)	15.52 (1.94)
Med		10.35 (1.86)	9.96 (1.88)		11.38 (2.00)	10.94 (2.05)
School Imm_A						−21.72 (9.35)
Book_A			57.93 (10.44)			36.57 (9.59)
R^2	0.45	0.48	0.48	0.43	0.46	0.46

G6 = Mathematics grade 6. NT6 = National test in mathematics in grade 6. *Achieve = Achievement measure used varies and the achievement measure used is given as the name of each column. Sex = 1 if boy, 0 if girl. Imm = 1 if student or student's parents not born in Tunisia. Med = 1 if student's mother has higher education than high school education, 0 otherwise. book = 1 if student's home has more than 100 books, Imm_A = aggregated Imm, Book_A = aggregated book. R2 = Explained variance.

Multilevel analyses are displayed for the subject grade 6 achievement measures and likewise in the right part of Table 5 these are given for the grade 6 national test achievement measure. Note that we examined all possible average student background variables on the school level, but only the significant school-level variables are shown in Table 5. The analyses indicated that on average being a nonnative student meant that TIMSS mathematics achievement was on average lower and being a boy meant on average a higher TIMSS mathematics achievement. A home with many books and a mother with a higher education were associated with higher TIMSS achievement in general. In addition, regardless of which achievement measure was used, being in a school with students with many books at home gave on average higher TIMSS achievement. In contrast, the aggregated immigration variable was only significant for national tests data. Students who received a higher grade in the national achievement measures had on average higher TIMSS mathematics achievement.

The multilevel analyses were similar to the linear regressions with student home background in terms of proportion of explained variance, which ranged from 0.46 (national tests) to 0.48 (grade 6). The explained variance with only the achievement measure and no other school background measure was a bit lower at 0.43 (national test) and 0.45 (subject grades). The intraclass correlation coefficients (ICCs) in the multilevel analyses were 0.11 (national test) and 0.13 (grade 6). Thus, the school context seemed to only have a small impact on the students' results.

Summarising the findings from the perspective of the posed research questions, there seems to be a quite high association between TIMSS mathematics achievement and national school achievement in Tunisia, although the association is lower than between the two national achievement measures. Further, there appears to be a strong association with TIMSS mathematics achievement and students' home background variables when it comes to immigration and socioeconomic status in terms of books at home and parental educational level, while there is no strong association with gender. Finally, the school context in terms of the average student background seems to only be able to explain a small amount of the variance.

This study aimed to examine the relationship between grades, national test scores, and TIMSS (Trends in International Mathematics and Science Study) mathematics achievement, as well as to analyze how TIMSS achievement relates to different student subgroups. The findings underscore a strong correlation between TIMSS results and national test scores and grades in Tunisia, regardless of whether these relationships are analyzed before TIMSS (grade 6) or after TIMSS (grade 9). Interestingly, when the merit value, which combines grades from 16 subjects, was used as a measure of achievement, the relationship was slightly weaker. This is expected given the inherent variability introduced by the involvement of multiple teachers in grading across various subjects. These findings align with prior studies such as Heppt, Tahir & Pant, which showed minimal gender differences, but notable effects of students' socio-economic backgrounds, including the mother's educational level and the number of books at home, on academic performance [23]-[25]. These results resonate with findings from previous studies [26]-[30].

The use of multilevel analysis to address the hierarchical structure of TIMSS data, incorporating unequal probability sampling, added robustness to this study. This approach provided nuanced insights into both student- and school-level influences on achievement. Although certain aggregated variables, such as the number of books at home, were significant when using grade 6 and national test scores, the aggregated migration variable only showed significance in national test analyses. Comparisons with linear regression analyses revealed that school-level variables accounted for only a small variance in achievement [31]-[33].

School quality exerts a larger influence on achievement in low-income countries compared to high-income countries like Tunisia. Conversely, family background factors, such as socioeconomic status, exert stronger effects in high-income contexts [34], [35]. These findings are consistent with other large-scale assessments, such as SAT studies, which demonstrate correlations between standardized test performance, high school grades, and socioeconomic factors. SAT performance among nonnative students, TIMSS results showed lower achievement for nonnative students, highlighting a persistent challenge in addressing disparities. A unique contribution of this study is its integration of TIMSS mathematics achievement with individual students' grades and national test scores in Tunisia. Including grade 6 measures and background information strengthens the explanatory power regarding Tunisia students' TIMSS mathematics performance. The strong correlations observed suggest that TIMSS can be effectively used as a trend indicator for student performance over time, providing strategic value for policymakers and educators. Although the study was conducted in a Tunisia context, its implications are likely relevant for other countries participating in TIMSS. Similar analyses in different national contexts could further validate these findings and provide comparative insights.

The study's findings emphasize the potential of TIMSS as a diagnostic and strategic tool for monitoring educational progress over time. Policymakers in Tunisia and other participating countries can leverage TIMSS data to align national assessments with international benchmarks, aiding in the formulation of evidence-based educational strategies. Moreover, the results highlight the importance of addressing socioeconomic disparities and supporting nonnative students to enhance equity and performance in education systems. Despite its contributions, the study has several limitations. First, it is confined to the Tunisia context, which may limit the generalizability of the findings to countries with differing educational systems and socio-economic profiles. Second, the study relied on aggregated variables, which may obscure individual-level nuances. Third, the merit value's variability, influenced by subjective grading practices, may introduce bias in the analyses. Finally, the cross-sectional nature of TIMSS data restricts causal interpretations, emphasizing the need for longitudinal designs to better understand the dynamics of achievement over time.

Future research should extend this analysis to other countries to examine the consistency and variability of the findings across diverse educational contexts. Additionally, longitudinal studies incorporating more granular measures of socioeconomic factors and school quality could provide deeper insights into causal relationships. Educational interventions targeting nonnative students and those from socioeconomically disadvantaged backgrounds should be prioritized to bridge achievement gaps. Policymakers should also consider refining national assessments to enhance alignment with TIMSS, ensuring their utility as tools for international comparison and policy evaluation.

4. CONCLUSION

This study highlights the robust relationship between TIMSS mathematics achievement, national test scores, and school grades in Tunisia, offering critical insights into the alignment between international assessments

and national educational metrics. The findings underscore the significant influence of socioeconomic factors, including parental education and the availability of educational resources at home, on academic performance, while confirming minimal gender disparities in achievement. By integrating TIMSS data with individual grades and national test scores, this research demonstrates the potential of TIMSS as a strategic tool for monitoring student performance over time and shaping educational policy. The analysis further reveals that, in Tunisia, student-level factors such as family background play a more substantial role in academic success compared to school-level variables, corroborating the Heyneman-Loxley effect observed in high-income countries. These findings also underscore the persistent challenges faced by nonnative students, drawing attention to the urgent need for targeted interventions aimed at reducing achievement gaps and promoting equity in education.

The implications of this study extend beyond Tunisia, providing valuable guidance for countries participating in TIMSS and similar international assessments. Policymakers can utilize these findings to strengthen the alignment of their national assessments with international benchmarks, enabling more effective tracking of educational trends and disparities. Additionally, the strong association between TIMSS results and national metrics suggests that countries can strategically use TIMSS data to refine their educational policies and interventions. Efforts to address disparities highlighted in this study should prioritize improving access to educational resources for socioeconomically disadvantaged students and offering tailored support for nonnative students. Investments in inclusive policies and practices could significantly enhance equity and performance within diverse educational systems.

To maximize the utility of TIMSS and deepen our understanding of the determinants of academic success, future research should extend this analysis to other national contexts, exploring variations in the relationships between achievement metrics across diverse educational systems. Longitudinal studies incorporating more granular data on socioeconomic factors and school quality are necessary to unravel the causal mechanisms behind these findings. Moreover, exploring the effectiveness of targeted interventions for disadvantaged subgroups will provide actionable insights for creating equitable and high-performing education systems globally.

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REFERENCES

[1] D. S. Bouhlila, and F. Sellaouti, "Multiple imputation using chained equations for missing data in TIMSS: a case study" *Large-scale Assessments in Education*, vol. 1, pp. 1-33, 2013, doi: 10.1186/2196-0739-1-4.

[2] E. Klieme, "TIMSS 2015 and PISA 2015: How are they related on the country level", *German Institute for International Educational Research (DIPF)*, 2016.

[3] I. Buabeng, K. A. Owusu, and F. D. Ntow, "TIMSS 2011 Science Assessment Results: A Review of Ghana's Performance", *Journal of Curriculum and Teaching*, vol. 3, no. 2, pp. 1-12, 2014, doi: 10.5430/jct.v3n2p1.

[4] J. Anamuah-Mensah, and D. K. Mereku, "On What Foundation is Africa Building its Science and Technology Base?: Africa\'s Participation in TIMSS-2003", *African Journal of Educational Studies in Mathematics and Sciences*, vol. 3, pp. 1-7, 2005, doi: 10.4314/ajesms.v3i1.38598.

[5] M. Wu, "A comparison of PISA and TIMSS 2003 achievement results in mathematics", *Prospects*, vol. 39, pp. 33-46, 2009, doi: 10.1007/s11125-009-9109-y.

[6] A. Petherick, R. Goldszmidt, E. B. Andrade, R. Furst, T. Hale, A. Pott, and A. Wood, "A worldwide assessment of changes in adherence to COVID-19 protective behaviours and hypothesized pandemic fatigue", *Nature Human Behaviour*, vol. 5, no. 9, pp. 1145-1160, 2021, doi: 10.1038/s41562-021-01181-x.

[7] I. Kulkov, J. Kulkova, R. Rohrbeck, L. Menvielle, V. Kaartemo, and H. Makkonen, "Artificial intelligence-driven sustainable development: Examining organizational, technical, and processing approaches to achieving global goals", *Sustainable Development*, vol. 32, no. 3, pp. 2253-2267, 2024, doi: 10.1002/sd.2773.

[8] A. Zancajo, A. Verger, and P. Bolea, "Digitalization and beyond: the effects of Covid-19 on post-pandemic educational policy and delivery in Europe", *Policy and Society*, vol. 41, no. 1, pp. 111-128, 2022, doi: 10.1093/polsoc/puab016.

[9] F. Yariv, "Evidence-based decision making or a tunnel vision effect? TIMSS, problem definition and policy change in Israeli mathematics education", *Critical Studies in Education*, 2018 doi: 10.1080/17508487.2018.1448877.

[10] K. Takayama, "The politics of international league tables: PISA in Japan's achievement crisis debate", *Comparative Education*, vol. 44, no. 4, pp. 387–407, 2008, doi: 10.1080/03050060802481413.

[11] J. Liu, P. Peng, B. Zhao, and L. Luo, "Socioeconomic status and academic achievement in primary and secondary education: A meta-analytic review", *Educational Psychology Review*, vol. 34, no. 4, pp. 2867-2896, 2022, doi: 10.1007/s10648-022-09689-y.

[12] M. F. Bashir, B. Ma, and L. Shahzad, "A brief review of socio-economic and environmental impact of Covid-19", *Air Quality, Atmosphere & Health*, vol. 13, pp. 1403-1409, 2020, doi: 10.1007/s11869-020-00894-8.

[13] L. B. Perry, A. Saatcioglu, and R. A. Mickelson, "Does school SES matter less for high-performing students than for their lower-performing peers? A quantile regression analysis of PISA 2018 Australia", *Large-scale assessments in education*, vol. 10, no. 1, pp. 17, 2022, doi: 10.1186/s40536-022-00137-5.

[14] M. D. Shakeel, and P. E. Peterson, "A half century of progress in US student achievement: Agency and Flynn effects, ethnic and SES differences", *Educational Psychology Review*, vol. 34, no. 3, pp. 1255-1342, 2022, doi: 10.1007/s10648-021-09657-y.

[15] I. U. Østbø, and H. D. Zachrisson, "Student motivation and parental attitude as mediators for SES effects on mathematics achievement: Evidence from Norway in TIMSS 2015", *Scandinavian Journal of Educational Research*, vol. 66, no. 5, pp. 808-823, 2022, doi: 10.1080/00313831.2021.1939138.

[16] E. Tomul, E. Önder, and E. Taslidere, "The relative effect of student, family and school-related factors on math achievement by location of the school", *Large-scale Assessments in Education*, vol. 9, no. 1, pp. 22, 2021, doi: 10.1186/s40536-021-00117-1.

[17] Y. Zhang, S. Russell, and S. Kelly, "Engagement, achievement, and teacher classroom practices in mathematics: Insights from TIMSS 2011 and PISA 2012". *Studies in Educational Evaluation*, vol. 73, pp. 101146, 2022, doi: 10.1016/j.stueduc.2022.101146.

[18] D. Wu, "Disentangling the effects of the school year from the school day: evidence from the TIMSS Assessments", *Education Finance and Policy*, vol. 15, no. 1, pp. 104-135, 2020, doi: 10.1162/edfp_a_00265.

[19] S. Johansson, E. Myrberg, and A. Toropova, "School bullying: Prevalence and variation in and between school systems in TIMSS 2015", *Studies in Educational Evaluation*, vol. 74, pp. 101178, 2022, doi: 10.1016/j.stueduc.2022.101178.

[20] T. D. Ziporyn, J. A. Owens, K. L. Wahlstrom, A. R. Wolfson, W. M. Troxel, J. M. Saletin,... and M. A. Carskadon, "Adolescent sleep health and school start times: setting the research agenda for California and beyond. A research summit summary", *Sleep Health*, vol. 8, no. 1, pp. 11-22, 2022, doi: 10.1016/j.sleh.2021.10.008.

[21] K. J. Rowley, C. C. Edmunds, M. J. Dufur, J. A. Jarvis, and F. Silveira, "Contextualising the achievement gap: Assessing educational achievement, inequality, and disadvantage in high-income countries", *Comparative Education*, vol. 56, no. 4, pp. 459-483, 2020, doi: 10.1080/03050068.2020.1769928.

[22] C. T. Elbæk, P. Mitkidis, L. Aarøe, and T. Otterbring, "Subjective socioeconomic status and income inequality are associated with self-reported morality across 67 countries". *Nature Communications*, vol. 14, no. 1, pp. 5453,2023, 2023, doi: 10.1038/s41467-023-41007-0.

[23] B. Heppt, M. Olczyk, and A. Volodina, "Number of books at home as an indicator of socioeconomic status: Examining its extensions and their incremental validity for academic achievement", *Social Psychology of Education*, vol. 25, no. 4, pp. 903-928, 2022, doi: 10.1007/s11218-022-09704-8.

[24] T. Tahir, U. Ishfaq, S. Begum, and M. Sharjeel, "Effect of socio-economic status of parents on the student's academic achievement", *Elementary Education Online*, vol. 20, no. 5, pp. 2063-2070, 2021, doi: 10.17051/ilkonline.2021.01.476.

[25] K. R. Pant, "Influences of parental socio-economic status on academic achievement: A case study of rural communities in Kailali, Nepal", *Contemporary Research: An Interdisciplinary Academic Journal*, vol. 4, no. 1, pp. 95-109, 2020, doi: 10.3126/craiaj.v4i1.32753.

[26] E. Early, S. Miller, L. Dunne, A. Thurston, and M. Filiz, "The influence of socio-economic background and gender on school attainment in the United Kingdom: A systematic review", *Review of Education*, vol. 8, no. 1, pp. 120-152, 2020, doi: 10.1002/rev3.3175.

[27] C. F. Rodríguez-Hernández, E. Cascallar, and E. Kyndt, "Socio-economic status and academic performance in higher education: A systematic review", *Educational Research Review*, vol. 29, pp. 100305, 2020, doi: 10.1016/j.edurev.2019.100305.

[28] T. Şengönül, "A review of the relationship between parental involvement and children's academic achievement and the role of family socioeconomic status in this relationship", *Pegem Journal of Education and Instruction*, vol. 12, no. 2, pp. 32-57, 2022, doi: 10.47750/pegegog.12.02.04.

[29] F. Zhang, Y. Jiang, H. Ming, Y. Ren, L. Wang, and S. Huang, "Family socio-economic status and children's academic achievement: The different roles of parental academic involvement and subjective social mobility", *British Journal of Educational Psychology*, vol. 90, no. 3, pp. 561-579, 2020, doi: 10.1111/bjep.12374.

[30] E. Vázquez-Cano, A. M. De la Calle-Cabrera, C. Hervás-Gómez, and E. López-Meneses "Socio-family context and its influence on students' PISA reading performance scores: Evidence from three countries in three continents", *Educational Sciences: Theory & Practice*, vol. 20, no. 2, pp. 50-62, 2020, doi: 10.12738/jestp.2020.2.004.

[31] J. B. M. Sanfo, "A three-level hierarchical linear model analysis of the effect of school principals' factors on primary school students' learning achievements in Burkina Faso", *International Journal of Educational Research*, vol. 100, pp. 101531, 2020, doi: 10.1016/j.ijer.2020.101531.

[32] V. López, M. Salgado, and R. Berkowitz, "The contributions of school and classroom climate to mathematics test scores: a three-level analysis", *School Effectiveness and School Improvement*, vol. 34, no. 1, pp. 43-64, 2023, doi: 10.1080/09243453.2022.2096645.

[33] M. Solem, P. Vaughan, C. Savage, and A. S. De Nadai, "Student-and school-level predictors of geography achievement in the United States, 1994–2018", *Journal of Geography*, vol. 120, no. 6, pp. 201-211, 2021, doi: 10.1080/00221341.2021.2000009.

[34] M. Peverill, M. A. Dirks, T. Narvaja, K. L. Herts, J. S. Comer, and K. A. McLaughlin, "Socioeconomic status and child psychopathology in the United States: A meta-analysis of population-based studies", *Clinical psychology review*, vol. 83, 101933, doi: 10.1016/j.cpr.2020.101933.

[35] M. Mogstad, and G. Torsvik, "Family background, neighborhoods, and intergenerational mobility", *Handbook of the Economics of the Family*, vol. 1, no. 1, pp. 327-387, 2023, doi: 10.2139/ssrn.3859488.

[36] A. Faber Taylor, C. Butts-Wilmsmeyer, and C. Jordan, "Nature-based instruction for science learning–a good fit for all: A controlled comparison of classroom versus nature", *Environmental Education Research*, vol. 28, no. 10, pp. 1527-1546, 2022, doi: 10.1080/13504622.2022.2076811.

[37] S. Shanmugam, "Gender-Related Differential Item Functioning of Mathematics Computation Items among Non-native Speakers of English", *The Mathematics Enthusiast*, vol. 17, no. 1, pp. 108-140, 2020, doi: 10.54870/1551-3440.1482.

[38] R. Smith, S. J. Warrican, A. Kumi-Yeboah, J. Cheema, and M. L. Alleyne, "Disrupting (mis) representation in the literacy achievement of "(under) performing" youth", *Journal of Education and Development in the Caribbean*, vol. 18, no. 2, pp. 111-165, 2020, doi: 10.46425/j518021775.

[39] A. Gromada, "Moderate gaming and internet use show positive association with online reading of 10-year-olds in Europe", *Computers and Education Open*, vol. 3, 100109, 2022, doi: 10.1016/j.caeo.2022.100109.

[40] G. Retief, Y. Woest, and N. Mthethwa, "Creative Writing in a University Bridging Program for Underprivileged STEM Students", *Journal of Creative Writing Studies*, vo;. 9, no. 1, pp. 7, 2024.