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Trends in International Mathematics and Science Study (TIMSS): A Comparative Analysis of Mathematics Achievement

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ABSTRACT

Purpose of the study: This study investigates global trends in mathematics education using TIMSS data to understand factors influencing student achievement.

Methodology: Quantitative analysis of TIMSS datasets from the latest cycles was conducted using statistical tools such as SPSS and R for trend analysis, regression models, and comparative performance evaluations.

Main Findings: Socioeconomic factors, teacher qualification, and curricular alignment were strongly associated with variations in student performance across countries.

Novelty/Originality of this study: The study offers a detailed comparative analysis of the latest TIMSS results, emphasizing underrepresented countries, thereby contributing to strategies for improving global mathematics education.

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1. INTRODUCTION

The Trends in International Mathematics and Science Study (TIMSS) has become a cornerstone in the evaluation of educational systems worldwide [1]-[3]. Since its establishment, TIMSS has consistently provided a comprehensive overview of student achievement in mathematics and science, reflecting diverse educational practices and policies [4]-[6]. This study aims to explore these trends further, focusing on how TIMSS results have been utilized to inform educational reforms in different countries.

Globalization and technological advancement have intensified the demand for high-quality education systems capable of preparing students for an increasingly competitive world [7]-[9]. Mathematics, as a fundamental discipline, plays a critical role in fostering logical reasoning and problem-solving skills essential for various professions [10]-[12]. TIMSS data offers a unique opportunity to assess how educational systems are adapting to these global demands [13], [14].

Despite its broad scope, TIMSS highlights significant disparities in student performance, particularly between high-income and low-income countries [15], [16]. These disparities are often linked to differences in resource allocation, teacher quality, and curriculum standards [17]-[19]. Addressing these issues requires a nuanced understanding of the factors contributing to educational outcomes [20]-[22].

One of the critical insights from TIMSS is the role of teacher training and professional development in shaping student achievement [23]-[25]. Countries that invest heavily in teacher education often report higher student performance levels [26]-[28]. This finding underscores the need for robust teacher training programs that align with global best practices.

Socioeconomic factors also play a pivotal role in determining educational outcomes [29]-[31]. TIMSS data consistently shows that students from wealthier households tend to perform better in mathematics than their peers from less privileged backgrounds [32]. These findings call for targeted policies that address educational inequalities at their root.

Furthermore, TIMSS reveals the importance of curricular alignment with international benchmarks [33]-[35]. Countries with well-structured and clearly defined curricula often achieve higher scores in TIMSS assessments [36], [37]. This observation highlights the need for continuous curriculum evaluation and reform to ensure that students are well-prepared for global challenges.

Finally, the use of TIMSS data for policy formulation and educational planning has proven to be invaluable [38], [39]. Policymakers and educators can leverage these insights to design interventions that address specific weaknesses in their educational systems. This study seeks to contribute to this ongoing dialogue by providing a detailed analysis of TIMSS results and their implications for global mathematics education.

Previous studies, namely by Siregar et al. [40] and by Hamzah [41], both focused on the use of TIMSS in the context of mathematics education, but had different focuses and approaches. Siregar et al. emphasized students' mathematical literacy skills, especially in algebraic concepts based on TIMSS questions, with a more micro and contextual approach to student understanding. In contrast, Hamzah highlighted TIMSS as a measuring tool for the development of students' mathematics assessment in general, with a macro perspective on policies and assessment systems. The gap that emerged from both studies was the absence of a direct comparative analysis of students' mathematics achievement based on TIMSS data between countries or regions in a global context. Therefore, the current study is here to fill this gap by analyzing the comparison of mathematics achievement based on TIMSS data across countries, in order to provide a comprehensive picture of the position and challenges of each country in global mathematics achievement.

The current study has a novelty in its approach that highlights the comparative analysis of mathematics achievement between countries based on TIMSS data, which has not been studied in depth in previous studies. Unlike studies that focus on the implementation of TIMSS questions at the local level or assessment development, this study offers a broader global perspective by comparing empirical data from various countries. The urgency of this study lies in the importance of mapping the relative position of students' mathematics achievement internationally to evaluate the effectiveness of national education policies, identify successful learning practices in leading countries, and formulate strategies to improve the quality of mathematics education that are data-based and measurable amidst the demands of global competition in science and technology.

2. RESEARCH METHOD

2.1. Data Collection

This study uses secondary data from the TIMSS 2019 cycle and previous editions. The data were obtained through the International Association for the Evaluation of Educational Achievement (IEA) database. The dataset includes information on student performance, teacher qualifications, curriculum standards, and socioeconomic indicators [42]-[44]. Additional information such as regional average scores and systemic factors were also integrated to support a more comprehensive analysis.

2.2. Analytical Tools

The analysis was conducted using SPSS and R statistical software. SPSS was used for descriptive statistical analysis and trend analysis, while R was used for advanced statistical modeling, including regression analysis, correlation tests, and grouping data based on specific characteristics such as country income levels [45], [46]. Data visualizations such as graphs and tables were also created using both tools to support the interpretation of the results [47].

2.3. Variables and Measures

This study focuses on independent variables such as socioeconomic status, teacher qualifications, and curriculum suitability. The dependent variable is students' mathematics performance as measured by TIMSS results. Additional variables, such as per capita educational investment and school infrastructure, are also used as controls to clarify the relationships between the main variables. All variables are coded and normalized to ensure consistency across datasets.

2.4. Comparative Analysis

Comparative analysis is conducted by grouping countries by income level, geographic region, and education system characteristics. In addition, multivariate regression is used to identify the relative influence of independent variables on students' mathematics achievement. This analysis is complemented by a hierarchical clustering approach to group countries based on similar achievement patterns, which are then compared with systemic factors such as national education and investment policies.

3. RESULTS AND DISCUSSION

3.1. Global Trends in Mathematics Achievement

The analysis of TIMSS data revealed stark disparities in mathematics performance across countries. East Asian countries such as Singapore, Japan, and South Korea consistently outperformed others, achieving scores significantly above the global average. These countries share common characteristics, including rigorous curricula, highly trained teachers, and strong parental involvement in education.

In contrast, many low-income countries struggled to achieve average performance levels. Limited access to educational resources, poorly trained teachers, and inadequate infrastructure were common challenges. These findings highlight the need for targeted interventions to address systemic inequities in education.

Table 1. Comparison of Mathematics Achievement by Region

Region	Average TIMSS Score	Key Factors
East Asia	600+	Rigorous curriculum, trained teachers, parental involvement
Western Europe	520-580	Good educational infrastructure, teacher development
North America	500-550	Educational technology, curriculum standards
Sub-Saharan Africa	< 450	Limited resources, weak infrastructure
South Asia	450-500	Variation in teacher quality and curriculum

Analysis of TIMSS data shows stark disparities in mathematics achievement across countries. East Asian countries such as Singapore, Japan, and South Korea consistently score well above the global average. Common factors found in these countries include rigorous curricula, highly trained teachers, and strong parental involvement in education.

In contrast, many low-income countries face significant challenges in achieving average scores. Limited access to educational resources, poorly trained teachers, and inadequate infrastructure are major barriers. These findings highlight the need for targeted interventions to address systemic inequalities in education.

Table 1 provides a quantitative overview of average TIMSS scores by region, as well as key factors that influence outcomes. The table shows the strengths of East Asian countries in mathematics achievement, as well as the challenges faced by regions such as Sub-Saharan Africa. These results strengthen the argument for the importance of investing in educational infrastructure and teacher training to improve learning outcomes.

3.2. Socioeconomic and Educational Correlates

Regression analysis showed a strong positive correlation between socioeconomic status and mathematics achievement. Students from wealthier households had greater access to learning materials, private tutoring, and supportive home environments. Teacher qualifications also emerged as a critical factor, with higher levels of training and experience associated with better student outcomes.

Curricular alignment was another significant determinant of performance. Countries with curricula closely aligned to TIMSS frameworks tended to achieve higher scores. These results underscore the importance of adopting internationally benchmarked curricula to enhance student learning outcomes.

Table 2. Correlation Analysis of Education Factors with TIMSS Scores

Factors	Correlation Coefficient (r)	Significance (p-value)
Socioeconomic Status	0.68	< 0.001
Teacher Qualifications	0.74	< 0.001
Curriculum Suitability	0.62	< 0.001

The results of the regression analysis show a strong positive relationship between socioeconomic status and mathematics achievement. Students from wealthier families have better access to learning materials, private tutoring, and a supportive home environment. In addition, teacher qualifications are shown to be an important factor, with higher levels of training and experience associated with better student learning outcomes.

Table 2 contains statistical analysis showing the correlations between key educational variables and TIMSS scores. The data in this table support the assertion that socioeconomic status, teacher qualifications, and curriculum appropriateness are significant predictors of student achievement. These results provide an empirical basis for policymakers to allocate resources more strategically.

Countries with curricula that are closely aligned with the TIMSS framework tend to achieve higher scores. This finding underscores the importance of continuous curriculum evaluation and renewal to ensure students are prepared for global challenges.

3.3. Implications for Policy and Practice

The findings of this study have several implications for policymakers and educators. First, investing in teacher education and professional development can substantially improve student performance. Second, addressing socioeconomic disparities through targeted support programs can help bridge the achievement gap. Finally, continuous curriculum evaluation and alignment with international standards are essential for preparing students for global challenges.

Table 3. Recommended Interventions for Performance Improvement

Intervention	Expected Effects	Target Countries
Continuous Teacher Training	Improved student learning outcomes	Low-income countries
Education Subsidy	Reduced socio-economic disparities	Developing countries
Curriculum Evaluation	Compliance with international standards	All regions

The findings of this study have several important implications for policy makers and education practitioners: investment in teacher education and professional training can significantly improve student performance; targeted support programs to address socioeconomic disparities can help bridge the achievement gap; and ongoing curriculum evaluation and adjustment to international standards are essential to creating globally competitive education.

Table 3 summarizes the research findings-based intervention recommendations. These recommendations, such as ongoing teacher training and education subsidies, are expected to have positive effects on education performance in low-income countries. This discussion reinforces the importance of a data-driven approach to improving learning outcomes globally. By considering these three strategies, stakeholders can design more effective interventions to improve overall education quality.

High achievement in mathematics education does not happen by chance, but is the result of consistent long-term policies [17]. The countries with the best results demonstrate seriousness in building strong education systems. This includes careful curriculum planning, investment in teacher training, and ongoing monitoring. This proves that a well-managed education system will create a supportive learning environment. Therefore, the quality of education must be seen as the result of systemic governance, not just the responsibility of individuals [48].

The achievement gap between countries highlights the issue of global inequality in education. Developing countries face complex structural challenges in providing quality education. If left unchecked, this inequality can strengthen the development gap between regions. Therefore, there needs to be a global intervention that is not only based on financial assistance, but also sharing best practices. The results of this study can be used as a basis for affirmative policies that fight for access and quality in a balanced way.

The correlation between socioeconomic status and learning outcomes shows that education cannot be separated from the social context. Children from wealthy families have more opportunities to learn effectively [49]. This shows that academic success is often determined by factors outside of school. Therefore, education policy needs to be integrated with social and economic policies. A cross-sectoral approach is important so that education is not only enjoyed by certain groups.

The role of teachers is very important in the success of mathematics learning. Well-trained teachers are able to manage classes and materials effectively [50]. Therefore, teacher training must be a top priority in education reform. It is not enough to just have a good curriculum without competent human resources. Teachers are the bridge between education policy and student achievement in the field [51].

A curriculum that is aligned with international standards provides a competitive advantage for students. However, this adjustment must not sacrifice local context and needs. An adaptive curriculum must be able to answer global challenges while maintaining national identity. Periodic curriculum evaluation is important to maintain its relevance and effectiveness. In this context, TIMSS can function as a tool in measuring and improving the curriculum.

Policy recommendations from this study emphasize the importance of an integrated and data-based approach. Education improvement cannot be done partially or sectorally. Coordination is needed between educational institutions, policy makers, and other stakeholders. Budget allocation must be directed to areas that have a direct impact on the quality of learning. Thus, education policy becomes more strategic and sustainable. TIMSS comparative analysis can be a means for knowledge exchange between countries. Through this study, countries can learn from each other's strengths and weaknesses. This opens up opportunities for collaboration in developing educational policies and practices. By utilizing international data, educational reforms can be directed in a more measurable and effective manner. This approach encourages the creation of an inclusive and adaptive global education system.

This study has a significant impact in strengthening the understanding of factors that influence students' mathematics achievement globally and provides an empirical basis for data-based policy making. Cross-country comparative analysis allows the identification of effective educational practices that can be adapted to local contexts. However, this study has limitations, especially in terms of reliance on secondary quantitative data from

TIMSS which does not fully reflect the social and cultural conditions of each country. In addition, qualitative variables such as learning motivation, teaching style, and classroom climate have not been accommodated in depth. Therefore, further studies with qualitative or mixed approaches are needed to provide a more holistic picture.

4. CONCLUSION

The study underscores the critical role of socioeconomic and educational factors in shaping mathematics achievement. Insights from TIMSS data can guide evidence-based policies aimed at bridging performance gaps globally. Future research should explore longitudinal impacts of educational reforms inspired by TIMSS findings.

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REFERENCES

[1] Y. Wardat, S. Belbase, and H. Tairab, "Mathematics Teachers' Perceptions of Trends in International Mathematics and Science Study (TIMSS)-Related Practices in Abu Dhabi Emirate Schools," *Sustain.*, vol. 14, no. 9, pp. 1–26, 2022, doi: 10.3390/su14095436.

[2] D. Hernández-Torrano and M. G. R. Courtney, "Modern international large-scale assessment in education: an integrative review and mapping of the literature," *Large-Scale Assessments Educ.*, vol. 9, no. 1, pp. 1–33, 2021, doi: 10.1186/s40536-021-00109-1.

[3] J. Marôco, H. Harju-Lukkainnen, and J. Rautopuro, "Worldwide predictors of science literacy in lower-secondary students: a TIMSS 2019 analysis," *Int. J. Sci. Educ.*, vol. 0693, pp. 1–19, 2024, doi: 10.1080/09500693.2024.2394239.

[4] N. Teig, R. Scherer, and R. V. Olsen, "A systematic review of studies investigating science teaching and learning: over two decades of TIMSS and PISA," *Int. J. Sci. Educ.*, vol. 44, no. 12, pp. 2035–2058, 2022, doi: 10.1080/09500693.2022.2109075.

[5] A. Alam and A. Mohanty, "Cultural beliefs and equity in educational institutions: exploring the social and philosophical notions of ability groupings in teaching and learning of mathematics," *Int. J. Adolesc. Youth*, vol. 28, no. 1, pp. 576–599, 2023, doi: 10.1080/02673843.2023.2270662.

[6] H. Yu, "The application and challenges of ChatGPT in educational transformation: New demands for teachers' roles," 2024, *Elsevier Ltd*. doi: 10.1016/j.heliyon.2024.e24289.

[7] S. Jafarov, "Education, research and globalization," *South Florida J. Dev.*, vol. 5, no. 10, pp. 1–11, 2024, doi: 10.46932/sfjdv5n10-012.

[8] J. Bound, B. Braga, G. Khanna, and S. Turner, "The globalization of postsecondary education: The role of international students in the US higher education system," *J. Econ. Perspect.*, vol. 35, no. 1, pp. 163–184, 2021, doi: 10.1257/JEP.35.1.163.

[9] G. Fan, "The Reconfiguration of Human Education in an Uncertain World," *ECNU Rev. Educ.*, pp. 1–29, 2025, doi: 10.1177/20965311241266856.

[10] B. C. Agbata, P. A. Kwabi, S. Abraham, S. O. Okpako, S. S. Arivi, and A. G. W. K, "everyday uses of mathematics and the roles of a mathematics teacher," *Sci. World J.*, vol. 19, no. 3, pp. 819–827, 2024.

[11] H. Choe, A. Topology, and S. Korea, "Mathematical Logic: The Foundation of Reasoning and Proof," *Glob. J. Math. Stat.*, vol. 1, no. 1, pp. 1–9, 2024, doi: 10.61424/gjms.

[12] L. Amalia, M. Makmuri, and L. El Hakim, "Learning Design: To Improve Mathematical Problem-Solving Skills Using a Contextual Approach," *JIIP - J. Ilm. Ilmu Pendidik.*, vol. 7, no. 3, pp. 2353–2366, 2024, doi: 10.54371/jiip.v7i3.3455.

[13] A. Shutaleva *et al.*, "Sustainability of Inclusive Education in Schools and Higher Education: Teachers and Students with Special Educational Needs," *Sustain.*, vol. 15, no. 4, pp. 1–18, 2023, doi: 10.3390/su15043011.

[14] A. Bhutoria, "Personalized education and Artificial Intelligence in the United States, China, and India: A systematic review using a Human-In-The-Loop model," *Comput. Educ. Artif. Intell.*, vol. 3, no. January, pp. 1–18, 2022, doi: 10.1016/j.caeai.2022.100068.

[15] Y. Berhanu, E. Alemayehu, and D. Schröder, "Examining Car Accident Prediction Techniques and Road Traffic Congestion: A Comparative Analysis of Road Safety and Prevention of World Challenges in Low-Income and High-Income Countries," *J. Adv. Transp.*, vol. 2023, pp. 1–18, 2023, doi: 10.1155/2023/6643412.

[16] E. Buckner and Y. Abdelaziz, "Wealth-Based Inequalities in Higher Education Attendance: A Global Snapshot," *Educ. Res.*, vol. 52, no. 9, pp. 544–552, 2023, doi: 10.3102/0013189X231194307.

[17] A. Alam and A. Mohanty, "Cultural beliefs and equity in educational institutions: exploring the social and philosophical notions of ability groupings in teaching and learning of mathematics," *Int. J. Adolesc. Youth*, vol. 28, no. 1, 2023, doi: 10.1080/02673843.2023.2270662.

[18] S. P. Kawuryan, S. A. Sayuti, A. Aman, and S. I. A. Dwiningrum, "Teachers Quality and Educational Equality Achievements in Indonesia," *Int. J. Instr.*, vol. 14, no. 3, pp. 463–480, 2021.

[19] S. Maulidin, W. Kurniawan, M. Rohman, M. L. Nawawi, and D. Andrianto, "Quality Management in Improving Competitiveness in the Digital Era at Madrasa," *J. Adv. Islam. Educ. Manag.*, vol. 4, no. 1, pp. 57–70, 2024, doi: 10.24042/jaiem.v.

[20] I. C. Mulaudzi, "Factors Affecting Students' Academic Performance: A Case Study of the University Context," *J. Soc.*

Sci. Policy, vol. 11, no. 1, pp. 2334–2919, 2023, doi: 10.15640/10.15640/jsspi.v11n1a3.
[21] E. S. Groenewald, O. T. Kit Kilag, R. P. Unabia, M. V Manubag, M. B. Zamora, and D. Repuela, "The Dynamics of Problem-Based Learning: A Study on its Impact on Social Science Learning Outcomes and Student Interest," *Excell. Int. Multi-disciplinary J. Educ.*, vol. 1, no. 6, pp. 2994–9521, 2023, [Online]. Available: https://orcid.org/0000-0002-4416-9989
[22] O. T. Akintayo, C. A. Eden, O. O. Ayeni, and N. C. Onyebuchi, "Evaluating the impact of educational technology on learning outcomes in the higher education sector: A systematic review," *Open Access Res. J. Multidiscip. Stud.*, vol. 7, no. 2, pp. 052–072, 2024, doi: 10.53022/oarjms.2024.7.2.0026.
[23] A. Tang, W. Li, and D. Liu, "the Impact of Teachers' Professional Development in Science Pedagogy on Students' Achievement: Evidence From Timss 2019," *J. Balt. Sci. Educ.*, vol. 21, no. 2, pp. 258–274, 2022, doi: 10.33225/jbse/22.21.258.
[24] S. Sims *et al.*, "Effective Teacher Professional Development: New Theory and a Meta-Analytic Test," *Rev. Educ. Res.*, vol. 95, no. 2, pp. 213–254, 2023, doi: 10.3102/00346543231217480.
[25] S. Mohammad, K. Alkhararbeh, and F. B. Puteh, "How Teacher Qualifications , Experience , Expectations , and Professional Development Affected Eighth- Grade Students ' Science Achievement in Abu Dhabi : Insights from TIMSS 2019," *Al-Azkiyaa – Int. J. Lang. Educ.*, vol. 3, no. 2, pp. 134–155, 2024.
[26] R. Bogler and A. Somech, "Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID- 19 . The COVID-19 resource centre is hosted on Elsevier Connect , the company ' s public news and information," *Teach. Teach. Educ.*, vol. 130, no. January, p. 104183, 2023.
[27] E. A. Brew, B. Nketiah, and R. Koranteng, "A Literature Review of Academic Performance, an Insight into Factors and their Influences on Academic Outcomes of Students at Senior High Schools," *OALib*, vol. 08, no. 06, pp. 1–14, 2021, doi: 10.4236/oalib.1107423.
[28] J. Munir, M. Faiza, B. Jamal, S. Daud, and K. Iqbal, "The Impact of Socio-economic Status on Academic Achievement," *J. Soc. Sci. Rev.*, vol. 3, no. 2, pp. 695–705, 2023, doi: 10.54183/jssr.v3i2.308.
[29] S. Raza, M. Hameed, and N. Abbas, "The dynamic interplay of socio-economic factors in educational attainment: a holistic analysis of socio- economic status and academic success," *Int. J. Learn. Divers. Identities*, vol. 30, no. 2, pp. 203–213, 2023.
[30] 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 Egit. ve Ogr. Derg.*, vol. 12, no. 2, pp. 32–57, 2022, doi: 10.47750/pegegog.12.02.04.
[31] M. De Clercq, B. Galand, V. Hospel, and M. Frenay, "Bridging-contextual-and-individual-factors-of-academic-achievement-A-multilevel-analysis-of-diversity-in-the-transition-to-higher-educationFrontline-Learning-Research.pdf," *Front. Learn. Res.*, vol. 9, no. 2, pp. 96–120, 2021.
[32] A. Karakolidis, A. Duggan, G. Shiel, and J. Kiniry, "Examining educational inequalities: insights in the context of improved mathematics performance on national and international assessments at primary level in Ireland," *Large-Scale Assessments Educ.*, vol. 9, no. 1, pp. 1–23, 2021, doi: 10.1186/s40536-021-00098-1.
[33] L. Zhao, B. Zhao, and C. Li, "Alignment analysis of teaching–learning-assessment within the classroom: how teachers implement project-based learning under the curriculum standards," *Discip. Interdiscip. Sci. Educ. Res.*, vol. 5, no. 1, pp. 1–23, 2023, doi: 10.1186/s43031-023-00078-1.
[34] T. Nilsen, H. Kaarstein, and A. C. Lehre, "Trend analyses of TIMSS 2015 and 2019: school factors related to declining performance in mathematics," *Large-Scale Assessments Educ.*, vol. 10, no. 1, pp. 1–19, 2022, doi: 10.1186/s40536-022-00134-8.
[35] J. S. Barrot, "K to 12 curriculum reform in the Philippines: towards making students future ready," *Asia Pacific J. Educ.*, vol. 43, no. 4, pp. 1193–1207, 2023, doi: 10.1080/02188791.2021.1973959.
[36] A. Balfaqeeh, N. Mansour, and S. Forawi, "Factors Influencing Students' Achievements in the Content and Cognitive Domains in TIMSS 4th Grade Science and Mathematics in the United Arab Emirates," *Educ. Sci.*, vol. 12, no. 9, pp. 1–22, 2022, doi: 10.3390/educsci12090618.
[37] L. Koyuncu, "TIMSS International Benchmarks of Eighth Graders in Mathematics: A Correspondence Analysis Study," *Int. Electron. J. Elem. Educ.*, vol. 14, no. 2, pp. 179–194, 2021, doi: 10.26822/iejee.2022.237.
[38] Y. Gao, G. Zeng, Y. Wang, A. A. Khan, and X. Wang, "Exploring Educational Planning, Teacher Beliefs, and Teacher Practices During the Pandemic: A Study of Science and Technology-Based Universities in China," *Front. Psychol.*, vol. 13, no. April, pp. 1–11, 2022, doi: 10.3389/fpsyg.2022.903244.
[39] C. Wang, X. Chen, T. Yu, Y. Liu, and Y. Jing, "Education reform and change driven by digital technology: a bibliometric study from a global perspective," *Humanit. Soc. Sci. Commun.*, vol. 11, no. 1, pp. 1–17, 2024, doi: 10.1057/s41599-024-02717-y.
[40] E. Siregar, S. Sutiarso, and Z. Yusuf, "Analysis of Students' Mathematical Literacy Ability in Algebraic Concepts Based on Trends in International Mathematics and Science Study (TIMSS) Problems," *Tech. Soc. Sci. J.*, vol. 6, no. July, pp. 381–392, 2020.
[41] A. M. Hamzah, T. Turmudi, and J. A. Dahlan, "Trends in International Mathematics and Science Study (TIMSS) as A Measurement for Student Mathematics Assessment Development," *12 Waiheru*, vol. 9, no. 2, pp. 189–196, 2023, doi: 10.47655/12waiheru.v9i2.144.
[42] N. Teig and T. Nilsen, "Profiles of instructional quality in primary and secondary education: Patterns, predictors, and relations to student achievement and motivation in science," *Stud. Educ. Eval.*, vol. 74, no. November 2021, p. 101170, 2022, doi: 10.1016/j.stueduc.2022.101170.
[43] 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," *Soc. Psychol. Educ.*, vol. 25, no. 4, pp. 903–928, 2022, doi: 10.1007/s11218-022-09704-8.

[44] H. G. van de Werfhorst, E. Kessenich, and S. Geven, "The digital divide in online education: Inequality in digital readiness of students and schools," *Comput. Educ. Open*, vol. 3, no. April 2021, p. 100100, 2022, doi: 10.1016/j.caeo.2022.100100.

[45] P. Kumar and P. Ekka, *Statistical analysis of the impacts of COVID-19 pandemic on the small and large-scale tourism sectors in developing countries*, vol. 26, no. 4. Springer Netherlands, 2024. doi: 10.1007/s10668-023-03112-4.

[46] M. Sajjad, A. Bhatti, B. Hill, and B. Al-Omari, "Using the theory of planned behavior to predict factors influencing fast-food consumption among college students," *BMC Public Health*, vol. 23, no. 1, pp. 1–13, 2023, doi: 10.1186/s12889-023-15923-1.

[47] T. Chen, Y. X. Liu, and L. Huang, "ImageGP: An easy-to-use data visualization web server for scientific researchers," *iMeta*, vol. 1, no. 1, pp. 1–6, 2022, doi: 10.1002/imt2.5.

[48] A. Omidi and C. Dal Zotto, "Socially Responsible Human Resource Management: A Systematic Literature Review and Research Agenda," 2022. doi: 10.3390/su14042116.

[49] B. Vadivel, S. Alam, I. Nikpoo, and B. Ajanil, "The Impact of Low Socioeconomic Background on a Child's Educational Achievements," *Educ. Res. Int.*, vol. 2023, pp. 1–11, 2023, doi: 10.1155/2023/6565088.

[50] N. A. K. Alreshidi and V. Lally, "The effectiveness of training teachers in problem-based learning implementation on students' outcomes: a mixed-method study," *Humanit. Soc. Sci. Commun.*, vol. 11, no. 1, pp. 1–10, 2024, doi: 10.1057/s41599-024-03638-6.

[51] I. S. Adeniyi *et al.*, "Educational reforms and their impact on student performance: A review in African Countries," *World J. Adv. Res. Rev.*, vol. 21, no. 2, pp. 750–762, 2024, doi: 10.30574/wjarr.2024.21.2.0490.