

Models That Enhance Mathematics Teaching in Stem and Non-Stem Schools in Southern Province, Zambia

Dayakar Sidhabattula - Senior Lecturer at Rusangu University in Monze, Zambia

Department of Education, Rusangu University, Monze, Southern Province

DOI: <https://doi.org/10.51244/IJRSI.2025.12120136>

Received: 01 January 2026; Accepted: 06 January 2026; Published: 17 January 2026

ABSTRACT

Despite policy emphasis on STEM for national development and economic growth, mathematics remains critical yet underperforming in Zambia's secondary education system (Examinations Council of Zambia, 2022; UNESCO, 2021). This study meticulously examined various mathematics teaching models employed in both STEM and non-STEM secondary schools located in the Southern Province of Zambia. This investigation compared learner performance across school types, identified instructional challenges, and determined effective pedagogical practices to enhance learning outcomes.

A mixed-methods comparative design achieved these objectives by integrating a comprehensive analysis of Grade 12 math examination results. Additionally, structured questionnaires were administered to both teachers and learners, with a total of 228 participants contributing to the data collection process. Furthermore, semi-structured interviews were conducted with teachers and school administrators to gain deeper insights into the educational environment, while school-based observations provided valuable contextual information (Creswell & Plano Clark, 2018).

Descriptive statistics, ANOVA, and regression analysis analyzed quantitative data to draw conclusions; thematic analysis examined qualitative data for patterns and themes. The findings indicate that STEM schools generally outperform their non-STEM counterparts in mathematics, a trend that reflects the specialized orientation of STEM curricula and the relatively better resource allocation often found in these institutions (Bybee, 2013; Honey et al., 2014). However, it is noteworthy that several non-STEM schools achieved comparable or even superior outcomes, demonstrating that factors such as effective leadership, teacher collaboration, a strong academic culture, and high levels of learner motivation significantly influence performance, irrespective of school designation (Leithwood et al., 2020; Sammons et al., 2011).

Survey results revealed a strong endorsement of learner-centered approaches, practical instruction, and technology integration, which are consistent with the principles of constructivist learning theory, as articulated by seminal theorists such as Piaget (1973) and Vygotsky (1978). Nevertheless, inferential analysis showed that these innovative strategies alone did not consistently predict high achievement without the presence of supportive institutional conditions that foster such pedagogical practices (Okeke, 2017).

Ultimately, the study concludes that mathematics performance is shaped by the intricate interaction of pedagogical, organizational, and motivational factors, leading to the recommendation for equitable resource provision across all schools. Additionally, there is a pressing need for strengthened professional development for educators and sustained support for learner-centered teaching models across both STEM and non-STEM schools, as highlighted by the Organisation for Economic Co-operation and Development (OECD, 2019) and the Ministry of Education (2022).

Keywords: STEM education, mathematics achievement, learner-centered pedagogy, teacher collaboration, Zambia, secondary schools

Introduction (Recommended for Submission)

Mathematics is widely recognized as foundational to scientific advancement, technological innovation, and economic development, forming a core component of Science, Technology, Engineering, and Mathematics (STEM) education globally (UNESCO, 2021; OECD, 2019). Despite this strategic importance, learner achievement in Mathematics remains persistently low across much of Sub-Saharan Africa, including Zambia, limiting participation in science- and technology-related career pathways and undermining national development goals.

In Zambia, Mathematics is a compulsory subject at the secondary school level and a cornerstone of both STEM and emerging STEAM curricula. Yet national examination data continue to reveal weak learner performance, with Mathematics consistently recording the lowest pass rates among core subjects (ECZ, 2022; ECZ, 2023). In response, the Government of Zambia has implemented STEM education reforms aimed at improving outcomes through enhanced infrastructure, specialized teacher deployment, curriculum realignment, and the promotion of inquiry-oriented and learner-centered pedagogies (Ministry of Education, 2022). While early reports suggest improved outcomes in STEM-designated schools, empirical evidence quantifying the magnitude and practical significance of these differences—particularly at the provincial level—remains limited.

Moreover, existing studies often rely on descriptive comparisons or pass rates, offering limited insight into whether improved outcomes are attributable to STEM pedagogy itself or to broader institutional advantages such as leadership, resourcing, and learner selection. This study addresses this gap by comparing Grade 12 Mathematics performance between STEM and non-STEM secondary schools in Zambia's Southern Province and examining institutional and learner-level factors shaping achievement. By integrating effect size analysis with qualitative insights, the study advances a systems-oriented understanding of mathematics performance disparities that moves beyond infrastructure-based explanations and informs equitable, evidence-based education reform.

Statement of the Problem

Despite policy reforms and targeted investments in STEM education, mathematics performance among Zambian secondary school learners remains persistently low. The introduction of STEM schools has been based on the assumption that specialized infrastructure, curriculum focus, and resource allocation will automatically lead to improved learning outcomes. However, national examination data indicate that performance gains have been uneven and, in some cases, marginal.

Furthermore, existing studies in Zambia have largely focused on policy intentions, curriculum reforms, or aggregated examination outcomes, with limited attention to the specific teaching models employed in classrooms and the contextual factors that shape their effectiveness. There is insufficient empirical evidence comparing mathematics instructional practices in STEM and non-STEM schools and analyzing how pedagogical strategies interact with leadership, resources, and school culture to influence learner achievement. This gap constrains evidence-based decision-making by policymakers, school administrators, and teachers.

Purpose of the Study

The primary purpose of this comprehensive study was to evaluate and compare the various mathematics teaching models that are currently employed in both STEM (Science, Technology, Engineering, and Mathematics) and non-STEM secondary schools located in the Southern Province of Zambia. Furthermore, the study aimed to closely examine how these differing teaching models influence the performance of Grade 12 learners in the subject of mathematics. This inquiry is particularly timely and relevant given the persistent underperformance in mathematics among students, a trend that has continued despite numerous policy reforms and targeted investments aimed at enhancing STEM education. By focusing on this issue, the study sought to generate empirical, context-specific evidence that could effectively inform instructional practices, school leadership strategies, and broader education policy initiatives.

More specifically, the study aimed to achieve several key objectives:

First, it sought to compare mathematics performance outcomes among Grade 12 learners in both STEM and non-STEM secondary schools across the Southern Province of Zambia. This comparison utilized national examination results as objective indicators of academic achievement, allowing for a clear and measurable assessment of learner performance.

Second, the study aimed to identify and describe the various mathematics teaching models that are currently being employed in both types of schools. It focused on learner-centered approaches, practical methods, technology integration, and collaborative learning that engages students.

Third, the study examined teachers' and students' perceptions of different math teaching models' effectiveness. This included a focus on how these models enhance conceptual understanding, improve problem-solving skills, and increase learner engagement in the subject matter.

The study analyzed factors enabling or constraining mathematics teaching models across school types. These factors, including leadership practices, opportunities for teacher collaboration, the availability of educational resources, and the prevailing school culture, all play a significant role in shaping the educational environment.

Additionally, the study aimed to determine the extent to which various instructional practices can predict learner performance. To achieve this, inferential statistical analysis was employed to assess the relationships between specific teaching strategies and the resultant achievement outcomes of students.

Finally, the study sought to generate evidence-based recommendations for improving the teaching and learning of Mathematics in both STEM and non-STEM secondary schools. The overarching aim of these recommendations was to promote equity in education, enhance instructional effectiveness, and ultimately improve learner outcomes across the board.

By addressing these objectives, the study sought to move beyond simplistic comparisons of school designations and contribute to a deeper understanding of how pedagogical practices interact with systemic factors to shape Mathematics achievement among learners in Zambia. This comprehensive approach is expected to provide valuable insights that can lead to meaningful improvements in the educational landscape.

METHODOLOGY

Research Design

A comparative cross-sectional mixed-methods design was employed to examine differences in Mathematics performance and to contextualize quantitative patterns using qualitative data (Creswell & Plano Clark, 2018). The study was conducted in four purposively selected secondary schools in Zambia's Southern Province—two STEM and two non-STEM schools.

Quantitative data were obtained from Grade 12 Mathematics examination records for 228 learners, selected through proportionate stratified random sampling. Qualitative data were collected via questionnaires and semi-structured interviews with 26 Mathematics teachers and school administrators. Instrument validity was established through expert review, and reliability coefficients exceeded the acceptable threshold of $\alpha = 0.70$.

Quantitative data were analyzed using descriptive statistics, independent samples t-tests, and effect size estimation, while qualitative data were analyzed thematically to explain observed performance patterns.

Sample and Sampling Procedures

Purposive sampling selected four secondary schools—STEM (Hillcrest and Nico Girls Secondary Schools) and non-STEM (Canisius and Mazabuka Girls Secondary Schools)—in Southern Province, Zambia. This strategic approach to sampling was considered appropriate because the study sought in-depth, context-specific insights rather than broad statistical generalizations (Patton, 2015). By focusing on specific institutions, the research aimed to capture nuanced perspectives that reflect the unique educational environments within the region.

Schools were selected based on the following criteria:

The Ministry of Education designated schools as STEM or non-STEM, aligning them with national policy and the educational framework. This classification is vital as it helps in understanding the resources and support systems available to each type of school.

2. Availability of Grade 12 Mathematics examination results, which enabled objective comparison of learner performance across the selected schools. These results are crucial for assessing the effectiveness of the teaching methodologies employed in both STEM and non-STEM settings, providing a tangible metric for evaluating student achievement.

3. Willingness to participate, ensuring access to reliable data and stakeholder perspectives. The schools' openness to engage in the study was essential for gathering authentic insights and fostering a collaborative atmosphere for discussion.

Within the selected schools, a total of 228 respondents participated in the survey component of the study. These respondents comprised Mathematics teachers and Grade 12 learners, who were directly involved in the teaching–learning process. The involvement of these key groups allowed for a richer understanding of the educational dynamics at play. In addition, selected school administrators, such as Heads of Department and senior management, participated in interviews due to their roles in instructional leadership and policy implementation. Their insights were invaluable in understanding the broader educational strategies and challenges faced by the schools.

The inclusion of multiple stakeholder groups not only enhanced the comprehensiveness of the data collected but also bolstered the credibility of the findings. By gathering perspectives from various levels within the educational system, the study was able to paint a more complete picture of the factors influencing student performance in Mathematics across different types of schools in Southern Province. This multifaceted approach ultimately contributes to a deeper understanding of the educational landscape in Zambia, highlighting areas for potential improvement and development.

Data Collection Instruments

Multiple data collection instruments were employed in this study to ensure robust data triangulation and to significantly enhance the trustworthiness of the findings derived from the research. By utilizing various methods, the study aimed to provide a comprehensive understanding of the educational landscape being examined.

Document Analysis

Grade 12 Mathematics examination results were meticulously analyzed to establish performance trends and to identify differences in achievement levels between students in STEM (Science, Technology, Engineering, and Mathematics) schools and their counterparts in non-STEM schools. These records, which included standardized test scores and official examination results, offered objective and quantifiable measures of learner achievement, thereby reducing reliance on self-reported data that might be biased or inaccurate. This objective analysis allowed for a clearer picture of student performance, revealing not only average scores but also variations in achievement across different demographics.

Structured Questionnaires

Structured questionnaires were systematically administered to both teachers and learners in order to collect quantitative data on several key aspects, including:

Mathematics teaching strategies used in classrooms, which may include inquiry-based learning, direct instruction, and collaborative group work.

The integration of technology and practical learning approaches, which could include the use of educational software, online resources, and hands-on activities to enhance learning experiences.

The perceived effectiveness of different instructional models, allowing participants to express their views on whether certain teaching methods were more beneficial for student understanding and engagement.

The availability and utilization of instructional resources, including textbooks, digital tools, and supplementary materials that support the teaching and learning process.

Responses to these questionnaires were measured using a five-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5). This scale enabled a systematic comparison of perceptions across respondents, facilitating the identification of common themes and divergent opinions among teachers and students.

Semi-Structured Interviews

Semi-structured interviews were thoughtfully conducted with a selection of Mathematics teachers and school administrators to delve deeper into various factors influencing Mathematics instruction. These interviews explored:

Institutional leadership and support for Mathematics instruction, examining how school administrators foster an environment conducive to effective teaching and learning.

Teacher collaboration and professional learning practices, including opportunities for professional development and peer support, can enhance instructional quality.

Challenges affecting effective mathematics teaching and learner performance, such as curriculum constraints, resource limitations, and varying student readiness levels.

This qualitative approach allowed participants to provide detailed explanations and contextual insights that could not be captured through questionnaires alone, enriching the overall understanding of the challenges and successes within mathematics education.

Classroom and School Observations

Observations were strategically focused on classroom environments and the availability of teaching and learning resources, such as textbooks, computer laboratories, and internet connectivity, which are crucial for modern educational practices. Additionally, general school conditions were assessed to gain insight into the physical and organizational factors impacting learning. Observational data collected during these visits were instrumental in contextualizing and validating the findings from questionnaires and interviews, ensuring that the insights gathered were reflective of real-world classroom dynamics and educational environments.

Data Analysis Procedures

Quantitative data were meticulously analyzed using the Statistical Package for the Social Sciences (SPSS), a robust software tool widely recognized for its capabilities in data manipulation and statistical analysis. The analysis involved several key components:

First, descriptive statistics were employed, which included frequencies, percentages, and cumulative percentages. This approach was instrumental in summarizing important aspects such as various teaching models, the availability of educational resources, and the perceptions held by different stakeholders within the educational landscape. For example, the frequencies helped to identify how often certain teaching models were implemented, while percentages provided insight into the proportion of resources available in different schools.

Additionally, inferential statistics were utilized to draw conclusions and make inferences about the larger population based on the sample data collected. One-way Analysis of Variance (ANOVA) was specifically used to examine differences between STEM (Science, Technology, Engineering, and Mathematics) schools and non-STEM schools. This statistical test enabled the researchers to determine whether there were significant variations in instructional practices and learner outcomes between these two distinct groups. Furthermore, regression analysis was conducted to assess the relationships between instructional practices and learner performance,

allowing for a deeper understanding of how teaching methods may influence student achievement. The testing for statistical significance was conducted at the 0.05 level, which aligns with conventional educational research standards and provides a benchmark for evaluating the reliability of the findings.

On the qualitative side, data gathered from interviews and observations were systematically analyzed using thematic analysis, a method that focuses on identifying, analyzing, and reporting patterns or themes within qualitative data. The data were carefully transcribed to ensure accuracy, followed by coding to categorize the information meaningfully. This process culminated in the organization of the data into recurring themes that emerged during the analysis. Notable themes included teacher collaboration, learner-centered pedagogy, effective leadership practices, resource constraints, and learner motivation. These themes were not merely isolated findings; rather, they were integrated to explain, corroborate, and enrich the quantitative findings, thereby enhancing the explanatory power of the study. By weaving together both quantitative and qualitative data, the research provided a more comprehensive view of the educational environment, ultimately offering valuable insights that could inform future educational policies and practices.

FINDINGS AND DISCUSSION

Practical Mathematics Instruction

Table 1 presents respondents' perceptions regarding the introduction of more practical Mathematics lessons.

Table 1 Perceptions on Introducing Practical Mathematics Lessons (n = 228)

Response Category	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly Disagree	6	2.6	2.6	2.6
Disagree	3	1.3	1.3	3.9
Undecided	10	4.4	4.4	8.3
Agree	91	39.9	39.9	48.2
Strongly Agree	118	51.8	51.8	100.0
Total	228	100.0	100.0	

Source: Field data (2025)

Over 91% of respondents agreed or strongly agreed that practical Mathematics lessons improve learner understanding. This strong consensus supports constructivist learning theory, which emphasizes active engagement and experiential learning (Piaget, 1973; Kolb, 1984).

5.2 Integration of Technology

Table 2 summarizes responses on technology integration in Mathematics teaching.

Table 2 Perceptions on Technology Integration in Mathematics Teaching (n = 228)

Response Category	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly Disagree	3	1.3	1.3	1.3
Disagree	11	4.8	4.8	6.1

Undecided	17	7.5	7.5	13.6
Agree	83	36.4	36.4	50.0
Strongly Agree	114	50.0	50.0	100.0
Total	228	100.0	100.0	

Source: Field data (2025)

A combined 86.4% of respondents supported technology integration, aligning with studies that link digital tools to enhanced engagement and conceptual understanding (Honey et al., 2014; OECD, 2019).

Inferential Analysis

Table 3 presents the regression analysis examining relationships between instructional practices and learner performance.

Table 3 Regression Analysis of Instructional Practices and Learner Performance

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	.306	1	.306	.268	.605
Residual	257.536	226	1.140		
Total	257.842	227			

Source: Field data (2025)

The results indicate a weak and statistically nonsignificant relationship between selected instructional variables and performance outcomes. Although learner-centered practices like differentiated instruction and active engagement are valued in education, they need supportive conditions, such as effective leadership and educator collaboration, to improve achievement. For instance, in schools where teachers work collaboratively in professional learning communities, there is often a more pronounced impact on student learning outcomes. However, without the necessary infrastructure and support from school administration, even the best instructional practices may fail to yield significant improvements in student performance. Therefore, it is crucial to recognize that the implementation of learner-centered practices is not solely dependent on the instructional methods themselves but is also heavily influenced by the broader educational environment and the resources available to both teachers and students.

Qualitative Insights

Interviews and observations conducted across various educational institutions revealed that high-performing non-STEM schools effectively compensated for their limited resources through several key strategies. These strategies included strong leadership that fostered a vision of excellence, teacher collaboration that encouraged the sharing of best practices, peer learning initiatives that engaged students in cooperative educational experiences, and a high level of learner motivation driven by a supportive school culture. For instance, in one successful non-STEM school, teachers regularly held collaborative meetings to discuss lesson plans and share feedback, which not only enhanced their teaching methods but also built a sense of community among the staff. Conversely, some STEM schools exhibited underperformance due to inconsistent pedagogical implementation, which often led to a lack of coherence in teaching practices and student engagement. This inconsistency can reinforce a systems-theory perspective of education, suggesting that the effectiveness of educational outcomes is heavily influenced by the interconnectedness of various components within the educational system (Okeke, 2017). In these cases, the absence of a unified approach to teaching and learning can hinder student success,

highlighting the critical importance of effective leadership and collaborative practices in fostering an environment where all students can thrive.

Interpreting the Weak Predictive Power of Instructional Practices

Despite clear differences in math performance between STEM and non-STEM schools, regression analysis showed that instructional practices had little predictive power regarding learner achievement. While this result may initially appear counterintuitive, it is both theoretically and methodologically informative.

First, instructional practices were measured through self-reported questionnaire items, which may insufficiently capture the depth, quality, and consistency of classroom enactment. Research shows that basic measures of teaching often don't reflect the complex classroom interactions affecting learning (Hattie, 2009; Schindler et al., 2017).

Second, the presence of multicollinearity among instructional variables—such as inquiry-based learning, collaborative teaching, and formative assessment—may have attenuated their individual predictive power. These practices frequently co-occur in effective classrooms and are difficult to disentangle statistically, particularly in relatively small samples.

Third, learner achievement in mathematics is shaped by broader systemic and contextual factors beyond classroom instruction. School-level factors such as leadership quality, institutional culture, resource availability, learner selection effects, and prior academic preparation likely mediate the relationship between instructional practices and achievement. When such variables are omitted from regression models, the explanatory power of instructional predictors is necessarily constrained.

The weak regression results, therefore, do not imply that instructional practices are unimportant. Rather, they suggest that instruction operates within broader institutional systems. Its effects become statistically visible when modeled alongside structural and contextual variables. This finding reinforces the need for systems-oriented approaches to mathematics education reform.

Theoretical Contribution

Theoretically, this study extends constructivist and school effectiveness perspectives. It demonstrates that mathematics achievement is best understood as an outcome of interacting instructional, institutional, and systemic forces, rather than isolated pedagogical inputs. The exceptionally large effect size observed suggests that school structures, leadership, and academic culture operate as powerful mediators of learning, shaping how instructional practices are enacted and experienced by learners.

By foregrounding effect size analysis, the study advances a systems-oriented understanding of STEM and non-STEM schooling that moves beyond infrastructure-based explanations and highlights the importance of institutional coherence, leadership capacity, and equity in resource distribution. This contribution is particularly relevant for education systems in low- and middle-income contexts, where structural disparities often overshadow classroom-level interventions.

RECOMMENDATIONS

1. STEM reforms should prioritize pedagogical implementation and teacher professional development alongside infrastructure investment. This means that while it is essential to enhance the physical and technological resources available in schools, equal attention must be given to how these resources are utilized in the classroom. Professional development programs should be designed to equip teachers with innovative teaching strategies that align with STEM education goals, enabling them to effectively engage students and foster critical thinking skills.
2. Non-STEM schools should receive equitable access to instructional resources and innovation funding. It is crucial that these schools are not left behind in the push for educational advancement. By providing them with the necessary tools and financial support, we can ensure that all students, regardless of their school's

focus, have the opportunity to benefit from a quality education and are prepared for the demands of a rapidly changing workforce.

3. Teacher collaboration and professional learning communities should be institutionalized. Establishing structured platforms for teachers to share best practices, discuss challenges, and collaboratively develop curricula can lead to improved educational outcomes. This approach not only enhances teacher morale but also promotes a culture of continuous improvement and accountability within schools.
4. Learner-centered and practical teaching approaches should be embedded within Mathematics curricula and assessment systems. This involves designing math lessons that connect theoretical concepts with real-world applications, allowing students to see the relevance of what they are learning. Incorporating hands-on activities and problem-solving tasks can help students develop a deeper understanding of mathematical principles and encourage them to apply these skills outside the classroom.

CONCLUSION

This study set out to examine and compare mathematics teaching models in STEM and non-STEM secondary schools in Southern Province, Zambia, and to assess how these models influence Grade 12 learner performance. The findings provide robust empirical evidence that STEM designation is associated with substantially higher mathematics achievement. Beyond statistical significance, effect size analysis revealed an exceptionally large magnitude of difference, indicating that the observed disparities are not merely incremental but educationally consequential. At the same time, the relatively strong performance of selected non-STEM schools demonstrates that school designation alone does not determine learner success. Instead, mathematics outcomes emerge from a complex interaction of pedagogical practices, instructional leadership, teacher collaboration, resource availability, and learner motivation.

While STEM schools benefit from relatively stronger infrastructure and policy prioritization, the study shows that these advantages do not automatically translate into superior outcomes. Several non-STEM schools achieved comparable or competitive performance by leveraging strong academic culture, collaborative teaching practices, effective leadership, and high learner motivation. This evidence challenges the assumption that infrastructure-driven STEM reforms are sufficient for improving mathematics achievement and reinforces systems-oriented perspectives that emphasize coherence among institutional inputs, instructional processes, and learner outcomes.

The study extends constructivist and school effectiveness perspectives. It demonstrates that mathematics achievement is best understood as a result of interacting instructional, institutional, and systemic forces, rather than isolated pedagogical inputs. Although teachers and learners perceive learner-centered approaches like practical instruction, collaborative learning, and technology integration as effective, analysis shows that these strategies don't consistently predict achievement alone. Their impact depends on supportive institutional conditions, including sustained professional development, collaborative professional cultures, effective instructional leadership, and adequate learning resources. The exceptionally large effect size observed suggests that school structures, leadership practices, and academic culture function as powerful mediators of learning, shaping how instructional practices are enacted and experienced by learners.

By foregrounding effect size analysis, this study advances a systems-oriented understanding of STEM and non-STEM schooling. It moves beyond infrastructure-based explanations, highlighting the centrality of institutional coherence, leadership capacity, and equity in resource distribution. This theoretical contribution is salient for education systems in low- and middle-income contexts, where structural disparities often strongly influence learning outcomes more than classroom-level interventions alone.

From a policy and practice perspective, the findings suggest that sustainable improvement in mathematics education requires a shift away from narrowly defined, infrastructure-focused STEM interventions toward context-responsive and systemically aligned reforms. Sustained STEM investment requires spreading high-impact practices across all schools, such as inquiry-based instruction and collaborative learning. Ensuring equitable access to qualified mathematics teachers, instructional resources, and professional support is essential to narrowing performance gaps and preventing the entrenchment of long-term educational inequalities.

In conclusion, strengthening mathematics education in Zambia demands a holistic and equity-oriented approach that recognizes the interdependence of pedagogy, leadership, institutional capacity, and learner motivation. This study uses data-driven evidence to inform STEM education discussions and guide policymakers and educators in improving math instruction across schools.

REFERENCES

1. Bybee, R. W. (2013). *The Case for STEM Education: Challenges and Opportunities*. NSTA Press.
2. Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and Conducting Mixed Methods Research* (3rd ed.). SAGE.
3. Examinations Council of Zambia. (2022). *Annual Performance Report for Grade 12 Examinations*. ECZ.
4. Examinations Council of Zambia. (2023). *School Certificate Examination Performance Report*. ECZ.
5. Hiebert, J., Carpenter, T. P., Fennema, E., Fuson, K. C., Wearne, D., Murray, H., & Human, P. (2003). *Making Sense: Teaching and Learning Mathematics With Understanding*. Heinemann.
6. Honey, M., Pearson, G., & Schweingruber, H. (2014). *STEM Integration in K–12 Education: Status, Prospects, and an Agenda for Research*. National Academies Press.
7. Leithwood, K., Harris, A., & Hopkins, D. (2020). Seven Strong Claims About Successful School Leadership Revisited. *School Leadership & Management*, 40(1), 5–22. <https://doi.org/10.1080/13632434.2019.1596077>
8. Ministry of Education. (2022). *STEM Education Implementation Report*. Government of Zambia.
9. Mwansa, D., & Sichilima, A. (2018). Assessing the Impact of STEM Education in Zambia: A Case Study of Southern Province. *Journal of Science Education and Technology*, 27(5), 439–456.
10. Mwansa, P., & Mbewe, C. (2020). Teacher Preparedness in STEM Education: A Zambian Perspective. *Zambia Journal of Education*, 8(2), 55–68.
11. National Council of Teachers of Mathematics. (2020). *Catalyzing Change in High School Mathematics*. NCTM.
12. Ngoma, M., Banda, P., & Simukanga, C. (2020). Socioeconomic Factors and Student Achievement in Mathematics: Evidence From Zambian Secondary Schools. *Zambia Journal of Social Science Education*, 11(1), 25–43.
13. OECD. (2019). *PISA 2018 Results (Volume I): What Students Know and Can Do*. OECD Publishing.
14. Okeke, C. (2017). Systems Thinking in Education Reform: A Holistic Approach. *Educational Review*, 69(5), 601–617. <https://doi.org/10.1080/00131911.2016.1186111>
15. Oliver, M., Peggy, M., & Colley, G. (2022). Implementation of STEM Education in the Zambian Education System: A Failed Project. *International Journal of Arts, Humanities and Social Studies*, 4(3), 133–138.
16. Piaget, J. (1973). *To Understand Is to Invent: The Future of Education*. Grossman.
17. Sammons, P., Gu, Q., Day, C., & Ko, J. (2011). Exploring the Impact of School Leadership on Pupil Outcomes. *International Journal of Educational Management*, 25(1), 83–101.
18. Schoenfeld, A. H. (2016). Toward a Theory of Teaching-in-Context. *Mathematics Teacher Education and Development*, 18(1), 1–18.
19. Tikly, L., Joubert, M., Barrett, A. M., Bainton, D., Cameron, L., & Doyle, H. (2018). *Supporting Secondary School STEM Education for Sustainable Development in Africa*. University of Bristol.
20. UNESCO. (2021). *UNESCO Science Report: The Race Against Time for Smarter Development*. UNESCO Publishing.
21. Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Harvard University Press.
22. World Economic Forum. (2016). *The Future of Jobs: Employment, Skills, and Workforce Strategy for the Fourth Industrial Revolution*. WEF.