❑   169

Effectiveness of Realistic Mathematics Education in Improving Grade 7 Students' Learning Outcomes in a Rural Zambian Secondary School

Allan Musonda[1], Leonard Mubila[2], Justina Mulenga[3]
[1]Department Mathematics Education, Copperbelt University, Kitwe, Zambia
[2,3]Department of Mathematics, School of Mathematics and Natural Sciences, Copperbelt University, Kitwe, Zambia

Article Info	ABSTRACT
	Purpose of the study: This study aims to examine the effectiveness of the Realistic Mathematics Education approach in improving mathematics learning outcomes of Grade 7 students in a rural Zambian secondary school. **Methodology:** A quasi-experimental design with a one-group pretest–posttest model was employed. The participants consisted of 26 Grade 7 students selected from a rural public secondary school in Zambia. Data were collected through mathematics achievement tests, classroom observation sheets, and student response questionnaires. Descriptive statistical analysis was used to evaluate learning effectiveness based on learning outcomes, student activities, and student responses. **Main Findings:** The results indicate that the implementation of Realistic Mathematics Education led to a significant improvement in students' mathematics achievement, with most students achieving the minimum mastery criterion and demonstrating a high normalized gain score. In addition, students showed active participation during learning activities and expressed positive responses toward the Realistic Mathematics Education -based instruction. **Novelty/Originality of this study:** These findings suggest that Realistic Mathematics Education is an effective instructional approach for enhancing mathematics learning in rural secondary school contexts in Zambia. *This is an open access article under the CC BY license*

Corresponding Author:
Leonard Mubila
Department of Mathematics, School of Mathematics and Natural Sciences, Copperbelt University, Kitwe, Zambia
Email: lemubila15@gmail.com

1. INTRODUCTION

Mathematics plays a crucial role in developing logical thinking, problem-solving skills, and analytical abilities required for daily life and future careers [1], [2]. In many developing countries, including Zambia, mathematics education is expected to equip students with competencies necessary to participate effectively in social and economic development [3], [4]. However, mathematics learning outcomes in rural secondary schools remain relatively low compared to urban areas, mainly due to limited learning resources, teacher-centered instructional practices, and students' difficulties in understanding abstract mathematical concepts [5], [6].

One of the major challenges in mathematics instruction is the tendency to present mathematical concepts in a formal and symbolic manner without meaningful connections to students' real-life experiences [7], [8]. This condition often leads students to perceive mathematics as a difficult and irrelevant subject, resulting in low motivation and poor learning outcomes [9], [10]. In rural Zambian contexts, where students' everyday experiences differ significantly from textbook examples, conventional teaching approaches may further widen the gap between mathematical concepts and students' understanding.

Realistic Mathematics Education, originally developed in the Netherlands, offers an alternative approach by emphasizing mathematics as a human activity that is closely connected to real-life situations [11], [12]. Realistic Mathematics Education encourages students to construct mathematical knowledge through contextual problems that are meaningful and imaginable for them [13], [14]. Through guided reinvention, progressive mathematization, and the use of self-developed models, students are actively involved in the learning process and gradually transition from informal reasoning to formal mathematical understanding [15], [16].

Several previous studies have reported that Realistic Mathematics Education can improve students' conceptual understanding, learning motivation, and problem-solving abilities [17], [18]. However, empirical studies investigating the implementation of Realistic Mathematics Education in rural African educational contexts, particularly in Zambia, are still limited [19], [20]. Most existing research focuses on urban settings or countries with more developed educational infrastructures, leaving a research gap regarding the effectiveness of Realistic Mathematics Education in rural secondary schools with constrained learning environments [21], [22].

The novelty of this study lies in the empirical application and testing of the effectiveness of the Realistic Mathematics Education approach in the context of rural secondary schools in Zambia, which have limited learning resources. Unlike previous studies, which have generally been conducted in urban settings or countries with more established educational infrastructure, this study specifically integrates the real-life context of rural students into mathematics learning and evaluates its effectiveness through three main indicators: learning outcomes, student learning activities, and student responses. Thus, this study provides new empirical evidence on the relevance and adaptability of Realistic Mathematics Education in the under-researched educational context of Sub-Saharan Africa.

The urgency of this research is driven by the low mathematics learning outcomes of students in rural Zambian schools, which are still dominated by teacher-centered learning practices and the presentation of abstract mathematical concepts that are detached from students' real-life experiences. This condition has the potential to widen the gap in education quality between rural and urban areas and hinder the development of students' mathematical thinking skills. Therefore, a contextual, meaningful learning approach is needed that is appropriate to the characteristics of rural students' learning environments. This research is important as an effort to provide alternative learning strategies that not only improve mathematics learning outcomes but also encourage active student engagement and positive attitudes toward mathematics in conditions of limited educational resources.

Therefore, this study aims to examine the effectiveness of the Realistic Mathematics Education approach in improving mathematics learning outcomes of Grade 7 students in a rural secondary school in Zambia. The effectiveness of the approach is evaluated based on three indicators: students' mathematics achievement, student learning activities, and student responses to the learning process. This study is expected to contribute empirical evidence on the applicability of Realistic Mathematics Education in rural African contexts and provide practical insights for mathematics teachers seeking innovative instructional strategies to enhance learning quality.

2. RESEARCH METHOD

2.1. Research Design

This study employed a quasi-experimental research design using a one-group pretest–posttest model [23], [24]. The design was selected to examine the effectiveness of the Realistic Mathematics Education approach in improving students' mathematics learning outcomes in a rural school context where random assignment and the use of a control group were not feasible. The research design allowed for the comparison of students' learning performance before and after the implementation of the Realistic Mathematics Education-based instruction.

2.2. Research Setting and Participants

The study was conducted in a rural public secondary school in Zambia during the 2023/2024 academic year. The participants consisted of 26 Grade 7 students, comprising both male and female learners, who were enrolled in one intact classroom. The school was selected purposively to represent typical characteristics of rural schools in Zambia, including limited instructional resources and students' strong reliance on real-life experiences from their surrounding environment.

2.3. Instructional Treatment

The instructional treatment involved the implementation of the Realistic Mathematics Education approach in teaching mathematics topics related to set theory. The learning process was designed based on the core principles of Realistic Mathematics Education, namely guided reinvention, progressive mathematization, didactical phenomenology, and the use of self-developed models. Learning activities were initiated through contextual problems closely related to students' daily experiences in rural settings, such as community activities, household practices, and local environments [25], [26]. Students were encouraged to explore, discuss, and construct mathematical concepts collaboratively under the guidance of the teacher.

2.4. Research Instruments

The data in this study were collected using four types of research instruments. The first instrument was an essay-based mathematics learning achievement test used as a pretest and posttest to measure students' understanding of mathematical concepts before and after the implementation of Realistic Mathematics Education-based learning. The test items were structured based on learning objectives and validated by mathematics education experts before use. The second instrument was a learning implementation observation sheet used to assess the quality of the Realistic Mathematics Education approach implementation during the learning process, including the organization of learning, the use of contextual problems, student engagement, and the teacher's role in facilitating learning. The third instrument was a student activity observation sheet used to record student engagement during learning, including participation in problem-solving, group discussions, question-and-answer sessions, and conclusion-drawing activities. The fourth instrument was a student response questionnaire given at the end of the learning to determine students' responses to Realistic Mathematics Education-based learning, which consisted of closed-ended statements with the answer options "agree" and "disagree" [27], [28].

2.5. Data Collection Procedures

The data collection procedure in this study was carried out in three stages. The first stage was the preparation stage, which included the preparation of learning tools, teaching materials, and the development and validation of research instruments before the study was conducted [29], [30]. The second stage was the implementation stage, beginning with a pretest to measure students' initial mathematical abilities. Next, Realistic Mathematics Education-based learning was implemented over several class meetings. At this stage, observations were also made of the implementation of the learning and student learning activities [31], [32]. The third stage was the final stage, which was carried out after the entire learning series was completed. At this stage, a posttest was given to measure student learning outcomes, then a student response questionnaire was distributed to obtain students' perceptions of the learning process that had been implemented.

2.6.`Data Analysis Techniques

Data analysis in this study was conducted using descriptive statistical methods [33], [34]. Learning effectiveness was evaluated based on three main indicators: mathematics learning outcomes, student learning activities, and student responses to learning. Mathematics learning outcomes were analyzed by comparing pretest and posttest scores, and calculating the average value, percentage of learning completion, and normalized gain (N-gain) score. Student learning activities were analyzed based on the percentage of active student engagement during the learning process. Meanwhile, student responses were analyzed by calculating the percentage of positive responses to items in the questionnaire. The learning process was declared effective if the average posttest score reached the minimum completion criteria, the N-gain score was in the at least moderate category, the level of student learning activity was in the good category, and student responses to Realistic Mathematics Education-based learning were dominated by positive responses.

3.   RESULTS AND DISCUSSION

3.1. Students' Mathematics Learning Outcomes

Students' mathematics learning outcomes were measured using a pretest and posttest administered before and after the implementation of the Realistic Mathematics Education approach. The descriptive statistics of students' pretest and posttest scores are presented in Table 1.

Table 1. Descriptive Statistics of Students' Pretest and Posttest Scores

Test	N	Minimum	Maximum	Mean
Pretest	26	35	65	48.27
Posttest	26	60	90	76.54

Table 1 shows that the mean pretest score was relatively low, indicating limited initial understanding of mathematical concepts among Grade 7 students in the rural Zambian school. After the implementation of Realistic Mathematics Education-based instruction, the mean posttest score increased substantially, exceeding the minimum mastery criterion. This improvement indicates that the Realistic Mathematics Education approach had a positive effect on students' mathematics achievement.

The findings of this study indicate that the implementation of the Realistic Mathematics Education approach had a positive impact on students' mathematics learning outcomes in a rural Zambian secondary school. As shown in Table 1, the substantial increase in the mean score from the pretest to the posttest demonstrates that students' conceptual understanding improved after participating in Realistic Mathematics Education-based instruction. This improvement suggests that learning activities grounded in real-life contexts helped students make meaningful connections between abstract mathematical concepts and their everyday experiences.

To further examine learning improvement, normalized gain (N-gain) scores were calculated. The distribution of students' N-gain categories is presented in Table 2.

Table 2. Distribution of Students' Normalized Gain (N-gain) Scores

N-gain Category	Number of Students	Percentage
High (g ≥ 0.70)	9	34.62%
Moderate (0.30 ≤ g < 0.70)	14	53.85%
Low (g < 0.30)	3	11.53%
Total	26	100%

As shown in Table 2, most students (88.47%) achieved moderate to high normalized gain scores. This finding suggests that the majority of students experienced meaningful improvement in their understanding of mathematics concepts after participating in Realistic Mathematics Education-based learning activities.

Further evidence of learning effectiveness is provided by the analysis of normalized gain scores presented in Table 2. The majority of students achieved moderate to high N-gain categories, indicating that the improvement in learning outcomes was not only statistically visible but also educationally meaningful. This finding supports the core principle of Realistic Mathematics Education, which emphasizes progressive mathematization, where students gradually develop formal mathematical understanding from contextual problem situations.

3.2. Student Learning Activities

Student learning activities were observed during the implementation of Realistic Mathematics Education-based instruction. The observation focused on students' participation in contextual problem-solving, group discussions, asking questions, and presenting solutions. The summary of student activity observations is presented in Table 3.

Table 3. Student Learning Activity Observation Results

Activity Indicator	Percentage (%)	Category
Participating in contextual problem-solving	82.69	Good
Engaging in group discussions	80.77	Good
Asking and answering questions	76.92	Good
Presenting ideas and conclusions	78.85	Good
Average	79.81	Good

Table 3 indicates that students demonstrated a high level of active participation during the learning process. The average activity percentage falls within the "good" category, suggesting that Realistic Mathematics Education successfully promoted student-centered learning in the rural classroom context.

Student engagement during the learning process also contributed significantly to the observed learning improvement. As summarized in Table 3, students demonstrated a high level of active participation across various learning activities, including contextual problem-solving, group discussions, and the presentation of ideas. Active involvement in these activities aligns with constructivist learning theory, which posits that knowledge is constructed through interaction and social negotiation. In rural classroom settings, where conventional instruction often limits student participation, the Realistic Mathematics Education approach appears to provide a more inclusive and engaging learning environment.

3.3. Student Responses

Students' responses toward the Realistic Mathematics Education-based learning approach were collected using a questionnaire administered after the instructional treatment. The results of student responses are summarized in Table 4.

Table 4. Student Responses toward Realistic Mathematics Education-Based Instruction

Response Category	Percentage (%)
Positive Response	88.46
Negative Response	11.54

The results in Table 4 show that the majority of students responded positively to the implementation of Realistic Mathematics Education. Students reported that learning mathematics through real-life contexts was more interesting, easier to understand, and more relevant to their daily experiences in rural environments.

In addition to cognitive and behavioral outcomes, students' affective responses toward learning mathematics were notably positive. The student response data presented in Table 4 show that a large proportion of students expressed favorable attitudes toward Realistic Mathematics Education-based instruction. These positive responses indicate that contextual learning not only enhanced students' understanding but also increased

their motivation and confidence in learning mathematics. Such affective improvements are particularly important in rural educational contexts, where negative perceptions of mathematics can hinder students' long-term engagement with the subject.

Overall, the findings of this study are consistent with previous research reporting the effectiveness of Realistic Mathematics Education in improving students' mathematics achievement, learning activity, and motivation. However, this study extends the existing literature by demonstrating that Realistic Mathematics Education can be effectively implemented in a rural African context with limited instructional resources. By integrating locally relevant contexts into mathematics instruction, Realistic Mathematics Education offers a practical and culturally responsive approach to improving mathematics education in rural secondary schools.

Despite these promising results, the study has limitations that should be acknowledged. The use of a one-group quasi-experimental design without a control group limits the generalizability of the findings [35], [36]. Additionally, the relatively small sample size restricts broader conclusions. Future research is recommended to involve comparative groups, larger samples, and longitudinal designs to further examine the long-term impact of Realistic Mathematics Education on students' mathematical understanding and problem-solving skills.

The findings of this study have several important implications for mathematics education practice, particularly in rural secondary school contexts. The improvement in students' learning outcomes and active participation, as reflected in the learning achievement and activity results, indicates that the Realistic Mathematics Education approach can serve as an effective instructional alternative to conventional teacher-centered methods [37], [38]. By utilizing real-life contexts familiar to students, Realistic Mathematics Education enables learners in rural settings to engage more meaningfully with mathematical concepts despite limited access to instructional resources.

From a pedagogical perspective, the positive student responses toward Realistic Mathematics Education-based instruction suggest that mathematics teachers in rural schools should consider integrating contextual problem-based learning into their daily teaching practices [39], [40]. The use of locally relevant examples, such as community activities and everyday situations, can enhance students' motivation and reduce negative attitudes toward mathematics. These findings imply that teacher professional development programs in Zambia should include training on Realistic Mathematics Education principles and strategies to support effective classroom implementation.

In terms of curriculum development, the results of this study imply that contextual and realistic learning approaches are compatible with the goals of mathematics education in developing countries [41], [42]. Curriculum designers and policymakers may consider incorporating Realistic Mathematics Education-oriented learning activities and materials into national mathematics curricula, particularly for lower secondary levels. Such integration could help bridge the gap between formal mathematical content and students' real-life experiences, especially in rural and under-resourced schools.

Improvements in students' mathematics learning outcomes after implementing the Realistic Mathematics Education approach demonstrate that learning that links mathematical concepts to students' real-life experiences can reduce the material's abstraction, particularly in rural school contexts. The everyday context used in learning allows students to gradually build conceptual understanding through a process of progressive mathematization. This finding reinforces the view that mathematics is more easily understood when presented as a human activity close to students' social and cultural realities, rather than simply a collection of symbols and formal procedures.

In addition to cognitive improvements, the high level of student learning activity during Realistic Mathematics Education-based learning demonstrates the success of this approach in creating student-centered learning [43], [44]. Students' active involvement in group discussions, contextual problem-solving, and the delivery of ideas and conclusions reflects a shift in students' roles from passive recipients of information to active learners. This aligns with constructivist theory, which emphasizes that knowledge is constructed through social interaction and meaningful learning experiences. In the context of rural schools that tend to still employ conventional learning, Realistic Mathematics Education has been shown to encourage more inclusive participation and interaction in learning [45], [46].

Students' positive responses to Realistic Mathematics Education-based learning also indicate that this approach impacts not only conceptual understanding but also affective aspects. Students' interest and comfort in participating in real-world context-based mathematics learning demonstrates increased motivation and confidence in learning mathematics. This is crucial because negative attitudes toward mathematics are often a barrier to learning success, particularly in environments with limited facilities and learning resources.

The findings of this study also make a significant contribution to the mathematics education literature by demonstrating that the Realistic Mathematics Education approach can be implemented effectively even in environments with limited learning resources. Utilizing local contexts and students' daily experiences as primary learning resources demonstrates that quality mathematics learning does not always depend on the availability of sophisticated media or technology [47], [48]. With appropriate lesson planning, teachers can optimize the surrounding environment as a meaningful and relevant learning tool.

Overall, the results of this study confirm that Realistic Mathematics Education is an adaptive and contextual approach to improving the quality of mathematics learning in rural schools. This approach has the potential to be a relevant pedagogical solution to bridge the learning quality gap between schools in rural and urban areas. Therefore, the application of Realistic Mathematics Education needs to be considered more broadly in the development of teacher learning and training policies, especially in areas with limited educational resources [49], [50].

Based on the findings and limitations of this study, several recommendations for future research can be proposed. Future studies are encouraged to employ experimental or quasi-experimental designs with control groups to allow for stronger causal inferences regarding the effectiveness of Realistic Mathematics Education. In addition, research involving larger samples and multiple rural schools would enhance the generalizability of the findings across different educational contexts in Zambia and other Sub-Saharan African countries.

Furthermore, future research may explore the long-term impact of Realistic Mathematics Education on students' higher-order thinking skills, such as problem-solving, reasoning, and mathematical communication. Investigating the integration of Realistic Mathematics Education with digital learning tools or community-based learning activities could also provide valuable insights into innovative instructional strategies that address the challenges of rural mathematics education.

4. CONCLUSION

This study investigated the effectiveness of the Realistic Mathematics Education approach in improving mathematics learning outcomes of Grade 7 students in a rural secondary school in Zambia. Based on the results of the pretest and posttest analysis, the implementation of Realistic Mathematics Education led to a substantial improvement in students' mathematics achievement, with most students achieving the minimum mastery criterion and demonstrating moderate to high normalized gain scores. These findings indicate that Realistic Mathematics Education is effective in enhancing students' conceptual understanding of mathematics.

In addition to cognitive learning outcomes, the study revealed positive behavioral and affective impacts of Realistic Mathematics Education-based instruction. Students showed high levels of active participation during learning activities and expressed predominantly positive responses toward the learning process. The use of contextual problems related to students' daily experiences in rural environments contributed to increased engagement, motivation, and confidence in learning mathematics.

Overall, this study concludes that Realistic Mathematics Education is a feasible and effective instructional approach for mathematics learning in rural secondary school contexts in Zambia. Despite limitations related to research design and sample size, the findings provide empirical evidence supporting the use of contextual and student-centered learning approaches to improve mathematics education in under-resourced settings. The results of this study may serve as a reference for teachers, curriculum developers, and policymakers seeking to enhance the quality of mathematics instruction in rural schools.

REFERENCES

[1] 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, Mar. 2024, doi: 10.54371/jiip.v7i3.3455.

[2] M. Jamil, N. Muhammad, and M. Aslam, "Critical Thinking Skills Development: An Analysis of Mathematics Curriculum 2006 (Grade-wise)," *Glob. Soc. Sci. Rev.*, vol. IX, no. I, pp. 22–29, Mar. 2024, doi: 10.31703/gssr.2024(IX-I).03.

[3] K. Kadonsi, "Developing Mathematical Resilience: Effective Strategies to Alleviate Mathematics Anxiety among Secondary School Students in Kalomo District, Zambia.," *Int. J. Res. Innov. Soc. Sci.*, vol. IX, no. VI, pp. 1630–1665, 2025, doi: 10.47772/IJRISS.2025.906000131.

[4] O. E. Onoshakpokaiye and A. H. E, "Science, Technology and Mathematics Education: A roadmap to Economic growth and Sustainable Development of the developing nations," *Indones. J. Educ. Math. Sci.*, vol. 6, no. 2, pp. 59–69, May 2025, doi: 10.30596/ijems.v6i2.23902.

[5] C. C. Tibane, O. M. Mafa-Theledi, T. P. Masebe, and M. Peter, "Challenges Experienced by Mathematics Teachers in the Implementation of Grade 12 Mathematics Curriculum in Community Learning Centres: South African Perspective," *Int. J. Learn. Teach. Educ. Res.*, vol. 23, no. 7, pp. 141–166, Jul. 2024, doi: 10.26803/ijlter.23.7.8.

[6] Z. H. Mavumba, E. A. Mtitu, and M. Ogondiek, "Implementation of Learner-Centred Teaching and Learning Approaches in Advanced Mathematics in Secondary Schools in Tanzania: Achievements and Challenges," *J. Issues Pract. Educ.*, vol.

11, no. 2, pp. 49–65, 2019, doi: 10.61538/jipe.v11i2.847.

[7]   R. Rathnayake and G. Jayakody, "On Intuition of the Concept of Limit: Real-life Examples Given by Secondary Mathematics Teachers," *Int. J. Res. Educ. Sci.*, vol. 9, no. 1, pp. 241–265, 2023, doi: 10.46328/ijres.3098.

[8]   Ş. Namli, "Comparing Ninth-Grade Students' Approaches to Trigonometric Ratio Problems Through Real-World and Symbolic Contexts," *Int. Educ. Stud.*, vol. 17, no. 4, pp. 70–84, 2024, doi: 10.5539/ies.v17n4p70.

[9]   A. Hendriyanto *et al.*, "The didactic phenomenon: Deciphering students' learning obstacles in set theory," *J. Math. Educ.*, vol. 15, no. 2, pp. 517–544, 2024, doi: 10.22342/jme.v15i2.pp517-544.

[10]   R. Darmayanti, "Lecturer vs. Practitioner: How is collaborative class assessment for math learning?," *Delta-Phi J. Pendidik. Mat.*, vol. 1, no. 1, pp. 58–64, Oct. 2023, doi: 10.61650/dpjpm.v1i1.37.

[11]   R. C. I. Prahmana, "Ethno-Realistic Mathematics Education: The promising learning approach in the city of culture," *SN Soc. Sci.*, vol. 2, no. 12, p. 257, Nov. 2022, doi: 10.1007/s43545-022-00571-w.

[12]   N. T. Da, "Realistic mathematics education and authentic learning: A combination of teaching mathematics in high schools," *J. Math. Sci. Teach.*, vol. 3, no. 1, p. em029, 2023, doi: 10.29333/mathsciteacher/13061.

[13]   S. Sevinc and R. Lesh, "Preservice mathematics teachers' conceptions of mathematically rich and contextually realistic problems," *J. Math. Teach. Educ.*, vol. 25, no. 6, pp. 667–695, Dec. 2022, doi: 10.1007/s10857-021-09512-5.

[14]   R. S. F. Iskandar and D. Juandi, "Study Literature Review: Realistic Mathematics Education Learning on Students' Mathematical Creative Thinking Ability," *SJME (Supremum J. Math. Educ.*, vol. 6, no. 1, pp. 35–42, 2022, doi: 10.35706/sjme.v6i1.5739.

[15]   G. Tessema, K. Michael, and S. Areaya, "Pre-service mathematics teachers' mathematization process in solving geometry problems," *Discov. Educ.*, vol. 4, no. 1, p. 358, Sep. 2025, doi: 10.1007/s44217-025-00551-1.

[16]   N. T. H. Duyen and N. P. Loc, "European Journal of Educational Research," *Eur. J. Educ. Res.*, vol. 11, no. 3, pp. 1245–1257, 2022.

[17]   F. R. Nashrullah, R. Rochmad, and A. N. Cahyono, "Mathematical Critical Thinking Abilities of Students in Terms of Self-Regulated Learning in Realistic Mathematics Education Assisted By Mobile Learning," *Mathline J. Mat. dan Pendidik. Mat.*, vol. 8, no. 3, pp. 1035–1056, Aug. 2023, doi: 10.31943/mathline.v8i3.469.

[18]   A. N. M. T. Lubis, W. Widada, D. Herawaty, K. U. Z. Nugroho, and A. F. D. Anggoro, "The ability to solve mathematical problems through realistic mathematics learning based on ethnomathematics," *J. Phys. Conf. Ser.*, vol. 1731, no. 1, p. 012050, Jan. 2021, doi: 10.1088/1742-6596/1731/1/012050.

[19]   K. Kadonsi, "Addressing Gender Disparities in Mathematics Achievement: A Case Study of Rural Schools in Kalomo District, Zambia," *Int. J. Res. Innov. Soc. Sci.*, vol. IX, no. IV, pp. 3282–3309, 2025, doi: 10.47772/IJRISS.2025.90400237.

[20]   K. Kadonsi, M. K. Kenneth, and S. Magdalene, "Exploring Mathematics Teachers' Attitudes towards Indigenizing Pedagogies in Mathematics Education in Southern Province, Kalomo; Zambia," *Int. J. Res. Innov. Soc. Sci.*, vol. VII, no. X, pp. 1931–1955, 2023, doi: 10.47772/IJRISS.2023.701148.

[21]   E. Mohammadpour and H. Yon, "Mathematics achievement at rural and urban secondary schools: a trends analysis," *Math. Educ. Res. J.*, vol. 37, no. 4, pp. 709–742, Dec. 2025, doi: 10.1007/s13394-024-00511-2.

[22]   C. C. Tibane, M.-T. O. Neo, M. T. Phanuel, and M. Peter, "Examining the Effect of Resource Constraints on Teaching and Learning of Grade 12 Mathematics in Gauteng Community Learning Centres," *Int. J. Learn. Teach. Educ. Res.*, vol. 23, no. 10, pp. 453–474, Oct. 2024, doi: 10.26803/ijlter.23.10.22.

[23]   A. Muse and J. M. Baldwin, "Quasi-Experimental Research Design," in *The Encyclopedia of Research Methods in Criminology and Criminal Justice*, Wiley, 2021, pp. 307–310. doi: 10.1002/9781119111931.ch61.

[24]   Y.-H. Lai *et al.*, "Impacts of Huddle Intervention on the Patient Safety Culture of Medical Team Members in Medical Ward: One-Group Pretest-Posttest Design," *J. Multidiscip. Healthc.*, vol. 16, pp. 3599–3607, Nov. 2023, doi: 10.2147/JMDH.S434185.

[25]   J. Morris, E. Slater, M. T. Fitzgerald, G. W. Lummis, and E. van Etten, "Using Local Rural Knowledge to Enhance STEM Learning for Gifted and Talented Students in Australia," *Res. Sci. Educ.*, vol. 51, no. S1, pp. 61–79, Sep. 2021, doi: 10.1007/s11165-019-9823-2.

[26]   K. Silseth and O. Erstad, "Exploring opportunities, complexities, and tensions when invoking students' everyday experiences as resources in educational activities," *Teach. Teach. Educ.*, vol. 112, p. 103633, Apr. 2022, doi: 10.1016/j.tate.2022.103633.

[27]   F. Al Nabhani, M. Bin Hamzah, and H. Abuhassna, "The role of artificial intelligence in personalizing educational content: Enhancing the learning experience and developing the teacher's role in an integrated educational environment," *Contemp. Educ. Technol.*, vol. 17, no. 2, 2025, doi: 10.30935/cedtech/16089.

[28]   G. Lampropoulos, E. Keramopoulos, K. Diamantaras, and G. Evangelidis, "Integrating Augmented Reality, Gamification, and Serious Games in Computer Science Education," *Educ. Sci.*, vol. 13, no. 6, p. 618, Jun. 2023, doi: 10.3390/educsci13060618.

[29]   E. Ediyanto, A. Sunandar, R. S. Ramadhani, and T. S. Aqilah, "Sustainable Instrument Development in Educational Research," *Discourse Commun. Sustain. Educ.*, vol. 13, no. 1, pp. 37–47, Jun. 2022, doi: 10.2478/dcse-2022-0004.

[30]   S. Ličen, M. Cassar, L. Filomeno, A. Yeratziotis, and M. Prosen, "Development and Validation of an Evaluation Toolkit to Appraise eLearning Courses in Higher Education: A Pilot Study," *Sustainability*, vol. 15, no. 8, p. 6361, Apr. 2023, doi: 10.3390/su15086361.

[31]   S. Sutrisno and J. A. Nasucha, "Islamic Religious Education Project-Based Learning Model to Improve Student Creativity," *At-tadzkir Islam. Educ. J.*, vol. 1, no. 1, pp. 13–22, Oct. 2022, doi: 10.59373/attadzkir.v1i1.3.

[32]   A. Yuliansyah and M. Ayu, "the Implementation of Project-Based Assignment in Online Learning During Covid-19," *J. English Lang. Teach. Learn.*, vol. 2, no. 1, pp. 32–38, 2021, doi: 10.33365/jeltl.v2i1.851.

[33]   Y. S. Ningsih, M. Mulia, and A. H. Lubis, "Development of Picture Storybooks with TheoAnthropoEco Centric Approach for Elementary School Students," *AL-ISHLAH J. Pendidik.*, vol. 15, no. 2, pp. 1888–1903, Apr. 2023, doi:

10.35445/alishlah.v15i2.2817.

[34] A. Gumantan, R. A. Nugroho, and R. Yuliandra, "Learning During the Covid-19 Pandemic: Analysis of E-Learning on Sports Education Students," *J. Sport Area*, vol. 6, no. 1, pp. 66–75, Feb. 2021, doi: 10.25299/sportarea.2021.vol6(1).5397.

[35] N. Marjamaa *et al.*, "Feasibility and Preliminary Outcomes of a Digital Intervention for Gaming-Related Problems and Well-Being: A Quasi-Experimental Study," *NAD Nord. Stud. Alcohol Drugs*, vol. 0, no. 0, pp. 1–20, 2025, doi: 10.1177/14550725251394129.

[36] S. Chen *et al.*, "Communication Skills Training to Improve Confidence and Skills in Pediatric Cancer Truth-Telling of Registered Nurses: A Quasi-Experimental Study," *Psychooncology.*, vol. 34, no. 7, Jul. 2025, doi: 10.1002/pon.70215.

[37] A. Yohannes and H.-L. Chen, "The effect of flipped realistic mathematics education on students' achievement, mathematics self-efficacy and critical thinking tendency," *Educ. Inf. Technol.*, vol. 29, no. 13, pp. 16177–16203, Sep. 2024, doi: 10.1007/s10639-024-12502-8.

[38] M. S. Islam, M. S. Sarker, S. S. Abir, F. Kamal, and B. K. Roy, "Effect of Student-Centered Teaching Approach on Academic Performance in Mathematics at the Secondary School Level," *IJORER Int. J. Recent Educ. Res.*, vol. 5, no. 6, pp. 1492–1505, Dec. 2024, doi: 10.46245/ijorer.v5i6.715.

[39] N. A'la and E. Elizar, "The relationship between mathematical literacy and the realistic mathematics education approach: A systematic literature review," *Beta J. Tadris Mat.*, vol. 18, no. 1, pp. 49–66, 2025, doi: 10.20414/betajtm.v18i1.696.

[40] Siswantari, S. S. Sabon, N. Listiawati, Y. Wirda, Zulkardi, and B. Riyanto, "Bridging mathematics and communication: Implementing realistic mathematics education principles for skill development," *J. Math. Educ.*, vol. 16, no. 2, pp. 729–752, Jul. 2025, doi: 10.22342/jme.v16i2.pp729-752.

[41] A. L. Palinussa, J. S. Molle, and M. Gaspersz, "Realistic mathematics education: Mathematical reasoning and communication skills in rural contexts," *Int. J. Eval. Res. Educ.*, vol. 10, no. 2, pp. 522–534, 2021, doi: 10.11591/ijere.v10i2.20640.

[42] N. Hakim, A. Apriyanto, M. Mardiati, and E. Sitepu, "Implementation of the Realistic Mathematics Education (RME) Approach in Geometry Learning in Secondary Schools," *Aksioma Educ. J.*, vol. 1, no. 3, pp. 17–30, Sep. 2024, doi: 10.62872/rgn3w339.

[43] K. Koerunnisa *et al.*, "The Influence of a Realistic Mathematical Approach on Student Learning in Elementary Schools," *J. Math. Instr. Soc. Res. Opin.*, vol. 4, no. 1, pp. 105–114, 2024, doi: 10.58421/misro.v4i1.282.

[44] R. Hayati, A. Asmayanti, and W. Prima, "Revitalizing Math Education: Unveiling the Impact of Holistic Mathematics Education Based 'Sistem Among' in Elementary Classrooms," *AL-ISHLAH J. Pendidik.*, vol. 16, no. 2, pp. 2454–2463, Jun. 2024, doi: 10.35445/alishlah.v16i2.4926.

[45] X. Wang, G. W. Young, M. Z. Iqbal, and C. M. Guckin, "The potential of extended reality in Rural Education's future – perspectives from rural educators," *Educ. Inf. Technol.*, vol. 29, no. 7, pp. 8987–9011, May 2024, doi: 10.1007/s10639-023-12169-7.

[46] M. Cevikbas and G. Kaiser, "Student Engagement in a Flipped Secondary Mathematics Classroom," *Int. J. Sci. Math. Educ.*, vol. 20, no. 7, pp. 1455–1480, Oct. 2022, doi: 10.1007/s10763-021-10213-x.

[47] O. O. Okoji and M. A. Olubayo, "Assessment of Availability and Utilization of Instructional Resources for Teaching Primary School Mathematics in Ilorin Metropolis, Nigeria," *African J. Educ. Stud. Math. Sci.*, vol. 17, no. 2, pp. 1–12, Feb. 2022, doi: 10.4314/ajesms.v17i2.1.

[48] J. Engelbrecht and M. C. Borba, "Recent developments in using digital technology in mathematics education," *ZDM – Math. Educ.*, vol. 56, no. 2, pp. 281–292, May 2024, doi: 10.1007/s11858-023-01530-2.

[49] S. Papadakis, M. Kalogiannakis, and N. Zaranis, "Teaching mathematics with mobile devices and the Realistic Mathematical Education (RME) approach in kindergarten," *Adv. Mob. Learn. Educ. Res.*, vol. 1, no. 1, pp. 5–18, 2021, doi: 10.25082/AMLER.2021.01.002.

[50] M. A. Tashtoush, Y. Wardat, R. AlAli, and S. Saleh, "Artificial Intelligence in Education: Mathematics Teachers' Perspectives, Practices and Challenges," *Iraqi J. Comput. Sci. Math.*, vol. 5, no. 1, pp. 60–77, 2024, doi: 10.52866/ijcsm.2024.05.01.004.