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**PRACTITIONER JOURNAL OF MATHEMATICS TEACHERS IN STEM
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About the Journal

Practitioners Journal of Teachers in STEM Education (PJTSE) is a publication of the Centre for Mathematics, Science and Technology Education in Africa (CEMASTEА). It is a Journal for teachers and by teachers that aims at publishing original work in the form of theories, research, models, and experiences that teachers can draw from to support curriculum implementation and improve practice in Science, Technology, Engineering and Mathematics (STEM). This is in line with the aspirations inherent in the Kenya Vision 2030, particularly in the Education and Training sector of the Social Pillar.

The importance of STEM education in today's rapidly evolving world cannot be overstated. STEM disciplines shape how we live and interact with our environment and fuel innovation and progress. The CEMASTEА Practitioner Journal of Mathematics and Science Teachers (PJTSE) proudly present a platform for sharing STEM research and classroom practices. The journal also provides teachers a platform to connect with colleagues from different schools and regions, fostering community and collaboration within the education sector.

STEM research is a gateway to understanding and addressing the most pressing challenges of our time. Through investigation and inventive thinking, STEM researchers unravel the mysteries of the universe, create groundbreaking technologies, and drive economic growth. This Journal celebrates the tireless efforts of teachers and teacher trainers who explore uncharted territories and redefine the boundaries of human knowledge in STEM education.

PJTSE is a peer-reviewed journal that employs a double-blind review process. The following editorial Board members and technical officers support publishing the PJTSE.

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Editorial

Welcome to the Practitioners Journal of Teachers in STEM Education (PJTSE). Initiated by CEMASTEА, the Journal provides a platform for STEM teachers to document and share their classroom experiences and pedagogical innovations. It highlights successes, challenges, and lessons learned, creating a vibrant space for professional growth. Each article represents a meaningful step toward teaching excellence and celebrates the dedication of our teachers.

The Journal fosters cross-disciplinary dialogue, bridging gaps between STEM fields and inspiring new ways of thinking. Each issue features practical case studies, emerging ideas, and reflections that speak to the realities of classrooms and teacher development. Our goal is to provide readers with relevant and actionable insights that enhance practice.

To enrich perspectives and strengthen our professional community, the PJTSE showcases contributions from diverse teachers and education practitioners. Together, their voices present a holistic view of STEM education and its role in addressing contemporary classroom challenges. As we advance, let us continue to embrace discovery, collaboration, and innovation.

We invite readers to share feedback and contribute articles to make the Journal a dynamic space where shared knowledge transforms practice. Plans are underway to transition PJTSE to an Online Journal System (OJS) platform, with ISSN registration in progress. This fourth Issue of the PJTSE is published on CEMASTEА's Website and e-Portal.

On behalf of CEMASTEА, I wish you inspiring reading of Volume 4, Issue 1. We welcome continued contributions from educators, trainers, and practitioners to sustain this collective journey of professional excellence.

Mrs. Jacinta L. Akatsa, HSC

CEO, CEMASTEА

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Student errors and misconceptions in learning secondary school mathematics: insights from Teacher Professional Appraisal and Development (TPAD) classroom experiences in Kenya

By Zaituni Otindo Ali

Abstract Student errors and misconceptions are a common phenomenon in the mathematics classroom, often impeding conceptual understanding and academic achievement. It is therefore important for teachers to possess the ability to identify and address such errors and misconceptions effectively using appropriate strategies in the course of curriculum implementation. This article presents an exploration of how mathematics teachers identify and respond to students' errors and misconceptions in teaching and learning secondary school mathematics in Kenya. The Teacher Professional Appraisal and Development (TPAD) framework fosters reflective teaching practices while equipping teachers with pedagogical tools to diagnose and address misconceptions. This paper draws from classroom experiences and insights derived from TPAD records of lesson observations, informal conversations, and document analysis. Findings indicate that teachers developed a clear understanding of students' errors and misconceptions, enabling them to design and apply effective instructional strategies to mitigate learning challenges. The study recommends that TPAD prioritize teacher development in diagnostic assessment and remedial practice and enhance pedagogical content knowledge to address gaps in student understanding. Moreover, TPAD can evolve from a performance evaluation system to a transformative tool for teacher growth and improved mathematics learning outcomes.

Keywords: *Student Achievement, Errors, Student Misconceptions, classroom experiences.*

1.0 Introduction

Mathematics serves as a fundamental discipline in secondary education, essential for cultivating logical reasoning, analytical thinking, and problem-solving competencies. However, persistent

student errors and misconceptions present a significant barrier to effective learning and academic achievement. Recent studies show that such errors often arise from conceptual misunderstandings or procedural inaccuracies, and if not systematically addressed, they can hinder learners' confidence and progress (Lin, 2024). In Kenya, the Teacher Performance Appraisal and Development (TPAD) framework provides a structured mechanism for educators to enhance pedagogical practices through lesson observations, reflective appraisal, and professional development (Teachers Service Commission [TSC], 2016). Given TPAD's emphasis on evidence-based improvement, this study explored how secondary mathematics teachers use the framework to identify, analyze, and correct student errors.

2.0 Review of related literature

2.1 Student Errors

Student errors and misconceptions in mathematics remain a persistent focus of educational research due to their implications for learning. Misconceptions reflect inconsistent conceptualizations of mathematical ideas, while errors stem from slips in reasoning or flawed execution (Hoth, 2022). Addressing these issues systematically is essential for developing deep mathematical understanding (National Council of Teachers of Mathematics [NCTM], 2020). Recent classroom-practice studies highlight the value of leveraging errors as diagnostic tools that help teachers uncover learners' thinking and adjust instruction responsively (Köpfer, 2022; Boström & Palm, 2023). This aligns with formative-assessment approaches that reframe misconceptions as opportunities for remediation and growth (Adhikari et al., 2023).

2.2 Common Student Challenges

Mathematical errors may be due to numerous elucidations like pace of work, the slip of a pen, slight lapse of attention, lack of knowledge or a misunderstanding. Some of these errors could be foreseen prior to a lesson and tackled at the planning stage to unravel the possible misconceptions. This can be done if the teacher has sound subject content knowledge and knowledge of what the misconception might be why these errors may have occurred and how to unravel the difficulties for the child to continue learning (Brodie, 2020). The first step for the teacher in error analysis is to correctly identify the specific errors revealed in students' work.

2.3 Lack of Knowledge

In Kenyan secondary schools, students' mathematical errors often stem from limited English proficiency, the official language of instruction (KICD, 2017). Effective mathematics teaching requires skillful bilingual communication to enhance conceptual understanding (Mbugua et al., 2020). The Competency-Based Curriculum emphasizes mathematical discourse for problem-solving (KICD, 2021), yet language barriers persist, leading to procedural, factual and conceptual errors (Mwangi & Wambugu, 2022), particularly in word problem interpretation (KNEC, 2023)

2.4 Procedural Errors in the Kenyan Context

Procedural errors in mathematics refer to mistakes that arise from incorrect application of mathematical rules, algorithms, or problem-solving procedures (KICD, 2017). In Kenyan secondary schools, these errors frequently manifest in various forms, including the misapplication of BODMAS rules in arithmetic operations (KNEC, 2022), misalignment of decimal points during calculations (Mwangi, 2021), and improper algebraic manipulation techniques (MoE, 2020). Such errors often reflect deeper learning challenges, including an overreliance on rote memorization without conceptual understanding (KEMI, 2019), insufficient practice of mathematical procedures (KNEC, 2023), and language barriers that hinder comprehension of mathematical instructions (Muthwii et al., 2020). Recent analyses of the Kenya Certificate of Secondary Education (KCSE) examinations reveal that procedural errors account for approximately 42% of all mathematical errors (KNEC, 2023). This high prevalence underscores the need for targeted instructional strategies to enhance procedural fluency. The Competency-Based Curriculum (CBC) addresses this challenge by emphasizing step-by-step problem-solving approaches, regular practice of mathematical processes, and the verbalization of solution methods (KICD, 2021). By integrating these strategies, the CBC aims to foster a deeper procedural understanding and reduce the frequency of such errors in Kenyan classrooms.

2.5 Factual Errors

Factual errors occur when students lack essential factual knowledge, such as mathematical vocabulary, terms, digit identification, place value, or formulas. These mistakes often arise from an inability to recall necessary facts or apply fundamental rules correctly (Ginsburg, 1987, as

cited in University of Kansas, n.d.). While such errors may not always indicate a deep conceptual misunderstanding, they frequently stem from memory lapses, insufficient automaticity in basic facts, or cognitive impulsivity (Geary et al., 2020). Recent studies highlight that weak retrieval of arithmetic facts—often due to inadequate practice or working memory limitations—can significantly hinder problem-solving accuracy (Szűcs & Myers, 2017; Peng et al., 2022). Additionally, students with math learning difficulties (MLD) are particularly prone to factual errors, as they may struggle with rapid fact recall despite understanding underlying concepts (De Visscher et al., 2018).

2.6 Poor Attention and Carelessness by the Learner

Mathematical errors frequently arise from students' lapses in concentration and careless mistakes during problem-solving processes (Lai, 2012; Mwangi & Kamau, 2023). Current research in Kenyan secondary education reveals that attention-related errors constitute approximately 20% of preventable mistakes in mathematics assessments (KNEC, 2023). These errors commonly appear in several forms, including computational slips such as sign errors or incorrect transcription of numbers, omission of essential solution steps, and misinterpretation of problem requirements resulting from hasty reading.

The underlying causes of these attention deficits are complex and multidimensional. Classroom environmental factors, particularly in overcrowded learning spaces, significantly contribute to student distraction (Ochieng' & Were, 2022). Additionally, cognitive overload occurs when learners face excessively complex problems without adequate preparation (KEMI, 2021). Perhaps most crucially, many students lack effective self-monitoring techniques to identify and correct their own mistakes (Ngugi et al., 2023).

2.7 Student Misconceptions in mathematics

Misconceptions lead to errors, but how are Misconceptions generated? Constructivist theory proposes that learners actively construct knowledge based on their prior knowledge in order to build new knowledge. The existing schema develops conceptual knowledge through the processes of accommodation and assimilation. When new knowledge merge into the existing schema then the experience is assimilation (Block, 2020). On the other hand, in case of conflict of new knowledge with the existing schema then accommodation occurs. This therefore, prompts

reorganization of the schema so as to incorporate the new knowledge (Gardee & Brodie, 2015). Furthermore, there is need for learners to be actively involved in the learning process so as to construct knowledge as well as reorganize this knowledge into a more powerful schema.

3.0 The Role of TPAD in Addressing Errors

In Kenya, the Teacher Performance Appraisal and Development (TPAD) system was introduced by the Teachers Service Commission (TSC) to promote accountability and enhance instructional quality. TPAD emphasizes self-assessment, classroom observation, lesson preparation, and professional development (TSC, 2016). It provides a structured framework for teachers to reflect on their practice and improve their ability to support learners effectively. Emerging studies suggest that TPAD can be a valuable tool for continuing professional learning. Ong'ondo and Ramani (2018) highlight that teacher using TPAD engage more critically with lesson planning and assessment, leading to improved classroom practices. However, there is limited empirical evidence on how TPAD specifically supports the identification and correction of mathematical errors and misconceptions. This study aims to fill that gap by exploring how mathematics teachers, within the context of TPAD, identify and respond to student errors based on their day-to-day classroom experiences.

4.0 Methodology

4.1 Research Design

This study employed a qualitative case study design to explore how mathematics teachers in secondary schools identify and address student errors and misconceptions within the framework of the Teacher Performance Appraisal and Development (TPAD) system. A case study approach was appropriate because it enabled an in-depth exploration and comprehension of real classroom practices in a natural setting, capturing teachers' live classroom experiences and contextual responses to students' learning challenges (Creswell & Poth, 2018; Yin, 2018).

4.2 Selection of study participants

The research was conducted in one public secondary school in Kenya, purposefully selected based on its active engagement with TPAD processes and the availability of experienced mathematics teachers. Four teachers of mathematics participated in the study. The teachers were

selected through purposive sampling to ensure they had been employed by the TSC and had attained at least two years of teaching experience and demonstrated familiarity with TPAD implementation in their teaching practice (Patton, 2015).

4.3 Participants' Demographic Characteristics

A total of four secondary mathematics teachers of both genders were involved in the study, two female and two male trained teachers. Three were first degree holders (Bachelor of Education) with teaching experience between 5 and 10 years. On the other hand, one was a Master's degree in Education holders with teaching experience of over 15years. Moreover, all participants have attended mathematics workshop and seminars in their course of their teaching which confirms that the teachers were all qualified to effectively implement the mathematics curriculum.

4.4 Data collection Methods

Several data collection strategies were employed, namely; interviewing the mathematics teachers, classroom lesson observation, informal conversations and document analysis. The multiple methods employed made it possible to triangulate the data and enrich the findings.

4.5 Classroom observations

Each participating teacher was observed in two mathematics lessons. The observations focused on how teachers identified student errors, responded to misconceptions, and integrated TPAD-informed strategies during instruction. Observation notes were guided by a semi-structured observation protocol aligned with TPAD indicators, since classroom observation is a widely used qualitative data collection method for capturing authentic teaching and learning practices in natural settings (Creswell & Poth, 2018; Merriam & Tisdell, 2016).

4.6 Interview

In-depth interviews were conducted with each teacher to gather their perspectives on student errors and the role of TPAD in shaping their responses. The interviews explored their diagnostic strategies, instructional decisions, and reflections on classroom experiences.

Informal conversations

Informal follow-up conversations took place after lessons to clarify specific teacher actions observed during class. These conversations provided immediate context and added insight into teachers' thinking processes.

4.7 Document analysis

Relevant documents, including lesson plans, TPAD self-appraisal forms, and samples of student work, were reviewed. These documents provided evidence of planning, assessment practices, and professional development reflections related to the identification and correction of student errors.

5.0 Data Analysis

Data was analyzed thematically using color coding. Observation notes, interview transcripts, and documents were first coded manually, and recurring themes were identified. Themes categorized as: types of student errors, strategies for error detection, corrective measures, and the influence of TPAD on teaching practice. Triangulation across data sources ensured consistency and enhanced the validity of the findings.

6.0 Findings

The presentation of the findings is systematically arranged according to themes developed from the data and other issues emerging from this study. The themes were organized as follows:

6.1 Strategies for identification of students' errors and misconceptions

Teachers' view on errors was evaluated during the interviews and this was an important data to enable explore how much information or the teachers understanding of errors. This is due to the assumption that for a teacher to be in a position to identify errors then understanding the types of errors student make is crucial. Moreover, this would also put the teacher in a good position to handle errors in the classroom. These strategies were aligned with TPAD standards, particularly in areas relating to lesson delivery, learner assessment, and feedback.

Illustrations and presentations on the board

Teacher RT1 explained that voluntary presentation on the board by learners is an avenue of identifying students' errors. He said;

Especially when I give work on the board so the students who volunteer to solve on the board, can exhibit those mistakes and those misconception from their working, I get to know the error and manage that and make a plan how to going assist. (RT 1, Personal communication, 27th May,2025).

During class observation, I noticed that when a student volunteered to present a question on the board as the others students observed keenly. The student made some error in the scaling of the

axes and there by the teacher asked other students to comment on the error on the scale and it was noted, rectified and the teacher explained clearly. Therefore, it was evident that the teacher noted the error in the presentation.

6.2 Verbal Responses and Probing Questions

Data from observation show that teachers also listened carefully to student explanations, asking follow-up questions to uncover conceptual misunderstandings.

6.3 Marking Students work

Data from the interviews and document analysis indicated that teachers are able to identify errors during the marking of students' quizzes, tests and assignments. This was also evident in document analysis as the teacher noted the error when marking and highlighted feedback in the students exercise book. The teachers' remarks were as follows:

“During individual assignment if you check their excise books individually, when you mark their work and then you can observe the errors “(RT 4, Personal communication)

6.4 Addressing students' errors and misconceptions

Student self-correction

Data from the interviews and class observation revealed that teachers encourage self-correction of errors by learners through probing to stimulate the learner's thinking and reasoning to rectify own mistakes. This helps the learner to slowly understand and come to terms with the wrong answer and be able to correct the misconception. Teachers explained how they handle errors in their classroom instruction as follows:

You need to be very attentive and patient because when they are presenting their work actually, they make some errors, therefore, you need to probe up to the level that they realize their mistake and correct them that is a nice way (RT 3, personal communication)

It was also observed in an instance when a student was invited to illustrate a question on the board and made an error of operation of signs in a solving simultaneous. The answer given as 3 was correct despite an error in the working; the teacher probed the learner to explain the working to the class. This gave the learner an opportunity to identify the mistake and hence made correction to obtain the right answer, thus reinforce correct thinking.

Teacher: Solve the simultaneous equation: $3x + 2y = 12$

$$x - 2y = -4$$

Student: Solution: Eliminating x

$$(3x + 2y = 12) \times 1$$

$$(x - 2y = -4) \times 3$$

$$3x + 2y = 12$$

$$3x - 6y = -12$$

Subtract the equations

$$3x - 3x + 2y - (-6) = 12 - (-12)$$

$$0 + -8y = 24$$

$$\frac{-8y}{-8} = \frac{24}{-8}$$

$$y = 3$$

Substitute: y in equation (ii)

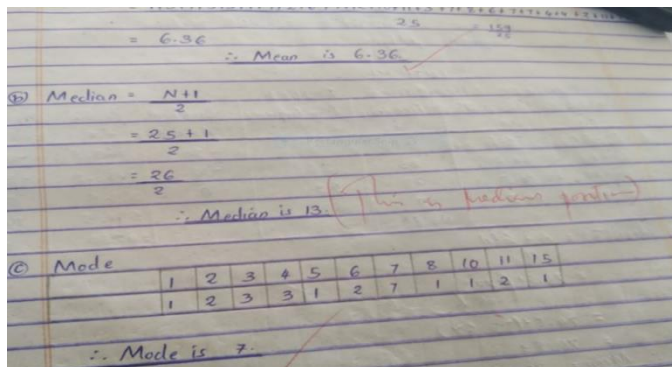
$$x - 2y = -4$$

$$x - 2(3) = -4$$

$$x - 6 + 6 = -4$$

$$x = 2$$

Figure 1: Student illustration on the board in class (Lesson for RT 3)



6.5 Varying teaching approaches

Varied teaching methods was highlighted for instance, remedial sessions (Reteaching), repeating exercise done, writing down questions on given concepts as a way of exposing students to many exercises and questions to enable the students to practice and rectify errors. Moreover, TPAD encourages integrating ICT in the lesson delivery which may show step by step illustration to correct misunderstanding.

Another teacher highlighted that learner should also exposed to problem solving by involving the learners in coming up with questions individually in the area of difficulty. This enables the students to be versed with the concepts of difficulty.

6.6 Review of teaching techniques

Data from the interviews and class observations indicate that, teachers address errors immediately when they occur during class instruction. They stop and be able to emphasize on the correct way of calculating. However, teacher RT 4 argued that it is also vital for the teacher to evaluate and reflect on the pedagogy used in the delivery. This is to indicate that the teachers approach of instruction may also contribute to errors. In their views they said:

Sometimes I can observe myself that the way I present students didn't understand therefore next time I have to rejuvenate myself so that find another way to ensure that the students can understand.....Now, you need to change yourself the way of teaching, your style of teaching (RT 4).

However, class observation, revealed that the teacher seemed to be the command and dominate class activities. The teacher further made an error in the illustrations during the lesson and continued with it to the end only to realize during confirmation but had to make immediate rectification of the error by going through the question again correcting the error made (Observation notes 16th May, 2025).

6.7 Peer correction

Some teachers encouraged students to explain concepts to their peers as a way of reinforcing correct thinking. This was also complementing the grouping of learners with mixed abilities to aid peer correction of errors.

These findings highlight the need for targeted instructional strategies that address both the environmental and cognitive aspects of mathematical problem-solving. Teachers must consider not only the mathematical content but also the learning conditions and students' metacognitive development to effectively reduce these attention-related errors. Recent pedagogical approaches emphasize the importance of creating focused learning environments while simultaneously developing students' self-regulation skills to enhance their mathematical precision and problem-solving accuracy.

7.0 Discussions

The findings of this study affirm the pivotal role that teachers play in diagnosing and addressing student errors in mathematics, a theme well-established in contemporary research (Bray, 2021; Smith & Stein, 2018). Aligning with recent work by Borasi et al. (2017) and Ashlock's (2016) updated framework, this study reinforces that student errors are not indicators of failure but productive catalysts for conceptual growth (Santagata & Yeh, 2019). Teachers leveraged TPAD-informed strategies to reframe mistakes as instructional opportunities, echoing Swan's (2015) assertion that errors serve as "cognitive stepping stones" (p. 42) and supporting Ansari's (2022) findings on targeted feedback in mathematics.

Teachers' use of real-time observation, probing questions, and formative assessments to identify and address misconceptions aligns with Halimah, Isa, and Zulkifli's (2024) systematic review of formative assessment practices, which emphasizes responsive teaching as a dynamic, iterative process. Their research demonstrates that immediate, feedback-driven adjustments to instruction are critical for addressing learner needs and fostering deep conceptual understanding (Wiliam, 2018). In this study, teachers' diagnostic approaches exemplified deliberate, formative practices, reinforcing the principles of responsive mathematics pedagogy (Hattie, 2017; Warshauer, 2015). These findings resonate with recent work on teacher noticing (Jacobs et al., 2021), which highlights how skilled educators interpret student thinking in the moment to guide instructional decisions.

Moreover, the study found that TPAD encouraged structured teacher reflection and intentional lesson planning, aligning with Kennedy's (2016) view that impactful professional development should be practice-based and student-centered. Teachers leveraged TPAD to assess instructional strategies and student learning, indicating its potential as a tool for professional growth when implemented supportively.

However, mirroring Wei, Chow, Huang, Huang, and Cheng's (2023) findings, effectiveness varied since some teachers used TPAD for meaningful improvement, while others treated it as

mere compliance. This disparity underscores the need for enhanced training and support to reinforce TPAD's developmental, rather than purely evaluative, role.

8.0 Conclusion

This study examined how mathematics teachers in Kenyan secondary schools identify and respond to student errors and misconceptions within the framework of the Teacher Performance Appraisal and Development (TPAD) system. The findings revealed that teachers actively used observation, formative assessments, and student engagement techniques to detect learning difficulties. They demonstrated an awareness of different types of errors: conceptual, procedural, and computational, and employed a variety of instructional responses including review of the teaching technique, re-teaching, peer support, and scaffolding.

Additionally, TPAD was found to play a positive role in promoting reflective teaching practices, with most teachers using it as a guide to improve their instructional strategies. These findings suggest that structured professional development systems like TPAD can enhance teacher effectiveness when well-aligned with classroom realities and teacher needs.

However, the study also identified inconsistencies in how teachers interpreted and utilized TPAD. While some engaged in reflective pedagogy, others treated it as a bureaucratic formality. This gap highlights the need for targeted support in building teachers' diagnostic and reflective capacities.

9.0 Recommendation

- i. The Ministry of Education and TSC should prioritize TPAD's role in instructional improvement over evaluation. Training should emphasize its use in diagnosing and addressing student learning gaps.
- ii. Pre-service and in-service programs should incorporate training on error analysis, formative assessment, and targeted misconception remediation in mathematics pedagogy. Schools should facilitate peer observation, lesson studies, and reflective forums to help teachers share and refine strategies for addressing student errors.
- iii. KICD and curriculum teams should develop practical guides on common mathematics errors and evidence-based teaching responses.
- iv. Further research should assess TPAD's influence on teaching practices across diverse schools to guide policy adjustments and implementation.

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Innovative Specimen Drying Approaches for Enhancing Biology Practicals in Modogashe Secondary School

By Pauline Wamuyu

Abstract A lack of reliable power supply in Modogashe Secondary School—due to the absence of connection to the national grid, old and dysfunctional solar panels, and erratic generator-based electricity—makes modern specimen preservation methods unfeasible. Similarly, the unavailability of common laboratory preservatives such as formalin has necessitated the development of alternative approaches to specimen preservation to enhance teaching and learning in Biology. This study investigated the effectiveness of three low-resource drying methods—direct sun drying, indoor drying, and sandwich drying—in preserving scorpions and camel spiders, which are abundant locally and suitable for observation due to their size and structural clarity. The experiment involved drying specimens for 24 hours under each method, with observations recorded on texture, size retention, and structural integrity. Findings showed that indoor drying produced the highest-quality specimens, retaining their original size, smooth texture, and structural integrity, while sun drying caused shrinkage and fragility, and sandwich drying required longer time to achieve full dryness. These results highlight indoor drying as a practical, cost-effective preservation method for schools lacking electricity and preservatives. The approach is easily adaptable to similar contexts and could be enhanced through longer drying periods, use of desiccants, and other environmental controls. Teachers in low-resource settings can apply indoor drying using mesh-covered petri dishes to maintain specimen integrity for effective practical lessons in Biology.

Keywords: *Camel spider, Scorpion, Indoor drying, Sun drying, Specimen preservation*

Introduction

Modogashe Secondary School, situated 160 km from Garissa town in Lagdera sub-county, faces significant infrastructural challenges that affect practical Biology teaching. The school is not connected to the national power grid, its existing solar panels are damaged, and its access to generator power from Wajir County is unreliable due to rationing and frequent damage to power lines—especially during the rainy and windy seasons. Additionally, daytime temperatures in the area can reach 41 °C, further complicating storage of biological specimens. In many schools,

formalin is the standard preservative for biological specimens (Zhao & Chen, 2021). However, formalin has limitations: its acidity can cause long-term tissue distortion, making it unsuitable for extended storage (Ndiaye et al., 2020). This challenge is compounded in rural schools where preservatives are often unavailable. Sun drying, one of the oldest preservation methods, offers a low-cost alternative. El-Nagar and Barkat (2019) describe it as a simple, energy-efficient technique requiring minimal equipment. According to Fouda et al. (2022), drying prolongs specimen shelf life by slowing chemical, enzymatic, microbiological, and physical reactions through water removal. However, Ismail and Gogus (2023) emphasize that drying method choice greatly influences the final quality of preserved materials. This study explores three innovative, low-resource drying approaches to identify the most effective method for preserving specimens for biology practicals in resource-constrained environments.

Methodology

Three scorpions and three camel spiders were collected locally, gently immobilized to prevent distortion, and placed in separate specimen bottles (A, B & C). The species were selected due to their abundance in the area and their large size, which facilitates detailed feature observation



Set A – Sun drying: Specimens placed in a petri dish, covered with steel mesh, and exposed to direct sunlight for 24 hours at an average temperature of 38 °C.

Set B – Indoor drying: Specimens placed in a mesh-covered petri dish inside the laboratory at an average temperature of 27 °C for 24 hours.

Set C – Sandwich drying: Specimens sandwiched between pages of a book and placed on a laboratory shelf for 24 hours.

All specimens were protected from predation using a mesh cover.

Results and Discussion

Table 1 shows physical changes observed in the specimens under different drying methods after 24 hours.

Table 1: Physical changes observed in the specimens under different drying methods

Drying Method	Drying Outcome	Breakability	Size Retention	Texture	Comments
Sun drying	Fully dried	Fragile; limbs broke	Shrunk	Rough	Fastest drying; distortion observed
Indoor drying	Fully dried	Intact; no breakage	Retained	Smooth	Best overall quality
Sandwich drying	Partially dried	Intact	Retained	Slightly compressed	Required a longer drying time

Direct sun drying caused dehydration leading to shrinkage and brittleness, likely due to rapid moisture loss creating unbalanced internal tension (Ismail & Gogus, 2023). Indoor drying preserved the specimens' structural integrity, size, and texture, making it the most suitable method for educational use. Sandwich drying retained structure but was less effective due to incomplete drying within the 24-hour period; however, it may be better suited for preserving plant specimens.

These findings align with previous literature on the importance of controlled drying to maintain structural quality (Fouda et al., 2022). Indoor drying proved effective without the need for specialized equipment, making it ideal for low-resource settings.

Conclusion and Recommendations

Drying is a viable, low-cost alternative to chemical preservation for biological specimens in schools with limited access to electricity and preservatives. Among the three tested methods, indoor drying emerged as the most effective, maintaining specimen quality critical for biology instruction.

Recommendations

- i. Schools in similar contexts should adopt indoor drying using mesh-covered petri dishes.

- ii. Further studies should examine extended drying periods, the use of desiccants, and simple environmental controls to enhance outcomes.
- iii. Teachers could experiment with these methods for different specimen types, including plants and small vertebrates, to broaden applicability.

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Instructional adherence and Learner autonomy: Effect on confidence, Self-esteem, and mathematics performance.

By George Soro

Abstract More often than not, learners are under the obligation to strictly adhere to the instructions as stipulated in the examination paper. The hallmark effect rests on the overall output after sitting the examination. This article explores the influence of examination instructional adherence versus autonomy on learners' motivation, self-esteem, and confidence in mathematics test performance. The article compares data from 15 K.C.S.E registered candidates over 10 test sessions with a complete mathematics paper 1 alignment. The first five test sessions were administered under conventional strict settings while the latter five were under liberal, self-directed task selection. The conclusive findings indicated that test environments promoting autonomy led to increased percentage scores attributed to confidence and psychological concentration, especially by low-performing learners. The study highlighted the importance of socially engaging assessment design in improving learning outputs in STEM education

Keywords: *Autonomy, Obligation, Self-esteem, Stratification, STEM.*

1.1 Introduction

Many learners face mathematics assessments that require strict adherence to predefined structures, regardless of their individual weaknesses and strengths. This often results in frustrations, anxiety, and low self-esteem—factors which hinder determination and resilience in academic performance, more so in mathematics. A consistent drop in academic performance lowers intrinsic motivation towards performing some tasks (Froiland, 2016). Learners who are anxious may be affected by time limits in mathematics tests more than those who are less anxious (Caviola et al., 2017). A strong sense of self-worth and confidence in one's ability can lead to greater motivation, better study habits, and ultimately higher scores (Alva & Manuel, 2017). While speed and accuracy are distinct cognitive abilities, rushing can lead to more errors, especially if the motivation to spend time on the task is low. Focusing on a smaller number of

problems allows for more deliberate and thorough work (Reunamäki, 2016). This article examines whether providing autonomy in assessment tasks can improve the learner's output in terms of scores.

Data were collected with permission from the participating school and learners in accordance with institutional ethical standards.

1.2 Objectives of the Article

- i. To compare the effects of teacher-centered instructional adherence versus learner-centered autonomy on mathematics learning outcomes.
- ii. To identify which approach (instructional adherence or learner autonomy) is a stronger predictor of learners' confidence, self-esteem, and mathematics performance.
- iii. To provide insights for educators and policymakers on balancing instructional adherence and learner autonomy to optimize learners' confidence, self-esteem, and mathematics performance.

2.1 Instructional oriented compliance to mathematics task solving

Five different sets of full paper 1 mathematics examination was administered on different days to some 50 learners registered for K.C.S.E. The duration of each paper was set at 2½ hours. Each paper was divided into two sections; section I which contained 16 questions while section II contained 8 questions. The strict instruction was that the learners were to do all the 16 questions in section I and 5 other questions in Section II. Each section was 50% and therefore upon scoring all the questions correctly, the learner would attain 100%.

After Each examination, the scripts were marked, the scores recorded and analyzed and later, the questions were revised before doing the next examination the following weekend. The table 1 below shows the scores attained by 15 learners who were picked randomly from the 50 learners registered in the class. The letters were used to represent the name of the learners.

Table 1*Scores under strict instructional adherence*

<i>Name</i> <i>Section</i>	<i>Test</i>														
	<i>Test 1</i>			<i>Test 2</i>			<i>3</i>			<i>Test 4</i>			<i>Test 5</i>		
	I	II	%	I	II	%	I	II	%	I	II	%	I	II	%
<i>A</i>	32	40	72	29	41	70	30	43	73	32	45	77	34	37	71
<i>B</i>	01	05	06	03	03	06	04	01	05	02	07	09	01	02	03
<i>C</i>	40	48	88	37	45	82	41	44	85	40	39	79	35	45	80
<i>D</i>	05	07	12	03	03	06	07	03	10	05	05	10	04	07	11
<i>E</i>	12	10	22	12	08	20	13	11	24	08	22	30	11	16	27
<i>F</i>	21	25	46	20	24	44	16	17	33	19	17	36	16	23	39
<i>G</i>	36	36	72	38	33	71	36	30	66	33	40	73	32	38	70
<i>H</i>	08	06	14	06	06	12	07	09	18	02	10	12	06	08	14
<i>I</i>	27	30	57	20	28	48	23	25	48	17	29	46	21	26	47
<i>J</i>	06	11	17	03	10	13	07	07	14	03	09	12	06	08	14
<i>K</i>	11	15	26	12	12	24	08	10	18	01	09	10	10	10	20
<i>L</i>	32	26	58	29	25	54	29	28	57	30	23	53	19	29	48
<i>M</i>	08	08	16	11	07	18	07	07	14	09	06	15	04	11	15
<i>N</i>	17	19	36	20	20	40	19	17	36	17	20	37	18	18	36
<i>O</i>	09	10	19	05	07	12	06	07	13	02	03	05	03	08	11
<i>MEAN</i>	37.4			34.6			34.3			33.6			33.7		

From the compiled results, it was realized that 10 out of 15 (67%) learners scored lower marks in the fifth test compared to the first test. 3 out of 15 candidates (20%) recorded a positive deviation while 2 out of 15 candidates (13%) remained static. All these happened despite the many test papers administered.

It was therefore evident that even with the increase in the number of mathematics examination test papers, most of the learners' score were not likely to deviate positively instead, majority of the learners would score either a constant result or a negative deviation. Again, consistent poor performance by some of the learners would turn out to be lowering intrinsic motivation and results into a low self-esteem and, withdrawal from the task (Kumar, 2017)

2.2 Liberal mathematics examination task solving approach.

Another five different sets of mathematics paper 1 examination were administered. However, the learners were left free to select the question and the number of questions to answer from any of the sections of the paper. After marking the scripts, the scores were compared to the trend of the first set of results. The table 2 below shows the new set of scores by the same learners under learner's autonomy system.

Table 2

Learner's autonomy task solving scores

Name	TEST 1			TEST 2			TEST 3			TEST 4			TEST 5		
	I	II	%	I	II	%	I	II	%	I	II	%	I	II	%
A	30	35	65	30	36	66	35	38	73	32	38	70	30	40	70
B	04	05	09	06	09	15	08	11	19	10	13	23	09	15	24
C	35	40	75	34	39	73	40	37	77	35	40	75	33	44	77
D	08	10	18	06	12	18	11	13	24	10	19	29	11	17	28
E	12	12	24	13	15	28	16	17	35	10	24	34	17	24	41
F	19	36	55	17	38	56	20	33	53	23	32	55	24	34	58
G	25	36	61	30	39	59	28	37	65	30	33	63	30	38	68
H	08	08	16	11	10	21	10	16	26	12	14	26	11	16	27
I	25	39	64	20	39	59	24	36	60	21	39	60	23	37	60
J	08	09	17	08	14	22	10	17	27	11	18	29	10	19	29
K	16	20	36	15	21	36	09	19	28	10	17	27	14	17	31

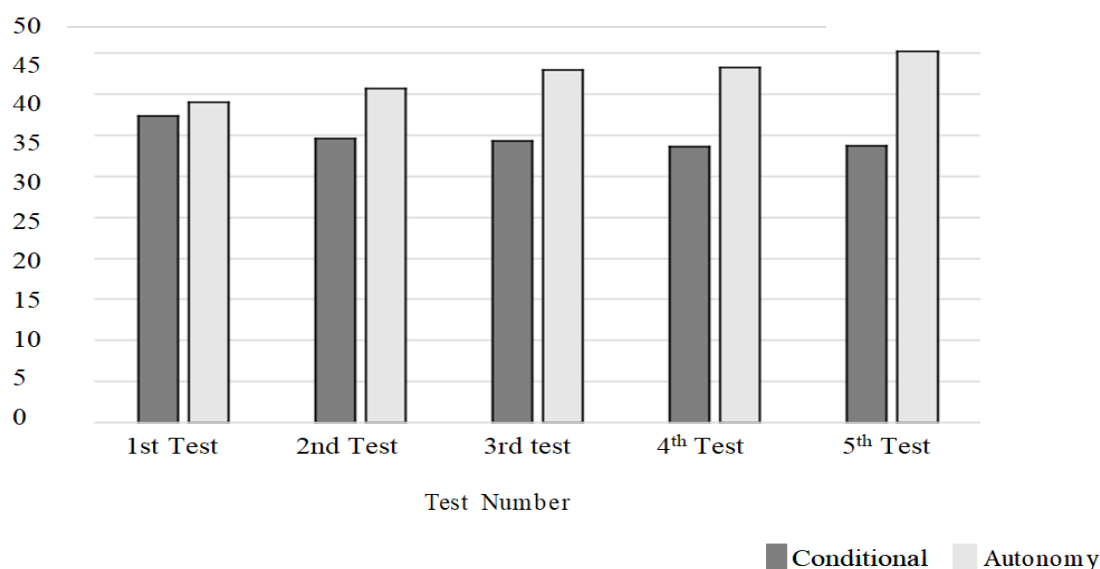
L	30	35	65	29	34	63	30	37	67	32	35	67	30	34	64
M	07	10	17	10	13	23	08	15	23	09	15	24	11	16	27
N	22	29	51	22	33	55	20	31	51	21	30	51	20	32	52
O	04	09	13	08	09	17	07	10	17	06	11	17	10	13	23
Mean			39.1			40.7			43.0			43.3			45.3

The results in table 2 above revealed that, 12 out of 15 candidates (80%) recorded a positive deviation when test 6 (first test) and test 10 (last test) were compared. 3 out of 15 learners (20%) declined and these 3 learners (A, C & G) decided to do all the 24 questions thereby limiting their chances of concentrating on fewer manageable tasks. On the other hand, the learners who decided to do fewer questions in both section I and II recorded a steady positive deviation.

The gross positive deviation in test mean scores was realized when majority of the learners were left at liberty to allocate more time to effectively focus on the tasks that they were more likely to answer accurately instead of rushing through all the questions to abide by the instructions given.

Figure 1

Comparative bar graphs for Mean Scores.



The graph above compares mean scores obtained through the learner's instructional adherence and, the learner's autonomy approach. The learner's autonomy test papers produced a gradual and steady positive deviation in the behavioral output which was measured in terms of the mean scores. The instructional adherence test papers showed no growth in the mean scores. Instead, there was a decline in the mean scores as the number of test papers was being increased. This may have been caused by low self-esteem, and a feeling of inadequacy.

3.0 Conclusion

The success or failure of the learning process borders on self-esteem, motivation, and academic engagement. The motivational system is an energizing catalyst that starts the action, and consistent poor results can significantly lower intrinsic motivation due to feelings of inadequacy, reduced self-confidence, and loss of interest in the subject or task. By choosing fewer tasks to solve, learners improve strategic time management and delve deeper into the task for better understanding, resulting in more correct answers. It is therefore incumbent upon teachers to minimize anxiety and stress by enabling learner autonomy in mathematics tasks. In a nutshell, the article aligns with social-emotional learning theory (Denham et al., 2019), which focuses on developing the skills, attitudes, and behaviors necessary for individuals to understand and manage their emotions, build healthy relationships, and make responsible decisions.

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Why Doesn't My Seat Vibrate? A Critical Incident Analysis in Teaching the Particle Model of Matter

By Dorcas G. Mwenda

Abstract This article reflects on a critical incident observed during a science lesson on the arrangement of particles in the states of matter. A learner's question about the apparent lack of "vibration" in their wooden classroom seat sparked a reflective examination of teaching approaches in conceptual science. Using a reflective practice approach, informed by theories of conceptual change and constructivism, the analysis draws from lesson observation, post-lesson teacher discussions, and collaborative reflection with peers. The incident is used to examine how such questions expose misconceptions and provide opportunities for deeper understanding. The findings underscore the need for teachers to proactively anticipate and effectively respond to learner curiosity using learner-centered approaches and purposeful questioning techniques. They also highlight the importance of applying conceptual-bridging strategies that connect abstract scientific ideas to learners' everyday experiences. The reflection underscores the importance of addressing learner misconceptions, harnessing questioning to foster scientific thinking, and embedding such skills in teacher professional development. The findings recommend integrating training on managing cognitive dissonance in science lessons into Continuous Professional Development (CPD) programs and encouraging school-based reflective lesson observation. They also emphasize the need to ensure adequate resource availability to support learners' conceptual understanding.

Keywords: *Critical incident, science misconceptions, conceptual change, learner questions, particle theory, teacher reflection.*

Introduction

As a teacher trainer specialising in in-service training for STEM teachers at the Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA), I support professional development aimed at improving classroom practice and learner outcomes. Following training for junior school teachers on leveraging virtual laboratories to reinforce

integrated science concepts, I undertook lesson observations to assess implementation in the field. This article focuses on one such lesson in a rural junior school, where the teacher was introducing the arrangement of particles and their behavior in solids, liquids, and gases.

Lesson Context and Curriculum Focus

The observed lesson aligned with the Competency-Based Education (CBE) Grade Eight Curriculum Designs of Kenya, within the strand on mixtures, elements, and compounds. Expected outcomes included describing particle arrangements and representing them visually. Learners were also expected to appreciate the significance of these arrangements. The teacher employed group work, Q&A, a video, and a **PhET** virtual simulation to illustrate particle behavior. Learners then worked in groups to draw the arrangements for solids, liquids, and gases, followed by class presentations. While the teacher covered arrangement, motion, spacing, and forces of attraction, the kinetic theory was not explored in detail.

The Critical Incident

While explaining that “particles in solids vibrate in fixed positions,” a learner asked, “Why is the wooden seat I am sitting on not vibrating?” This unexpected question—a textbook example of a critical incident (Tripp, 2012)—disrupted the lesson and challenged the teacher’s ability to translate microscopic theory into macroscopic reality. The question exposed a misconception—expecting visible vibration—rooted in everyday experiences (Scott, Mortimer, & Ametller, 2019).

Reflection and Analysis

Post-lesson reflections with participating teachers acknowledged the lesson’s strengths: strong content knowledge, good lesson pacing, and effective activities. However, the learner’s question dominated the discussion. Teachers noted the challenge of handling unexpected inquiries and the need to develop strategies for responding without derailing lessons. Literature (Brookfield, 2017; Jones & Taylor, 2021) suggests that such questions are not disruptions but opportunities for conceptual change (Chi & Menekse, 2023). In this case, the learner’s reasoning was logical—based on prior knowledge that vibrating objects (e.g., phones) produce visible or tactile effects—

but clashed with the scientific explanation. This highlights the importance of conceptual bridging—connecting microscopic theory to macroscopic phenomena using models, analogies, and demonstrations.

Implications for Practice

This incident demonstrates how learners process science content and the value of embracing challenging questions as formative assessment tools. Teachers should:

1. Anticipate common misconceptions and integrate strategies to address them.
2. Use critical incidents as triggers for inquiry-based learning.
3. Develop questioning techniques that draw out learners' reasoning before clarifying misconceptions.

Recommendations

1. Embed critical incident analysis into teacher Continuous Professional Development (CPD) programs to enhance reflective practice and problem-solving skills.
2. Establish collaborative lesson observation forums where teachers can share experiences, analyze practices, and exchange constructive feedback.
3. Provide access to high-quality simulations and physical models to help teachers make abstract concepts more concrete and relatable for learners.

Conclusion

A learner's question about a "non-vibrating" seat revealed a conceptual gap between everyday experience and scientific theory. Rather than seeing such incidents as disruptions, teachers should embrace them to foster curiosity and guide learners toward scientific reasoning. Embedding reflective practice and conceptual bridging strategies in teacher training can strengthen pedagogical content knowledge and improve science teaching outcomes.

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“Cracks in the Foundation: How Weak Foundation Skills Undermine Effective Teaching and Learning Mathematics”

By Dennis Ochieng’ Onyango

Abstract Mathematics plays a foundational and essential role in STEM education. It is the core enabler that support other disciplines, making the STEM education cohesive, rigorous and practical. Mastery of Mathematics empowers learners to innovate, analyze and solve complex challenges in STEM. This study investigates the influence of inadequate foundation skills on learners’ performance in Mathematics, highlighting the critical role these skills play in academic success. These skills include basic numeracy, number sense, mental arithmetic and logical reasoning which form the corner stone upon which higher level Mathematical understanding is built. When learners proceed to the next grade without developing these skills, they experience challenges in connecting related contents. This study is based on classroom observations, learner assessments and teacher interviews to identify specific ways in which the gaps in foundation skills are reflected in learner’s performance. The results indicate that these learners with inadequate foundation skills experience difficulty with understanding, often make errors during math calculations and have low confidence, affecting their motivation and engagement, resulting in poor academic results that lead to long-term disinterest in Mathematics. The study explores the implications of these findings for instructional practice, putting emphasis on early identification and bridging these gaps through differentiated teaching and re-teaching strategies. In general, the study highlights why it’s necessary for teachers to give priority on developing learners’ foundation skills to improve Mathematics performance, attitude and confidence.

Keywords: *Foundation Skills, Mathematics Performance, Instructional practice, Confidence and Attitude.*

1.0 Introduction

Mathematics remains a persistent challenge for many learners in today's classrooms, despite its foundational role in enabling success across Science, Technology, Engineering, and Mathematics (STEM) disciplines. As a core enabler, mathematics equips learners with essential skills such as logical reasoning, problem-solving, and quantitative analysis—skills that are vital not only for academic progression but also for effective participation in the modern world. Yet, mathematics is frequently associated with anxiety, low performance, and disinterest among learners, raising important questions about the root causes of these challenges.

Through years of classroom teaching, it has become increasingly evident that the difficulties learners face in mathematics are often not due to the complexity of the subject matter at their current grade level, but rather due to critical gaps in foundational skills that were never adequately developed in earlier years. These foundational skills—such as basic numeracy, number sense, mental arithmetic, and logical reasoning—are more than just early learning milestones. They are the cognitive tools upon which all future mathematical learning is built. When these skills are underdeveloped, learners struggle to make connections between concepts, apply strategies, or even comprehend mathematical instructions.

This issue is further exacerbated by the widespread practice of promoting learners to higher grades without confirming their readiness in terms of mathematical foundations. As a result, many learners enter middle and upper primary or secondary grades ill-prepared to engage with new content, leading to repeated failure, frustration, and a loss of confidence in their ability to succeed in mathematics. They become passive in class, avoid participation in problem-solving tasks, and often disengage entirely—both emotionally and academically. This cycle of struggle and discouragement becomes increasingly difficult to break as learners advance, creating long-term academic and psychological consequences.

The central problem addressed in this article, therefore, is the impact of inadequate foundational mathematical skills on learners' ability to effectively engage with and succeed

in higher-level mathematics. This gap not only compromises academic performance but also undermines learners' confidence, self-efficacy, and long-term interest in the subject. From this perspective, the article argues that foundational skill deficits should not be treated as isolated issues but as systemic barriers that require deliberate instructional attention and intervention.

Drawing from classroom observations, learner assessments, and teacher interviews, this article investigates the specific ways in which gaps in foundational skills are reflected in learner behavior and academic performance. It also explores the practical implications for mathematics instruction, particularly in the context of competency-based education (CBE), where strands are interlinked and learning is meant to be progressive.

By focusing on the classroom realities of mathematics instruction, this article seeks to empower educators with the insight and strategies needed to rebuild and strengthen learners' mathematical foundations. Addressing these foundational gaps is not a remedial step—it is an essential, proactive component of high-quality mathematics teaching. Strengthening these foundations will not only enhance learners' performance but also foster greater confidence, curiosity, and long-term engagement with mathematics and other STEM fields.

2.0 The Importance of Foundational Skills in Mathematics

From my experience as a mathematics teacher, I have come to recognize that learners' success in higher-level math is deeply rooted in the strength of their foundational skills. These include basic numeracy, number sense, mental arithmetic, and logical reasoning. Without these, students often struggle not just with complex problems, but even with understanding what a question is asking. Mathematics is not simply about memorizing formulas; it is a language of reasoning and patterns. Foundational skills serve as the grammar and vocabulary of this language. According to Siegler and Lortie-Forgues (2017), number sense and basic arithmetic fluency in early grades are strong predictors of later math achievement. When learners possess these skills, they can manipulate numbers flexibly and logically, allowing them to grasp more abstract mathematical concepts with confidence. In my classroom, learners who demonstrate fluency with basic operations and logical reasoning tend to approach problem-solving tasks with curiosity and confidence. On the other hand, those who lack these basics often show signs of anxiety and

avoidance, which affect their long-term academic development. For instance, I was using learners from grade 8 in marking a volleyball pitch for a friendly game. I gave them the measurements and told them that the lines must meet at 90° . I then sat back and watched as they carried out the activity and I realized that learners with fluency in logical reasoning were confident to take the lead as those with less skills watched. This clearly indicates that inadequate foundation skills not only affect their academic performance but also influence their general behavior outside class, especially when performing tasks that are mathematics related. They demonstrate low confidence and avoidance to such activities, as supported by Kim, Lee, and Lee (2021), who found that foundational math fluency significantly influences students' self-efficacy and engagement

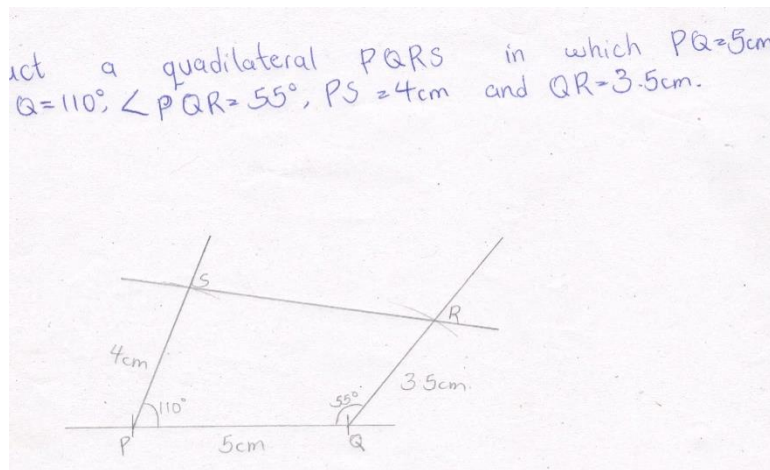
2.1 Challenges arising from inadequate foundation skills

Each academic year, I encounter learners who have advanced to the current grade without mastering essential prior knowledge. These learners typically struggle to connect new content with past learning, making even routine lessons frustrating. For instance, during a lesson on fractions, I noticed several learners unable to proceed with basic operations like finding equivalent fractions because they lacked understanding of division and multiplication facts. The consequences extend beyond academics. Learners with weak foundational skills often develop negative attitudes toward mathematics. They make frequent errors, even in simple tasks, and quickly lose motivation (Boaler, 2019). I've observed how this leads to a vicious cycle: poor performance reduces confidence, which further lowers engagement, resulting in even weaker outcomes. This issue is not isolated, research by Watts et al. (2017) highlights that early math achievement strongly predicts later success in higher-order mathematics, including algebra, due to the cumulative and hierarchical nature of mathematical knowledge.

All classroom observations, learner assessments, and examples of learner work referenced in this study were used with the informed consent of the learners. They were assured that their participation was voluntary, and their identities were kept confidential. The examples provided are used solely for educational and research purposes to improve instructional practices and do not include any identifying information.

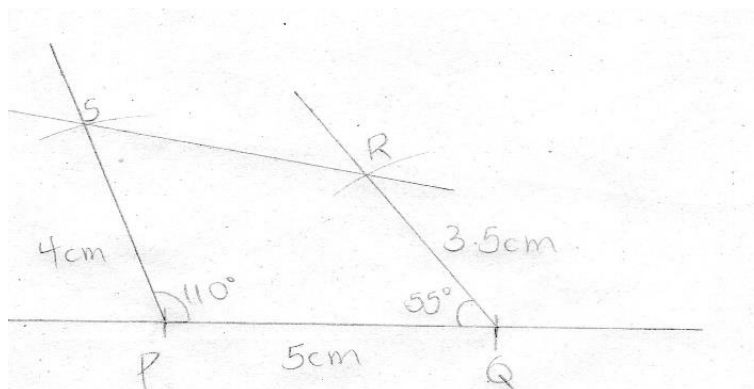
Critical incident: As a Mathematics teacher, I was teaching Grade 8 Mathematics on how to construct an irregular quadrilateral PQRS in which $PQ=5\text{cm}$, angle $SPQ=110^\circ$, angle $PQR=55^\circ$, $PS=4\text{cm}$ and $QR=3.5\text{cm}$. Below is a response of learner A.

Figure 1: Learner's response before re-teaching "the use of a protractor"



The above response from learner A was one of the many responses I received from the class, nearly 90% of the learners. Considering how angle PQR and SPR have been measured, it's a clear indication that the learner doesn't understand how to use a protractor. The learner is not aware when to use the outer or inner scale of the protractor, a concept taught in grade 5. This made my lesson difficult as I could not proceed further. If at least 90% of the learners were making this error, I can therefore conclude that the concept of "using a protractor" taught in grade 5 was not understood and therefore consequently affect their comprehension of advanced concepts (Sonnenschein et al., 2020). In my next lesson, I went back to grade 5 Mathematics and discussed with my learners how to measure angles using a protractor. The learners really appreciated the lesson and were seemingly understanding the concept. I asked them to re-do the previous work and most of them were able to get it right. Below is a response from learner B.

Figure 2: Learner's response after re-teaching "the use of a protractor"



Due to the spiral nature of the strands in CBE curriculum, a concept not understood in a given grade affects the learners' understanding of similar strands in other grades. Therefore teachers should find it easy to re-teach from lower grades in order to improve learners' foundation skills.

2.2 Insights from the Classroom: Observations and Evidence

My reflections are supported by informal and formal classroom assessments, alongside one-on-one conversations with learners. During a diagnostic test at the beginning of the term, I found that nearly 40% of my learners could not accurately perform operations with whole numbers—skills expected to be mastered in lower grades. Classroom observations further revealed that these learners relied heavily on counting fingers, used inefficient methods, or gave up entirely when presented with multi-step problems. Interviews with fellow teachers showed a shared concern about learners being promoted without foundational readiness, which creates learning gaps that are difficult to close later on as seen in the below excerpts.

My reflections are supported by informal and formal classroom assessments, alongside one-on-one conversations with learners. During a diagnostic test at the beginning of the term, I found that nearly 40% of my learners could not accurately perform operations with whole numbers—skills expected to be mastered in lower grades. Classroom observations further revealed that these learners relied heavily on counting fingers, used inefficient methods, or gave up entirely when presented with multi-step problems. Interviews with fellow teachers showed a shared concern about learners being promoted

without foundational readiness, which creates learning gaps that are difficult to close later on as seen in the below excerpts.

Figure 3: Excerpts from teachers' interviews

"I've had to stop mid-lesson to explain concepts like place value or multiplication facts that should have been mastered years earlier."— Teacher A, Grade 7 Mathematics

"The biggest challenge is time. The curriculum expects us to move on, but when almost half the class can't add or subtract properly, how do we teach fractions or algebra effectively?"— Teacher B, Grade 8 Mathematics

"It's heartbreaking when learners are labeled 'weak' in math, but the real issue is they missed something basic early on. With the right support, many start to improve and even enjoy the subject."— Teacher C, Grade 6 Mathematics

"You can see the difference in confidence between learners who have strong number sense and those who don't. The ones with gaps tend to hesitate, avoid answering questions, or give up entirely. It's not a matter of laziness — it's fear of being wrong."— Teacher D, Grade 5 Mathematics

"When I re-teach something from an earlier grade, some learners light up and say, 'Oh, now I get it!' That's when you realize how important it is not to assume prior

knowledge. Sometimes we have to go back to go forward." — Teacher E, Grade 8 Mathematic

These findings are supported by the work of Carpenter et al. (2017), who emphasize the need for teaching to build on learners' existing knowledge and address misconceptions early. In my experience, failing to do so results in surface-level learning and poor retention.

2.3 Strategies for Strengthening Foundational Skills

Addressing these challenges requires deliberate, targeted action. In my practice, I have adopted a strategy of early diagnostic assessments, followed by grouped re-teaching sessions. Learners with similar gaps are grouped and taught using concrete manipulatives and visual aids to reinforce basic concepts. This approach is consistent with differentiated instruction models (Tomlinson, 2021), which allow learners to progress from their current level rather than assuming a uniform starting point. Additionally, I integrate math talks and mental math exercises into daily routines to build fluency and encourage flexible thinking. These short, focused activities have helped learners improve not just their accuracy, but also their confidence in explaining their reasoning. Moreover, collaboration with parents and other teachers has proven vital. Sharing learner progress and involving guardians in home-based practice has supported consistency and reinforcement. As noted by Hattie (2018), teacher clarity and feedback are among the most powerful factors influencing student achievement. Ultimately, strengthening foundational skills is not an add-on, but a core aspect of effective mathematics teaching. When these skills are prioritized, learners show measurable improvements in understanding, participation, and enthusiasm for mathematics.

Conclusion

The experiences and reflections presented in this article affirm the indispensable role of foundational mathematical skills in shaping learners' academic journey and confidence. From classroom incidents to diagnostic assessments and peer discussions, the evidence is consistent: learners who lack mastery of basic numeracy, arithmetic operations, and logical reasoning are at a marked disadvantage—not only in their engagement with current topics but also in their long-term mathematical development. Through targeted interventions such as re-teaching earlier content, using concrete manipulatives, and embedding daily fluency-building activities, I have witnessed substantial improvement in learner performance and confidence. These approaches support the view that foundational

gaps are not simply obstacles to overcome but opportunities for meaningful instructional intervention. Importantly, the success of these strategies is rooted in understanding that learning is cumulative and that curriculum strands, especially within a competency-based framework, are deeply interconnected. This reflection also underscores the need for systemic attention to learner readiness and progression. Teachers must be empowered to assess, reteach, and adapt instruction based on actual learner needs rather than curricular pacing alone. Collaboration among educators, parents, and school leadership is essential to ensure consistent support and reinforcement of foundational concepts. Ultimately, strengthening foundational mathematical skills is not just a remedial task—it is a proactive, essential element of quality teaching. When learners are equipped with these skills, they are more likely to develop resilience, curiosity, and confidence in mathematics and beyond. As practitioners, we must continuously reflect on and respond to the foundational needs of our learners, recognizing that a strong mathematical base is the springboard for deeper understanding and lifelong learning.

Acknowledgements

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Number Puzzles: An Innovation in Teaching & Learning Mathematics.

By Stephen Muchiri Gitau

Abstract Learning of Mathematics in Kenyan secondary schools is affected by various factors which include lack of interest among learners in Mathematics, negative attitude towards the subject and continuous poor performance in mathematics examinations (KNEC, 2022).

The purpose of this article is to share my experience with my students in my 2024 Form 4 class. The article illustrates how teachers can use number puzzles to develop learners' positive attitude towards Mathematics and arouse interest by using innovative skills that enhance understanding of Mathematics and hence lead to improve in performance.

The critical incidence that sparked the process of developing number puzzles was when I requested Form 4 learners to search for Kenya certificate of secondary education (KCSE) past papers and solve some questions. I quickly noted how low performers easily took up tasks which previously in class they shied away from. Learners fought for an opportunity to present their findings. I requested them to write at least one question drawn from any topic and direct it to their peer who in turn presented his or her question in exchange. This created a multiplier effect. Then an idea struck me: What if we compiled the questions presented by the learners in form of a number puzzle similar to the crossword puzzles? An idea was born and we implemented it in groups. Continued use of number puzzles precipitated into an improved performance in KCSE Examination.

Key words: *Bloom's Taxonomy, Knowledge Construction, Number Puzzle, Performance.*

Introduction

The construction of number puzzles and their subsequent use in learning mathematics add to the hands-on and minds-on activities for learners.

The Number Puzzle finds relevance in learning Mathematics since it is learner driven. Learners identify a topic of their choice and use it as the basis of creating the puzzle which has both questions and answers.

This process enhances competencies such as critical thinking, collaboration, communication, problem solving, among others. These are the competencies advocated for in the new Competence Based Education (CBE). Further, the use of number puzzles requires and uses a combination of skills including: manipulative, cognitive, application, analysis and synthesis.

Theoretical frame works: Revised Bloom's taxonomy & knowledge construction and re-construction.

The Construction of Number puzzles is based on two theoretical frame works:

First, the revised Bloom's Taxonomy levels of learning which ranks creating and constructing knowledge at the highest level of learning, (Shabatura, 2022). Interestingly, all six levels of the revised Bloom's taxonomy are used in constructing number puzzles. These are: remembering (recall), understanding, applying, analyzing, evaluating and creating. Secondly, the theory of knowledge construction and re-construction. The process of constructing the number puzzles involves a lot of knowledge construction. Schön (2013) emphasized that knowledge is often constructed and evolved during the process of solving problems.

Knowledge construction and reconstruction basically refer to the active process where learners (students) build new knowledge upon their existing knowledge so as to develop new understanding (Saleem *et al.*, 2021). This involves integrating new information with prior knowledge, engaging in critical reasoning, and strategically using cognitive skills. It's not simply about absorbing information, but rather about actively creating meaning and developing new perspectives.

The learner must remember facts taught, understand them, apply them in coming up with the questions, do analysis of the best and most applicable question. Learner must evaluate the questions during the debugging stage, and finally create knowledge of his/her own through the process of developing and using Number Puzzles.

This article seeks to explain how number puzzles can be used to help learners create a positive attitude towards Mathematics, create Interest in Mathematics to the extent the learners can do a lot on their own and hence lead to an Improvement in performance in their examinations.

In this article we shall see the gaps filled by use of the number puzzle. First, we have learners who are books-shy but love digital-learning. When text books are used as the only learning resources for these learners, they perform poorly. Hence, number puzzles create a platform where the digital-loving learners work from. These learners find questions and answers and are able to present their final project. The challenge of encouraging learners who either have low interest in the mathematics or have a misconception that mathematics is difficult, have found a solution in the use of the number puzzle. Learners have an opportunity to show what they know and a “moment of success” when they complete number puzzles.

Through this article we have demonstrated the philosophy of a teacher as “facilitator” of learning and not “teaching” mathematics. The teacher guides the learners through the process and helps them in eliminating errors, corrects mis-understandings and any collisions in the work. The learner construct and re-constructs knowledge of what they have learnt. This greatly enhances their understanding of that particular concept. In this project I created my own puzzles, did a presentation and let learners’ critic my work. Learners also created their own puzzles, presented their work and I allowed other learners to critic the presented work.

The process of Constructing a Number Puzzle.

The process of Constructing a Number puzzle involves eight (8) steps.

Step 1: Topic/Sub-topic/Strand/Sub-Strand/combined topics/combined learning areas.

Identifying an area of interest for example a topic/strand, subtopic/sub strand or the entire syllabus. For, example a learner may choose the Topic: Equations of a line in Form 2 syllabus, with sub-topics: gradient of a straight line, equation of parallel lines. The learner will select the preferred questions.

Learners are also free to have the scope of their questions being from varied topics based on their level of study.

This level requires learners to use the lowest level of revised Bloom's taxonomy: Remembering (simple recall) and recognition of facts like the topics and sub topics or strand and sub strand.

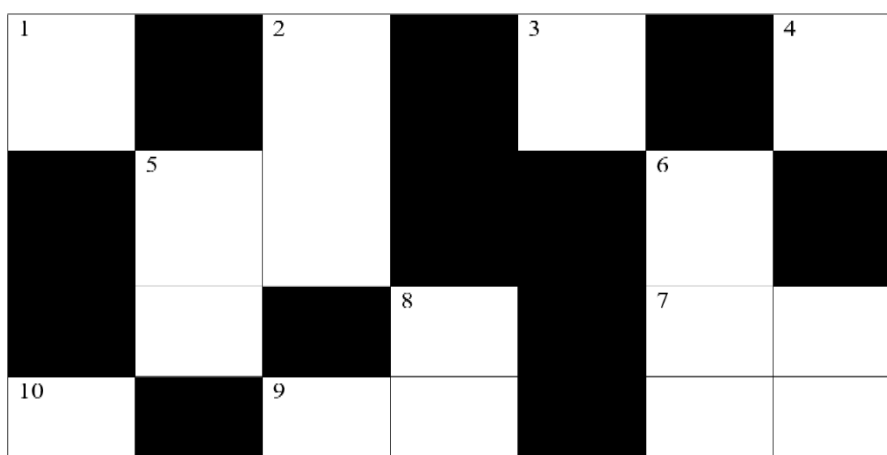
The main challenge I encountered at this level was that learners would choose their easiest topic and may tend to redo or overdo that topic. This was overcome by having the learners list all topic and tick on the ones already done, hence avoiding repetition of the same concept/topic.

Step 2: Laying the frame work of your puzzle box.

Laying the frame work of your puzzle box in terms of number of columns and rows to use. The learners sketched it out on a piece of paper using a pencil and a ruler. This enabled erasing and corrections to be done easily.

This level develops in learner's manipulative and cognitive skills where they design the picture of the overall result that they wish to create. A lot of collaboration is required when the students work in groups.

Figure 1. Sample frame work for a puzzle.



Step 3: Writing down the questions and working out the answers on paper.

Writing down the questions and working out the answers on paper. The learner will highlight the final answer and post it on a separate marking scheme.

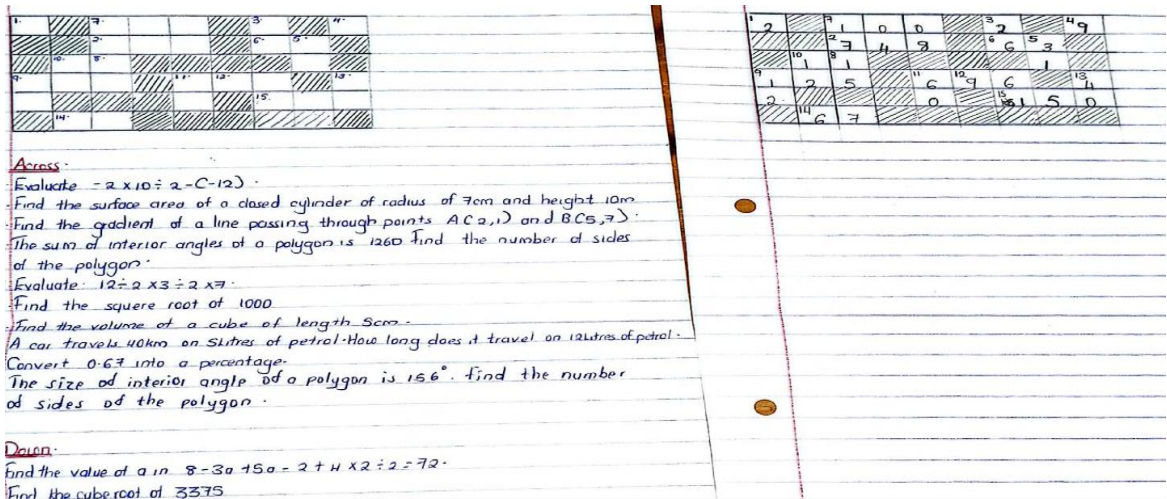
This level requires use the third level of Bloom's Taxonomy: Application, learners apply the facts, rules, concepts and ideas learnt in developing and solving questions which they place in the puzzle.

One major challenge experienced by learners is that if they worked in a small group may be of two, they often run dry of questions. This was solved by allowing the learners to work collaboratively as they sought questions and answers for their work.

Figure 2. A group of learners in their initial stages of developing their number puzzle.



Figure 3. A picture of learners' rough draft of questions and answers ready to be converted into soft copy.



Step 4: Keying in the work on Word processors or Spreadsheets (soft copy)

Keying in the work in a word processor such as Microsoft Word or a Spreadsheet such as Microsoft Excel and undertaking necessary adjustments. This level requires the use of fourth level of Bloom's taxonomy - Analysis. Here learners break down the questions and answers in suitable forms that fit either "Across" or "Down" the puzzle.

One challenge encountered at this level was that typing-in was time consuming for learners and this was solved by encouraging learners to type-in their work during free time after classes and on over the weekend.

Figure 4: A picture of students works after converting it into soft copy.

<u>Across</u>	<u>Down</u>
1. $X + 10 = 45$	1. $X/6 + 17 = 22$
2. $2m - 100 = 142$	3.. $6p + 50 = 800$
4.. $m^2 = 676$	4.. $7b - 12 = 128$
5.. $1/2x = 25$	6.. $n/8 = 64$

Figure 5: Picture of students work after automating the answer sheet.

PAWEL4: CROSS NUMBER PUZZLE

TOPIC: SOLUTION OF SIMPLE LINEAR EQUATIONS.

Instructions : 1. Every open box can hold only one integer only, for a two digit answer use two boxes and for three digit answer, use three boxes.
 2. Solve for the unknown value in each case and using that value fill in the box.

Question table						Answer Table					
1			2		3						
		4									
	5										
6			7								
		8			9						
10				11							

Across		Down	
1.	$X + 10 = 45$	1.	$X/6$
2.	$2m - 100 = 142$	3.	$6p + 50 = 800$

Step 5: Debugging.

This refers to the process of checking out for any errors. A mistake may arise due to wrong entry in rows or columns which may bring conflict of entries. Other sources of error/ mistake may come from wrong calculation of expected answer.

To overcome such challenges, learners were encouraged to do cross checking of their work with other groups. The teacher also guided learners on how to solve mistakes in their work.

This step uses the 5th level of Bloom's taxonomy: Evaluation. Here learners make judgements about the suitability of a question and whether it gives a correct answer without ambiguities or other possible answers.

Figure 6: picture of a teacher assisting a learner debug his work.



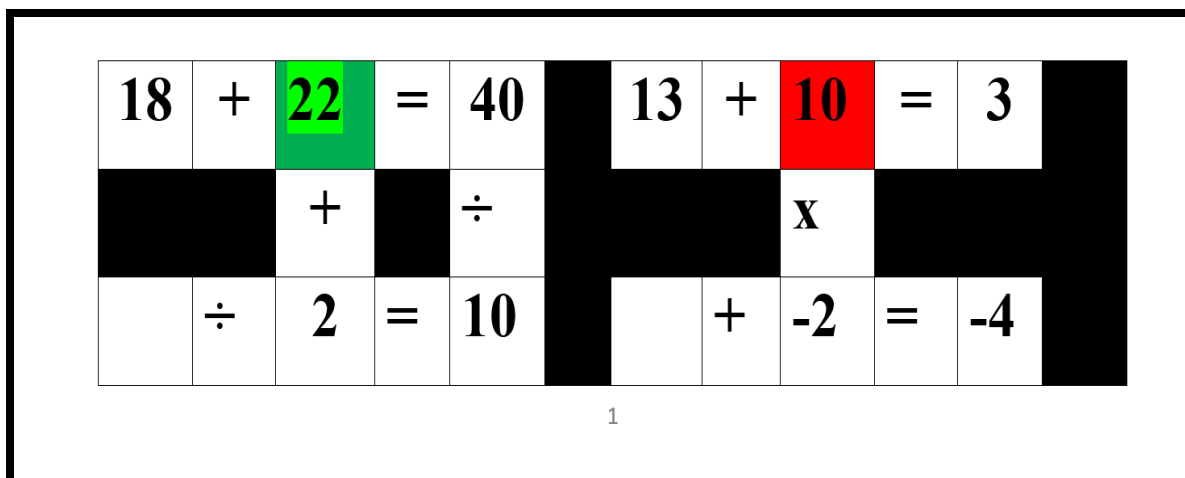
Step 6: Automating

This entails creating the settings where a correct answer in the answer button once entered shows “green colour” and a wrong answer show “red colour”. Here one challenge encountered was that not all learners were conversant with the Spreadsheet.

However, we overcome this problem by having learners train one another on the necessary skills required to do the automation.

This step uses the 6th level of Bloom’s taxonomy: Creating; we construct and re-construct knowledge from what has been learnt. The learners combine parts of their work to make a whole one item (Disch *et al.*, 2024).

Figure 7: A picture of the finished work of a learner that shows correct and a wrong answer.



Step 7: Gamifying

This entails converting the static work on the spreadsheet into a game with setting like: points earned option to have multiple-players with leader boards, etc. Further, learners may create User Interface (UI) by creating responses like: Congratulations, won! correct, Try again!

This level requires learners to have basic skills in Programming. However, it is not mandatory to have it as the soft copy games is enough.

Step 8: Commercialization-

This entails programming where the puzzle is uploaded on a website and other users are offered the chance to play the game after subscription to a website: Educational Resources Centre. This step is a higher order step for learners.

Conclusion

In conclusion, the development and use of Number Puzzles led to a remarkable improvement especially a shift in overall grade from lower grades to a higher one. The positive results had both qualitative and quantitative aspects. On qualitative aspect it, I noted that low performers who hardly answered questions in class, were the most active in presenting their projects. This shows that they had changed their attitude positively towards Mathematics and their level of Interest in solving Mathematics rose. They showed a lot of mastery in use of ICT devices like

projectors and desktop computers. This could be attributed by to the fact that they found learning using number Puzzles as full of fun, discovery and creativity. There was extended time learners engaged with one another, with the teacher and textbooks during the research and developmental stages of the Number puzzles. Number Puzzle is a good example of project work. Hence, Number Puzzles are very good in helping learners develop positive attitude towards Mathematics as it enables them “own” the learning process.

My take away message to teachers

Teachers can use Number Puzzles to stir ownership of the learning process in Mathematics amongst learners as learners will feel that they have created their own knowledge from what they have understood. My urge to all teacher is to facilitate their learners in acquiring this skill and it will create a positive impact in the way learners learn Mathematics.

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Invisible Currents: Intervening in Gendered Pathways through Reflective Physics Pedagogy

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Abstract This article shares my lived experience as a physics educator in a girls-only Kenyan secondary school, where I have witnessed persistent gendered patterns in how students engage with the subject. Despite initial curiosity and capability, many girls opt out of physics when it becomes elective—not due to lack of ability, but because of subtle cultural messages, social expectations, and pedagogical practices that shape their sense of belonging. Drawing on years of classroom observation and reflective practice, I explore how gendered pathways in physics education can be disrupted through intentional, identity-affirming teaching. I describe specific interventions—including inclusive language, visible role models, collaborative rituals, and reflective prompts—that have helped reframe physics from an intimidating subject into a space for exploration, agency, and confidence. These strategies are not merely instructional tweaks; they are cultural shifts that reposition girls as active participants in science, capable of shaping their own narratives. By situating physics education as both curriculum and culture, I argue that teachers play a critical role in either reinforcing or challenging exclusionary norms. My approach is grounded in practitioner inquiry and guided by a commitment to equity, relevance, and student voice. The article offers practical strategies and reflective prompts for educators seeking to foster gender-responsive classrooms where all learners—especially girls—can thrive. Ultimately, this work is a call to reimagine physics not just as content to be delivered, but as a relational and transformative experience. When girls see themselves in the subject—in its stories, expectations, and possibilities—they not only stay, they soar.

Keywords: *Gender-responsive pedagogy, physics education, student agency, practitioner inquiry, science identity*

1.0 Introduction: Physics with potential

Physics has long been perceived as a subject reserved for the few—often male, often elite. In my classroom at a girls-only secondary school in Kenya, I have seen how this perception quietly shapes students’ choices, even when their curiosity and capability suggest otherwise. Many girls begin their physics journey with enthusiasm, only to withdraw when the subject becomes optional. This disengagement is not rooted in academic struggle, but in a deeper sense of misalignment between their identities and the dominant image of physics.

This article is part of my ongoing effort to challenge exclusionary norms and contribute to a wider conversation about equity in science education. It documents how intentional, reflective teaching can intervene in gendered pathways and create a classroom culture where all students—especially girls—feel seen, valued, and capable.

2.0 Literature

Despite growing efforts to promote STEM education among girls in Kenya, physics remains one of the least chosen subjects by female students at the secondary level. Studies consistently show that girls’ disengagement from physics is not due to lack of ability, but rather to entrenched cultural narratives, pedagogical practices, and systemic barriers that shape their sense of belonging. For instance, Kusimba et al. (2023) found that while girls in Elgeyo Marakwet County often outperform boys in physics assessments, they still perceive the subject as masculine and inaccessible, leading to lower enrollment rates. Similarly, Mugendi et al. (2024) highlighted that perceived difficulty, lack of contextual relevance, and limited exposure to role models significantly influence girls’ decisions to opt out of physics.

While national policies such as Kenya’s Education and Training Sector Gender Policy (2015) advocate for gender equity in STEM, there remains a critical gap in classroom-level interventions that address the lived experiences of girls. Most existing studies focus on enrollment statistics or broad policy recommendations, with limited attention to how everyday teaching practices can either reinforce or disrupt gendered pathways. This article responds to that gap by offering a practitioner’s perspective—grounded in classroom experience—on how intentional, gender-responsive pedagogy can reframe physics as a space of agency, relevance, and belonging.

3.0 Process

3.1 Intentional Teaching Moves

Transforming girls' experiences in physics requires more than curriculum adjustments—it demands a shift in how the subject is lived and felt in the classroom. My teaching practice has evolved to center relational, inclusive and identity-affirming strategies that help students see themselves as capable physicists. One of the most impactful changes has been the use of inclusive metaphors and analogies. Rather than presenting physics as abstract and detached, I draw on everyday experiences that resonate with my students' lives. For example, I have likened electric circuits to community networks or gravitational fields to the pull of relationships—images that invite curiosity and connection. These metaphors not only make physics more accessible but also challenge the notion that scientific thinking must be impersonal or masculine. Representation also plays a critical role. I intentionally introduce visible female role models in physics—not just historical figures, but contemporary scientists whose work intersects with our syllabus. These stories are woven into lessons, posters, and reflective prompts, offering students mirrors in which they can see their own potential.

Classroom rituals have become another cornerstone of my practice. From shared lab reflections to peer-led investigations, these collaborative routines foster a sense of belonging and shared ownership of learning. I also encourage reflective journaling, where students explore their evolving relationship with the subject. These entries often reveal shifts in confidence, curiosity, and identity—signals that physics is becoming a space of possibility rather than exclusion.

3.2 Beyond the syllabus

This work has taught me that physics is not just a body of knowledge—it is a cultural experience shaped by relationships, expectations, and identity. When girls are invited to co-create the meaning of physics through inclusive language, collaborative rituals, and emotional safety, the subject becomes more than a syllabus. It becomes a space where they can imagine themselves as thinkers, creators, and scientists.

My teaching philosophy now centers on relational pedagogy—an approach that foregrounds

student voice, emotional presence, and cultural relevance. This stance challenges the traditional image of physics as detached and competitive, offering instead a vision of science as communal, reflective, and transformative.

3.3 Educators Insights

For educators seeking to foster inclusive physics classrooms, these strategies offer a starting point. They are meant to be adapted, questioned, and built upon in your own context. Inclusive metaphors, visible role models, collaborative rituals, and reflective journaling are not just techniques—they are invitations to reimagine what physics can be.

These insights are grounded in classroom experience and practitioner inquiry. They affirm that teachers are not just deliverers of content, but co-constructors of culture. When we teach with intention, we create spaces where all students—especially girls—can thrive.

4.0 Conclusion

This practitioner inquiry has revealed the nuanced and often invisible ways in which gendered pathways shape girls' engagement with physics in Kenyan secondary schools. Through sustained classroom observation and reflective journaling, I have documented how cultural expectations, emotional undercurrents, and pedagogical habits subtly influence students' sense of belonging in the subject. These patterns often manifest not in overt resistance, but in quiet withdrawal, hesitation, or self-doubt—signals that are easily missed in traditional instructional models.

In response to these observations, I have implemented a series of intentional teaching strategies aimed at reframing physics as a space of agency, relevance, and identity. These include the use of inclusive metaphors that connect physics concepts to students' lived experiences, the integration of visible female role models to challenge exclusionary narratives, and the cultivation of collaborative rituals that foster peer support and shared ownership of learning. Reflective journaling has also emerged as a powerful tool, allowing students to explore their evolving relationship with physics and affirm their place within it.

These strategies are not isolated techniques but part of a broader pedagogical stance—one that views teaching as relational, responsive, and transformative. By foregrounding student identity,

emotional safety, and cultural relevance, educators can begin to disrupt the invisible currents that shape girls' trajectories in physics. This work affirms that change begins in the classroom, and that teachers, through reflective and intentional practice, hold the power to reshape science education for equity and inclusion.

Acknowledgement

I am grateful to my students, whose voices and reflections continue to shape my understanding of what physics can be. I also acknowledge the support of fellow educators and networks committed to equity in STEM, whose dialogue and collaboration have enriched this work.

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Improving Learners' Mastery of Food Tests: A Case of a Secondary School in Embu County

Eutace Ngigi Mwaniki

Abstract This article shares a classroom practice undertaken at St. Barnabas Gatirari Secondary School, a sub-county day school in Embu County, Kenya. At the end of Term One 2025, it was observed that Form Four candidates could not perform basic food tests in their Biology practical examinations. To address this gap, I implemented a strategy of repeating food tests at the beginning of lessons for three consecutive weeks, each activity lasting about five minutes. The objective was to improve learner confidence, self-efficacy, and performance in Biology practicals. The article documents the methodology, learner responses, and outcomes of this intervention. Indicators of success included increased learner initiative, improved quiz scores, and adoption of the approach by other teachers. This case demonstrates how repeated practice and learner-centered demonstrations can enhance mastery of Biology practicals even among learners with low entry behavior.

Keywords: *Food tests; Nutrition in plants and animals; Practical activities; Procedures; Observations*

1.0 Introduction

St. Barnabas Gatirari Secondary School is a sub-county day school in Mbeere South Sub County, Embu County. In 2025, ten students were enrolled in Form Four Biology. The majority of these learners were low achievers with KCPE marks below 200, often struggling with practical tasks. This article discusses an intervention introduced to address their difficulties in conducting food tests. The purpose was to move learners from zero marks on food test questions to demonstrating competence and enjoyment in practical activities.

2.0 Problem Statement

During the end-of-term exams in Term One, all learners failed the question on food tests. Most could not write the procedure, identify observations, or draw valid conclusions. Their lack of self-efficacy reflected findings by Von der Mehden et al. (2024), who noted that learner

perceptions of failure affect performance. It was evident that more guided, repetitive practice was needed to bridge this gap.

3.0 Literature Review

Practical activities play a crucial role in science learning. Batz et al. (2015) demonstrated that peer tutoring and repeated practice help low-achieving students succeed in Biology. Granato et al. (2017) emphasize the link between Biology and food sciences, noting the importance of laboratory practices in real-world applications. Active learning strategies in STEM classrooms, such as guided demonstrations and formative feedback, have been shown to increase learner engagement and outcomes (Freeman et al., 2014; Prince, 2021). In Kenya, studies highlight that frequent exposure to experiments enhances confidence in handling reagents and recording observations (Ndirangu & Chege, 2018). These insights informed the intervention applied in this case.

4.0 Methodology

To address the problem, I introduced repeated class demonstrations of food tests. Each practical took about five minutes and was conducted at the beginning of three lessons per week for three weeks. Learners were required to master the procedures and expected observations for both positive and negative results. To align with the scheme of work, the Biology department allocated an extra free lesson weekly. In each subsequent lesson, one learner was randomly selected to repeat the previous day's test before proceeding to a new one. This ensured retention and accountability.

5.0 Findings

After two weeks, learners demonstrated growing confidence and enthusiasm. For instance, they voluntarily wrote procedures and expected outcomes on the board without teacher prompting. Quiz results showed improvement: two students scored 6/6, one scored 4/6, three scored 3/6, one scored 2/6, and three scored 0/6. This progress suggested that while some still struggled, the intervention had measurable impact. Learner voice was also evident. One remarked, 'I can now remember the steps without looking at the book.' Another said, 'The practice makes it easy and fun.' Other Biology teachers in the school adopted the same approach after observing its success.

6.0 Conclusion

This case demonstrates that even low-achieving learners can master Biology practicals when guided through repeated, short, learner-centered demonstrations. While three learners still required more practice, the intervention improved overall performance and self-efficacy. Teachers should consider integrating such repetitive, formative activities into their teaching of practical concepts in STEM.

7.0 Acknowledgements

I wish to acknowledge the support of CEMASTEAs trainers and management for equipping us with skills in practitioner article writing. I also thank the Embu County TSC Director, the Principal of St. Barnabas Gatirari, and fellow Biology teachers for their encouragement. Finally, I am grateful to my Form Four students for their cooperation throughout the intervention.

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Communities of Practice: Sustaining the Best Practices in the Implementation of Competency-Based Education.

By Alice M. Liyosi

Abstract Sustaining active and professionally relevant Communities of Practice (CoPs) is one of the effective mechanisms to address the challenges faced by the junior school STEM teachers, for them to successfully implement Competency-Based Education (CBE) in Kenya. CBE requires teachers to change their approaches of instruction from the traditional to the 21st century pedagogical approaches. Teachers' Service Commission (TSC) through the Retooling Programme and Centre for Mathematics Science and Technology Education in Africa (CEMASTEa) through various its In-Service Education and Training (INSET) capacity-building programmes have periodically trained the junior school teachers. However, there is a gap in continuous monitoring and support to ensure that the junior school teachers implement CBE effectively. This challenge could be addressed through mechanisms that encourage continuance. Formation of active county and school CoPs using WhatsApp, gave junior school STEM teachers an opportunity to continuously actualize the learning outcomes of the retooling and other capacity-building activities in their schools.

As a senior trainer in my county, I have the responsibility to coordinate trainers' activities. With the guidance and support of my County Teacher Capacity Development Committee (CTCDC), CBE compliant and experienced teachers, junior school teachers get the support. They are the CoP champions in their schools. Using technology and face-to-face interactions, we share knowledge and

skills through trainings, the best practices and possible solutions to the challenges they face. The positive impact of CoPs has continued to be felt as the teachers could interpret the curriculum designs and adapt the learner-centred pedagogical approaches. Active CoPs consequently, offer the best link between capacity-building and effective implementation of CBE hence the need to sustain the CoPs, is significant.

Key Words: *Sustaining the Communities of Practice, WhatsApp groups, Learner-centred pedagogical approaches, Network*

1.0 Introduction

1.1: Background

In response to the dynamics of shifting from 8-4-4 system of education in Kenya to CBE, one of the key supports needed by junior school STEM subject teachers was the sustained active CoP platforms. These platforms engage the teachers and continuously apply the knowledge and skills in real classroom experiences. In contrast to the one-off workshop or more intensive ‘boot camp’ approaches, (Stanca *et al.*, 2022) CoPs can also be used to bridge the divide between research experts and educational practitioners by purposefully bringing them together into a collaborative community. In Trans Nzoia County, the need for a linked CoP arose from the gaps I identified; through my observation and interactions with junior school STEM teachers. There was a general disconnect between what was being taught and what is in the curriculum designs, the need for sustaining learner-centred pedagogies, ICT integration in the teaching and learning processes. These gaps formed the domain for both the county and school CoPs. As a senior trainer in the county, one of my roles is to promote professional development activities in my school and by extension, the county. I therefore lead the CoP at the county through a WhatsApp group.

We started in year 2024 and currently has 117 member teachers from 84 schools mainly teaching STEM learning areas across the county. Other members in the county CoP, apart from the junior school teachers include: the CEMASTEIA Primary School Activities Coordinator, the

CEMASTEALiaison Officer, County Quality Assurance and Standards O, the Kenya Primary Schools Head Teachers Association (KEPSHA) county chairperson, Secondary County Trainers' Representative and the county's chairperson of the Curriculum Support Officers (CSOs). The facilitators are some Strengthening Mathematics and Science Education (SMASE) county trainers and some Retooling Trainers. Transdisciplinary CoPs theory (Cundill *et al.*, 2015), emphasises on nurturing of cross-sectoral collaboration to solve complex challenges.

To sustain CoP activities and benefit more teachers, the junior school teachers are the CoP champions in their respective schools where they have formed school WhatsApp groups. I offer support and guidance alongside the CEMASTEAL officers in the school CoPs. The need for teachers participating in professional learning communities to sustain the practice, is also supported by interaction and engaging ourselves in activities that add value continuously, based on their inadequacies in the implementation of CBE. The Community Productivity Theory; (Spiliotopoulou *et al.*, 2020), acknowledges that sustainable CoPs increase productivity by sharing knowledge, fostering innovation and building collective capacity through use of multiple forms of community capital such as social, human and natural capital to improve well-being and sustainability.

1.2 Problem Statement

With the paradigm shifts in the education system in Kenya, where junior school education level and new learning areas were introduced, there have been intensified efforts notably by the Ministry of Education (MoE), CEMASTEAL and TSC in collaboration with Kenya Institute of Curriculum Development (KICD), and the Kenya National Examination Council (KNEC) to capacity-build the JS teachers to conform to the requirements of the new education system. However, the knowledge and skills gained from the training activities were not put into practice as teachers still used the conventional teacher-centred methods of instruction, mainly, lecture method. This was mainly due to lack of guidance, support, motivation and follow-up, to ensure continuance which could reinforce the practicability aspect of the acquired knowledge and skills during capacity-building activities, in schools.

1.3: Purpose

The focus was on the practical ways of sustaining CoPs to help JS STEM teachers put into practice the knowledge and skills acquired during their capacity-building trainings in their schools. Sustained CoPs formed a follow-up mechanism where teachers continuously help one another to acquire the 21st century skills in teaching and learning, interpret the curriculum designs and adapt the learner-centred pedagogical approaches in schools.

2.0 Methodology

2.1: Participants

An engagement strategy to create awareness about the value and purpose of CoPs, was done during the Retooling and CEMASTEAs capacity-building activities by the CTCDC Executive members of which I am a member too, in Trans Nzoia County. This promoted recruitment and participation of junior school teachers in the county CoP. Afterwards, they created individual school CoP groups and added their staff mates to the CoPs.

2.2: Data Collection

In order to gather substantive data, both quantitative and qualitative methods were used.

2.2.1: Quantitative Methods

A survey on the number of teachers in the county CoP, their professional details, the schools, the zones, the subcounties and the junior school STEM learning areas they teach, using online platforms to get their responses.

2.2.2: Qualitative methods

Activity monitoring using whatsapp and the reports sent to the county's CoP activities email, helps keep track of the actions taken by the teachers to achieve the intended outcomes. The use of focus groups within CoPs have helped capture the teachers' real-life experiences. Successes, challenges, possible solutions and areas that teachers need to be supported. Individual teachers' experiences have also had their personal experiences captured on school CoPs as well as interviews during face-to-face meetings with some participants.

3.0 Findings

During the county CoP meeting after completion of the first schools' action plan cycle on interpretation of the curriculum designs, one member reported that before the formation of the CoP the teachers in her school generally relied on textbooks in which some of the content had been shifted to other grades or removed from the curriculum designs before the rationalised books were distributed. Other teachers who were not conversant with the content, went ahead and either engaged learners in just copying notes from the text books or skipped the concepts. Another member appreciated the fact that, teachers in his school were able to unpack the specific learning outcomes into lesson learning outcomes, prepare professional documents needed to facilitate CBE lessons and employ learner-centred pedagogical approaches in the teaching and learning processes. The teachers who were not well-versed with the content could search for information from the internet

Figure 3.1: WhatsApp Screenshot chats

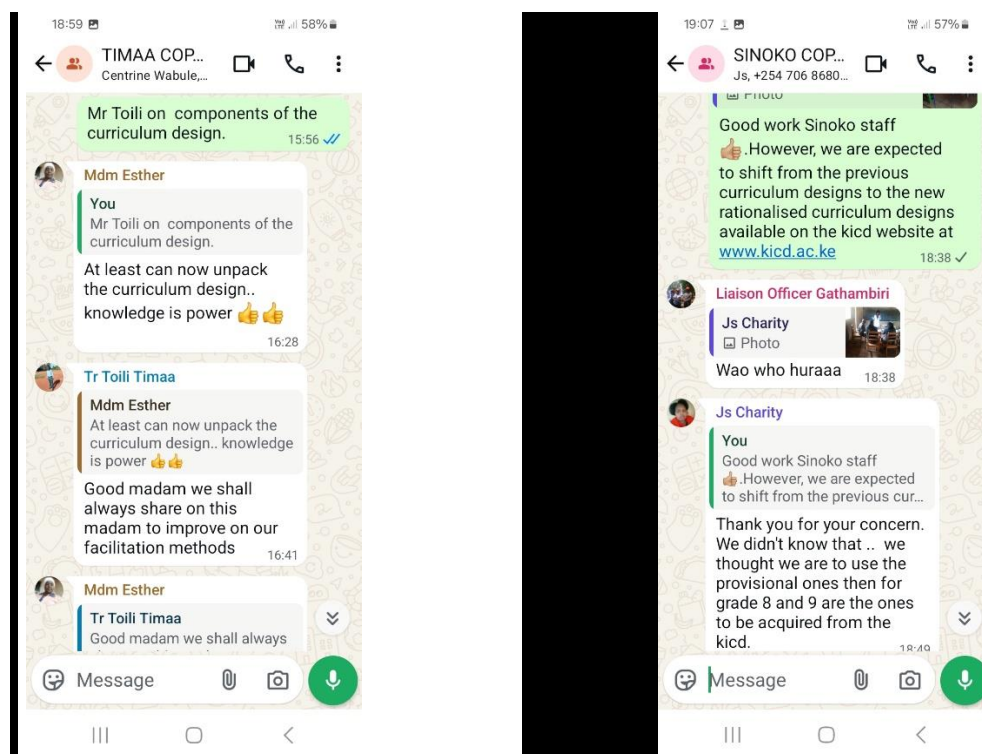
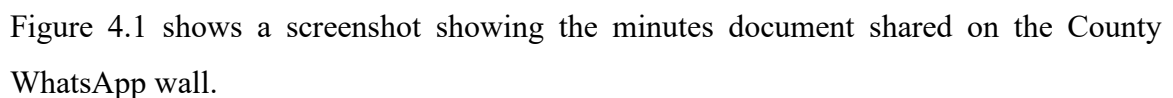


Figure 3.1: Screenshots showing WhatsApp chats from different schools, where teachers appreciate the CoPs in imparting knowledge and skills on interpretation of the curriculum designs.

4.1: Committed Leadership and Support.

Figure 4.1: A screenshot showing the minutes of the meeting



66

Formation of the county and school-based CoP WhatsApp groups have helped the junior school teachers to interpret the curriculum designs, embrace and adapt the learner-centred pedagogy as required by CBE.

Figure 4.2: A screenshot showing the county's CoP group

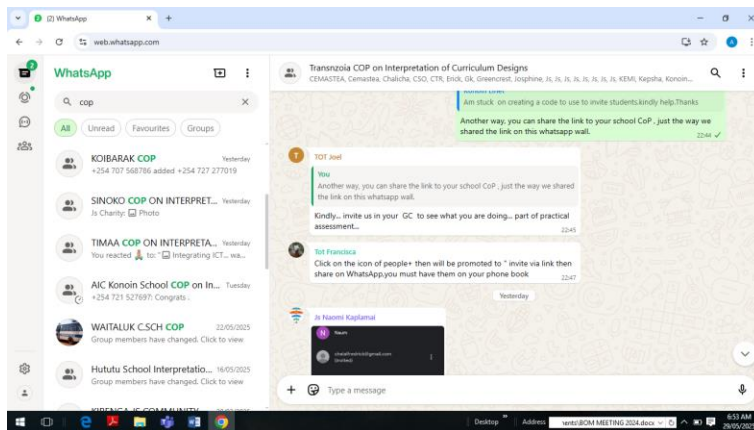


Figure 4.2: A screenshot showing the county's CoP group and some of the school-based CoP WhatsApp groups.

The county's CoPs activities email: transzoiaactivityreports@gmail.com helps keep track of CoP activities in the county and schools as leaders of the CoP groups send their activity reports. The email is accessed by the CTCDC executive members. The filed reports are kept by the CQASO who is the secretary to the CTCDC.

The responses on the google forms has helped in keeping track of the activities in schools and offering support.

Figure 4.3: Screenshots of google form responses

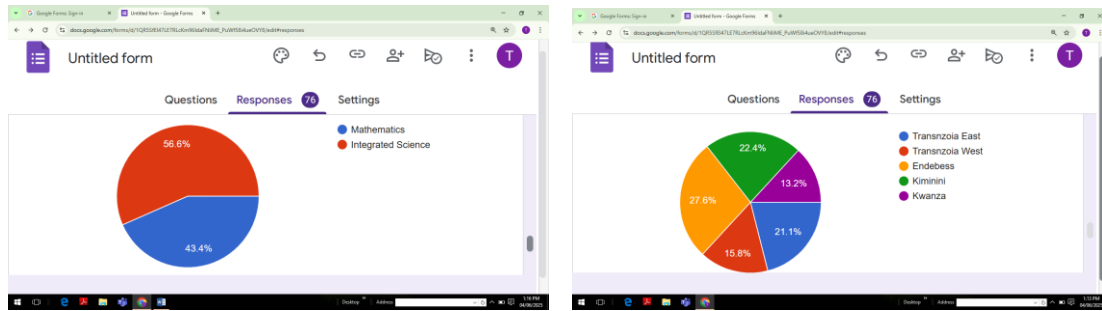
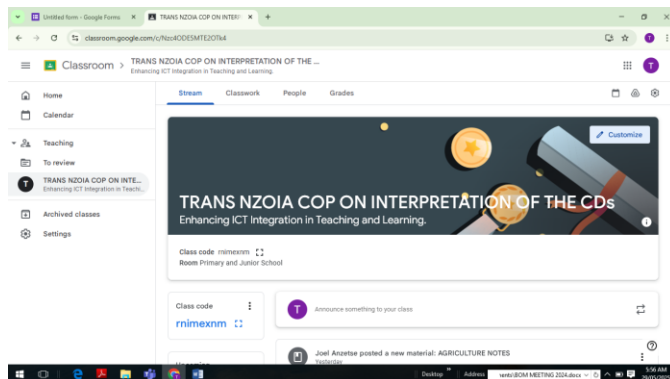


Fig 4.2.2: Screenshots of google form responses showing participants STEM learning areas and the sub-counties in which their schools are located. The creation of the respective schools' and county's Learning Management Systems; Google Classroom by the school CoP leaders in schools and I respectively, have enabled increased activity towards 21st century pedagogical approaches. This has encouraged the teachers to employ ICT Integration in the teaching and learning processes. The knowledge and skills are being used by teachers in the respective schools in the teaching and learning processes. The training materials are sent to the LMS for the junior school teachers to interact, do assignments and submit as practice. The facilitators award marks and comment to give more guidance and return. To sustain the CoP, the junior school teachers cascade to their schools' Google Classrooms of which I am one of the teachers.

Figure 4.4: A screenshot of the county's Google Classroom



4.3: Maintaining Regular Feedback.

This has helped to build a strong connection among the participants, the leadership and the activities. The members were issued letters informing them that they are leaders of the CoP in their schools. Other ways include chats on WhatsApp and phone calls. CTCDC executive members also occasionally find time to make interactions with the members either in their schools or other fora.

4.4: Encouraging active participation and recognition.

The support and leadership have always been encouraging junior school STEM teachers to share the best practices in the teaching and learning through the WhatsApp groups. Five most active school CoPs were in May 2025, recognized as their schools were selected for the CEMASTEIA STEM Outreach Programme where junior school learners benefitted. In June 2025, two more schools with active CoPs were identified for Monitoring and Support visits by CEMASTEIA team on Climate Change and Mitigation Activities. The activities were shared both in the county and school CoPs. This has motivated the junior school STEM teachers in other schools to intensify the sharing of the best practices on their CoPs.

Figure 4.5: Pictures of junior school learners using digital devices and teachers participating in an INSET group activity

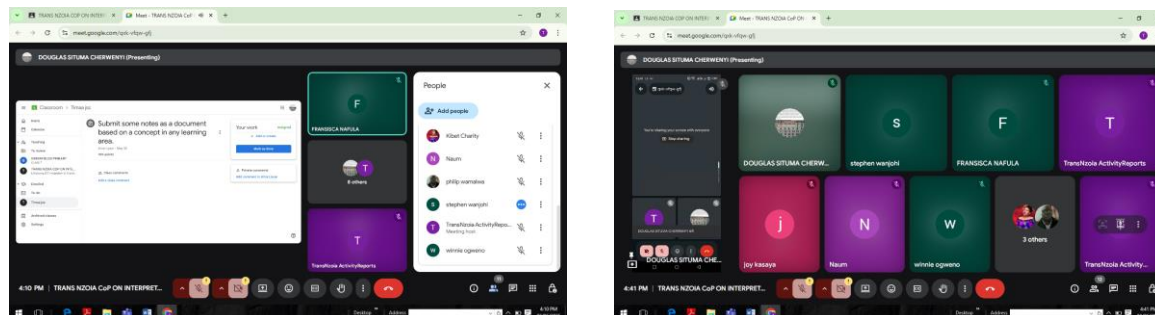


Figure 4.5: Pictures of junior school learners using digital devices and teachers participating in an INSET as shared in some school CoP groups.

4.5: Adaptability and Evolution

The county CoP gives an opportunity for the participants to give their views through regular meetings or chats on WhatsApp. They also share the best practices and make relevant presentations according to the needs of the STEM teachers during online training sessions. The junior school STEM teachers have made significant improvements in adapting ICT integration in the teaching and learning process.

Figure 4.6: Screenshots of a County online presentation by Junior School STEM facilitator.



5. Recommendations

For CoPs to remain active in order help address challenges facing junior school STEM teachers, the following ought to be considered:

- More training to be offered for CoP leaders to acquire leadership and management skills.
- The County and School CoP leaders to be considered for participation in all learner-centred pedagogy trainings in the country and county respectively in order to capacity-build them on the latest trends.
- More sensitization needed for school administrators to embrace and support CoP activities in their schools.
- Budgetary allocation for CoP activities at national, county and school levels is crucial in sustaining the CoPs.

6. Conclusion

From the findings, sustained CoPs play a vital role in helping the junior school STEM teachers competent enough to implement CBE. The determination by the junior school STEM teachers in Trans Nzoia to embrace, adapt and effect the changes necessary in CBE curriculum delivery and assessment methods is motivated by sustained CoPs. Efforts to sustain CoPs should therefore be put in place to ensure continuance throughout. This could be done by mainly impacting leadership skills to CoP champions right from school level leveraging on technology as it is cost effective, motivating teachers in schools that sustain active CoPs and participation through a

deliberate plan. The good will and the support of the school administration as well as a budgetary allocation for CoP activities would create a conducive environment for CBE learning outcomes to be actualized since CoPs would be sustained.

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Engaging Junior school learners through online Assessments: Teaching Mixtures Effectively

By James K Gitiro

Abstract This article explores the use of online assessment tools to enhance learner engagement and conceptual understanding. The exploration was done using Grade seven Integrated Science, with a focus on the topic of mixtures. This online assessment is an intervention to address the challenge of low motivation and limited interactivity in traditional science instruction. A classroom-based intervention was conducted in a class of 68 learners with varied ability. A blended assessment approach was used, incorporating Google Forms and Kahoot! at different stages of the lesson; pre-lesson, during instruction, and post-lesson. Learners demonstrated a performance improvement of 35% in post-test scores, increased learner enthusiasm and strengthened peer collaboration. Despite challenges such as device-access limitations and internet instability, the intervention demonstrated that digital assessment can make science lessons more engaging leading to improved learner outcomes. The article provides practical recommendations for integrating formative online assessment in resource-limited learning environments. Additionally, this contributes to the growing evidence base for EdTech use in STEM education.

Keywords: *Digital Assessment, Formative Feedback, Integrated Science, Learner Engagement, STEM Education*

Introduction

Learner engagement in STEM subjects is a critical process, especially when teaching abstract concepts. Traditional pedagogical approaches often fail to stimulate curiosity or provide real-time feedback, which is essential for teachers to facilitate learning. With global emphasis on 21st-century skills, educators should adopt strategies that assess and provide immediate feedback during learning to ensure active learner participation. Studies have shown that digital assessment tools can significantly improve learner motivation and comprehension (Brown, 2021; Levy & Wilson, 2022). However, adoption remains limited in many under-resourced schools. This article addresses that gap by documenting an intervention that integrates online assessments into Grade Seven Integrated Science lessons. The objective was to evaluate the impact of digital formative assessment tools on learner engagement and understanding, offering practical strategies for classroom implementation (Miller, 2022; Nguyen, 2020).

Integrating online Assessment in teaching Mixtures

Teaching Context

The intervention was implemented in a Grade Seven class comprising 68 learners with diverse academic abilities. The lesson focused on identifying, classifying, and separating mixtures. Instruction was spread over three sessions through a blended learning model combining face-to-face delivery and digital resource integration (Smith & Adams, 2023).

Methodology and Tools

To gauge prior knowledge, learners were first engaged in completing a Google Form quiz. During the lesson, Kahoot! was used to deliver live formative questions after key content segments. After the lesson, a second Google Form provided reflective self-assessment and summative feedback. These tools offered immediate results and insights. Learners were regrouped based on performance patterns to encourage peer learning. The teacher used Kahoot analytics to modify instruction in real-time and address misconceptions. The approach aligns with Gatende's (2023) findings that real-time feedback mechanisms enhance learning depth.

Findings and Observations

Participation: Over 90% of learners actively participated in the digital quizzes.

Understanding: Post-assessment scores improved by 35%, indicating enhanced comprehension.

Table 1: Learners performance before and after use of online assessment

Mark List For Grade 7			
	Strand : Mixtures		Assessment Report
Name	Before Kahoot	After Kahoot	
Peter	50	67	
Joan	60	81	
Achuchu	40	54	
Lena	50	67	
Lenaipoyo	60	81	
Ekale	80	100	
Fatma	70	94	

Engagement: Learners described the lesson as "fun" "interactive" and "easier to understand."

Figure 1: Traditional assessment method



Figure 2: Group discussions using an online assessment tool



Collaboration: Group discussions flourished during Kahoot! Sessions, reinforcing teamwork.

Learners described the lesson as *fun, interactive, and easier to understand*. Collaborative group discussions flourished during Kahoot! sessions, reinforcing teamwork and active learning. These results support prior findings that interactive technologies boost engagement and content mastery (Gatende, 2023; Brown, 2021). They are also consistent with Professor Anne Gatende of Virtual Learning Solutions, Kenya (2023), who found that real-time feedback mechanisms improve learning depth.

Challenges Encountered

- **Device Access:** Learners shared devices since the school does not have enough for every learner.
- **Connectivity:** Internet disruptions occasionally delayed lesson progression.
- **Learning Curve:** Learners needed brief orientations to navigate through the digital resources confidently.

Despite these issues, learners adapted quickly, and digital fluency improved over time (Levy & Wilson, 2022).

Conclusion

Online assessment tools are a valuable resource for enhancing engagement and understanding in STEM subjects such as Integrated Science. By offering real-time feedback to learners, interactivity is fostered, collaborative learning is enhanced. Online assessment tools transform traditionally passive lessons into dynamic experiences. Even in low-resource environments, thoughtful integration of digital assessment tools can lead to enhanced achievement of learning outcomes.

Acknowledgment

The author acknowledges the contributions of the Grade 7 learners, the school's ICT team, and the teaching staff who supported the intervention. Appreciation is also extended to the Ministry of Education for promoting digital innovation in classrooms. More appreciation to Prof. Anne Gatende of Virtual Learning Solutions for empowering teachers to leverage on technology.

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Hoisting Mathematics Performance in Remote Schools

By Leakey Ndwiga Njeru

Abstract This study explores learners' perceptions of mathematics and identifies strategies to enhance performance in remote schools. It was prompted by an observation of students' negative attitudes toward early morning remedial lessons. A structured questionnaire was used to collect data from 55 learners, of whom 36 responded. Findings revealed that 70% of the learners understand concepts when taught in class but rarely revise independently. About 60% find mathematics challenging, 30% miss lessons due to absenteeism, and 40% report discouragement from peers. The study recommends interventions such as remedial sessions for absentees, daily consultation hours, and topical weekend tests. These measures are significant in strengthening learner engagement, improving performance, and supporting access to STEM careers. The study demonstrates the applicability of student-centered strategies in improving mathematics outcomes in rural settings.

Keywords: *Hoist, remedies, student-centered, STEM, mathematics performance*

1.0 Introduction

Mathematics plays a central role in the Kenyan education curriculum and serves as a gateway to science and technology-related careers. Persistent underperformance in rural and remote schools limits learners' access to STEM pathways (Murphy, 2021). Factors such as inadequate revision, poor learner attitudes, and irregular attendance contribute to this challenge (Tshabalala & Ncube, 2013). Understanding learners' perceptions can therefore inform interventions that enhance

conceptual mastery and engagement (Perman, 2021). This article presents a teacher-led reflection on learners' experiences and classroom-based remedies to improve mathematics outcomes.

1.1 Critical incident

One evening as I ended my mathematics lesson in one of the classes, one student requested whether we could have an early morning session to conclude on the topic we were doing. I asked for the feeling of others and they agreed. As I walked past the class after the lesson, I overheard a student complain of the lesson. He asked others in Swahili “mnasema aje kesho asubuhi na labda hamuelewi kitu?” (you are requesting the teacher to come in the morning and maybe you aren't understanding anything?) I assumed the question and came back the following morning as agreed. As I reflected on the incident, I felt that I needed to do a research to understand their take on mathematics. This forms the basis of the article.

1.2 purpose and objective of this study

The main purpose of this study is

- a) To understand the perception of students as far as mathematics is concerned
- b) To understand some of the experiences of students when studying, revising and doing mathematics exams
- c) To obtain student centered remedies to improve mathematics performance in rural schools

2.0 Methods of data collection

Having overheard my students lament about an early morning remedial lesson, I reflected on the incident and decided to use a questionnaire to understand their take on mathematics. I asked them to reflect on their experiences when learning mathematics and their encounters when revising for mathematics exams. They were also to reflect on some their experiences when doing exams and some of the reasons why they perform lowly in mathematics. I also asked them to reflect on some of the remedies that could help them improve on their performance.

3.0 Data/responses

Out of 55 students in the class, 36 responded to the questions. 11 were absent and 8 did not give their responses. 70% agreed that they understand concepts when they are taught during the lesson. Unfortunately they easily forget concepts since they rarely revise for mathematics but only do assignments. The few who revise get discouraged especially if they encounter difficult concepts or concepts they missed while out of class. During exams, 60% of the students are unable to do all the questions and end up leaving blank spaces. Some are unable to manage their time and others take a lot of time interpreting questions. About 30% of the students argued that they miss concepts taught while they are out whenever sick or out for activities. 20% argued that they rarely find teachers to consult during their free time. 60% of the students perceive mathematics as a generally challenging subject.

Table 3.1 Summary of Learner Responses

Research question	Response	Percentage
Understand concepts during lesson	Understand	70%
	Don't understand	30%
Revise for exams	Revise regularly	40%
	Rarely revise	60%
Answering questions during exams	Attempt all	40%
	Don't attempt all	60%
General view of mathematics	Difficult	60%
	Moderate	25%
	Easy	15%

3.1 Findings

The findings reveal that inadequate revision habits, absenteeism, and negative peer influence contribute to low performance in mathematics. Learners' perceptions of difficulty also discourage independent study. Similar trends have been reported in other rural settings, where

learners' motivation and social support significantly affect mathematics outcomes (Tshabalala & Ncube, 2013; Perman, 2021). These insights underscore the importance of continuous assessment and remedial support tailored to learners' needs

3.2 Remedies

The students proposed various remedies: remedial lessons for absentees, peer collaboration, and scheduled consultation hours. They also suggested weekly topical assessments to encourage consistent revision. These strategies align with research emphasizing learner-centered interventions to enhance participation and retention (Murphy, 2021; Perman, 2021).

4.0 Conclusion

The study highlights that learner attitudes, irregular revision, and limited consultation opportunities hinder mathematics achievement in remote schools. By implementing student-centered approaches such as remedial lessons, peer mentoring, and scheduled assessments, schools can strengthen learner engagement and confidence. Enhancing mathematics performance will empower learners from rural areas to pursue STEM-related pathways

5.0 Recommendations

- i. School-level action: Schools should institutionalize remedial programs and regular topical assessments to support continuous learning.
- ii. Teacher practice: Teachers should adopt formative feedback techniques and offer consultation hours for struggling learners.
- iii. Policy level: CEMASTE A and the Ministry of Education should support capacity-building initiatives that promote evidence-based teaching in rural contexts

Acknowledgement

I would like to sincerely appreciate CEMASTE A and its team for giving us the opportunity to share our experiences and thoughts in the process of teaching mathematics. I would also like to register my gratitude to our school administration and head of department for accepting to

support some of the programs meant to assist students improve in their mathematics performance. Lastly, I would like to appreciate my students for cooperation so far.

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The Alchemist's Revelation in the Math Classroom: Bridging Gaps in Algebraic understanding through Learner-led Engagement.

By David Odhiambo Owino

Abstract This practitioner journal explores a critical moment of pedagogical reflection and transformation within a Form 4 mathematics classroom, following an alarming performance in a departmental Paper 2 examination. With only 14 out of 49 students scoring above 30%, and the majority failing to apply core algebraic concepts such as the difference of two squares, rational expressions, and factorization, the results revealed deep conceptual gaps despite visible enthusiasm during peer collaboration. Triggered by a spontaneous classroom scene where learners engaged energetically yet inaccurately with a math problem, the experience became a catalyst for rethinking instructional approaches. This journal documents a targeted, multi-layered intervention that incorporated visual aids, mathematical modeling, targeted remediation, structured error analysis, and peer-led collaborative learning. Drawing from educational theorists such as Boaler, Hattie, and Vygotsky, the strategies aimed not only to repair conceptual understanding but to foster student agency and shared accountability. The impact was immediate and promising. Students demonstrated renewed confidence, increased participation, and gradual improvement in applying algebraic identities with precision. Furthermore, the classroom culture shifted from passive reception to active, critical inquiry. Peer teaching structures allowed students to learn from and with one another. This journal argues for a diagnostic, student-centered approach to instruction, particularly in algebra, where misconceptions often persist undetected. It also

highlights the transformative potential of learner-led engagement when coupled with strategic teacher guidance and courage to confront confusion.

Keywords: *Algebra, Learner Engagement, Peer Learning, Remediation, Formative Assessment*

Introduction

As a mathematics teacher for Form 4 class, I often find myself reflecting on the best ways to nurture not only their mathematical knowledge but also their confidence and curiosity. Recently, a situation unfolded that left me both deeply moved and determined to find more effective ways of supporting my students.

The bell had rung, signaling the end of a particularly disheartening day. The recent Form 4 Paper 2 examination results left me questioning everything. With an average score of only 50% across the board and 35 out of 49 students failing to reach 30%, I felt compelled to act. Only four students scored between 50–60%. How could I bridge this chasm of misunderstanding? How could I ignite the mathematical spark in students who seemed to have lost all hope? This journal entry recounts a pivotal moment that reshaped my perception of student engagement and the intervention strategies that followed.

The Study Context

The Head of Department (HoD) in my school administered a Mathematics Paper 2 exam to Form 4 class. The scripts were marked using the conveyor belt method, and the results were deeply disheartening across the 6 streams: In my class of 49 students, only 14 students scored 30% and above, and of these, a mere 4 scored between 50–60%. Getting 45% in the test was highly likely and the success should have been more widespread underscoring the stark reality of gaps in understanding, particularly in algebraic concepts. As their subject teacher, these results weighed heavily on me, filling me with worry about their mathematical journey and sparking a personal mission to turn things around.

The very next day, driven by a need to understand their struggles, I remained in the office for an extra 20 minutes, poring over their books to identify patterns of misconceptions and common

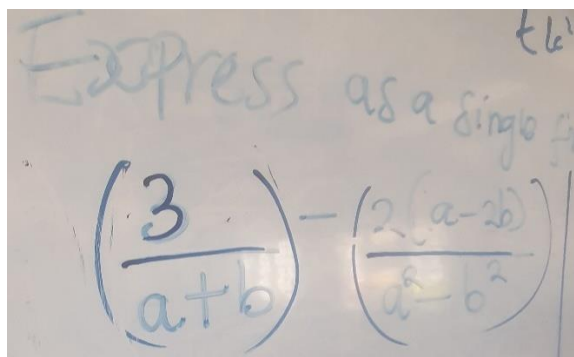
errors. This delay meant I arrived at class 20 minutes late, and as I approached the classroom door, I was met with an unexpected sight: one student stood confidently at the board, working through a mathematics problem while the rest of the class was fully engaged, offering suggestions and discussing the next steps. The atmosphere was electric with collaboration and a shared enthusiasm for the subject, an inspiring scene that gave me a glimmer of hope.

Yet, upon closer inspection, I quickly realized the entire class had approached the problem incorrectly from the very start. They were attempting a Form 2 algebra problem involving:

- a) simplifying by factorization using the difference of two squares $a^2 - b^2 = (a + b)(a - b)$.
- b) simplifying rational expressions with algebraic denominators and
- c) finding a common denominator to combine the two fractions.

Despite the lively engagement, the solution was veering further from correctness, consuming precious class time without a productive outcome. The fact that students couldn't apply these steps reflects gaps in several foundational areas of algebra, not just the difference of squares, but also recognizing standard algebraic identities, managing algebraic fractions and understanding how expressions can be rewritten using factoring. This experience highlighted a profound need: to bridge the gap between enthusiasm and accurate understanding, and to harness that collective energy toward genuine mathematical growth.

Figure 1 shows the problem and the students' attempted solution.



Express as a single fraction

$$\left(\frac{3}{a+b}\right) - \left(\frac{2(a-b)}{a^2-b^2}\right)$$

$$\begin{array}{l}
 159 \\
 3(a^2 - b^2) - (2a^2 - 4ab + 2ab - 4b^2) \\
 \hline
 3a^2 - 3b^2 - 2a^2 + 4ab - 2ab + 4b^2
 \end{array}$$

I had to stop the students from expanding the denominator, which was their next step

Intervention Strategy

The main problem identified was a lack of foundational understanding in algebraic concepts, particularly in applying core factorization methods such as the difference of two squares. Despite their energy, enthusiasm, and teamwork, students struggled to recognize and apply the correct algebraic principles. This led to long, inaccurate problem-solving processes, revealing deep misconceptions and gaps in conceptual knowledge.

To address this gap, I adopted only one targeted intervention strategy, visual aid and modeling, which I supported with targeted remediation and practice, error analysis and feedback, and collaborative and peer-led learning.

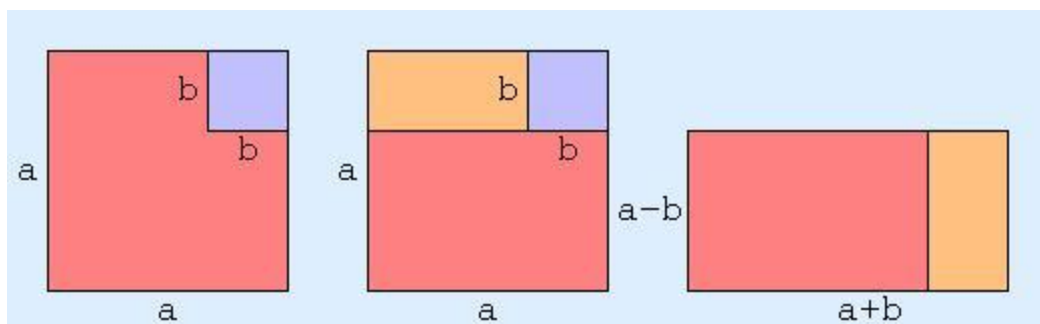
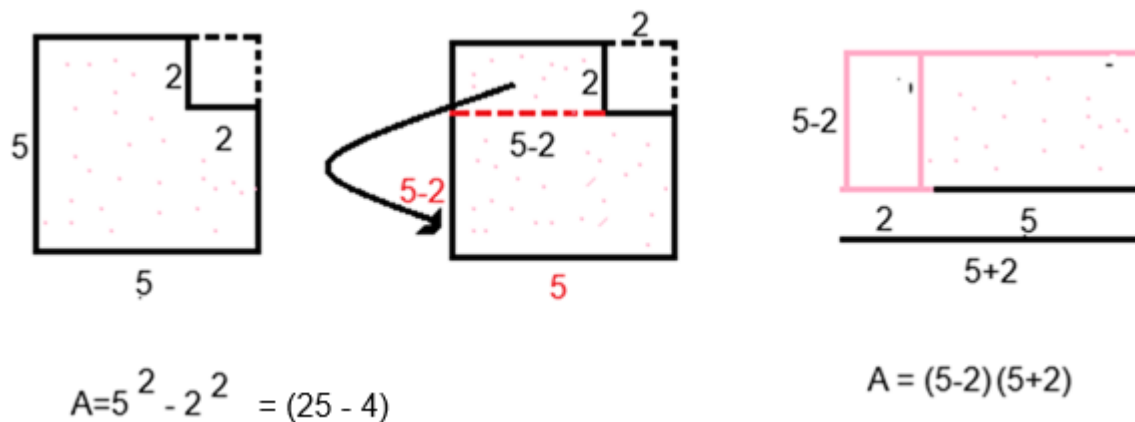
Use of Visual Aid and Modeling

Students often struggle with abstract algebraic expressions because they cannot visualize what the symbols represent. Using visual aids can make such concepts more accessible. During follow-up lessons, I made a simple chart illustrating the difference of two squares using real numbers. I then replaced the numbers with letters and compared the results. To make it more engaging, I integrated a PowerPoint presentation to create motion during the re-assembling of rectangles. This helped students see the structure of the expression and understand how simplification works.

Modeling correct-problem-solving processes on the board, step by step, also allowed students to compare their own thinking with a logical and concise method. According to Boaler (2016),

visual representations and modeling help students develop conceptual understanding by connecting symbols to meaning.

What would be the remaining area if a square of 2 by 2 was cut out from a bigger square 5 by 5?



After a smaller square (side = b) is removed from a larger square (side = a), the remaining part can always be re-assembled into a rectangle measuring $(a + b)$ by $(a - b)$. Therefore, tangible manipulation demonstrates that the area $(a^2 - b^2)$ is visually and spatially equivalent to the area of the rectangle, $(a + b)(a - b)$.

We solved the problem in two steps as follows:

$$\frac{3a - 3b - 2a + 4b}{(a + b)(a - b)} = \frac{a + b}{(a + b)(a - b)} = \frac{1}{a - b}$$

This provided a memorable, conceptual anchor that was far more powerful than the memorization. However, for long lasting memorization, the following strategies can also help address such challenges.

Targeted Remediation and Practice

Effective remediation requires moving beyond general practice to focus intensely on the specific skills and concepts that are lacking. When a foundational concept is weak, it creates a domino effect, making it impossible to tackle more complex problems (Hattie, 2009).

Recognizing that the entire Form 4 class faltered on a Form 2 concept, I created a worksheet that contained only the problem areas identified by students. I structured the questions according to difficulty level and dedicated specific lesson time to remediation. This progressive difficulty allowed the students to solidify their understanding at each level before moving on, preventing them from becoming overwhelmed and ensuring the foundational skill was secure.

Error Analysis and Feedback

Mistakes are not just failures, they are invaluable diagnostic tools and opportunities for deep learning. A culture of error analysis encourages students to investigate their own thinking and understand the logical flaws in their approach (Boaler, 2015).

I stratified the class of 47 into four groups, each containing 12 students of varying abilities. Each group took a 50-mark test every Tuesday and Friday for two weeks. I marked their work, analyzed the errors in their workings, and sometimes took pictures of selected scripts. I then printed and posted the inconsistencies on the class notice board. These questions became the foundation for peer and collaborative learning.

By guiding the entire class through a non-judgmental analysis of their shared mistakes, I addressed misconceptions directly and publicly. This collective approach proved more powerful than individual correction. It helped destigmatize errors, reframing them as a natural part of the mathematical learning process.

Collaborative and Peer-Led Learning

The observation of students actively helping each other is a strength to be leveraged, not a behavior to be quieted. Structured collaborative learning harnesses this peer-to-peer energy, improving both academic achievement and interpersonal skills.

When students explain a concept to a peer, they are forced to clarify their own understanding, leading to deeper learning for both the “teacher” and the “learner” (Vygotsky, 1978). In my class, peer teaching was led by the strata chairpersons. However, each student was first required to attempt the problem silently on their own for two minutes to ensure individual accountability.

After that, they turned to a partner to discuss their approaches before the leader clarified any missteps.

This structure helped guide them toward the correct methodology and reinforced accurate concepts while promoting a culture of shared responsibility and mutual growth.

Impact and Reflection

Implementing these interventions brought a noticeable shift, not just in student performance, but in the atmosphere of the classroom. Students who had once sat passively during mathematics lessons were now actively participating, asking questions, and confidently attempting problems. The visual aids and modeling strategies seemed to unlock previously abstract ideas, making concepts more tangible and less intimidating. The PowerPoint animations, in particular, drew students in and helped them grasp the logic behind identities such as the difference of two squares.

The targeted practice sessions revealed that many students had long carried misconceptions that had gone unaddressed. As we worked through progressively structured worksheets, I began to see lightbulb moments; small nods, quiet smiles, and growing confidence as they correctly simplified expressions or combined algebraic fractions for the first time. While progress was uneven across the class, the majority of students showed improvement not only in accuracy but also in attitude.

The greatest transformation, however, came through peer-led collaboration. Students began to hold each other accountable for their thinking. Group leaders emerged naturally, and even those who had previously struggled began to speak up during feedback sessions. The printed scripts with errors posted on the notice board no longer caused shame but instead, they sparked debate and analysis. Mistakes became a shared learning tool rather than a personal failure.

Reflecting on this experience, I've come to realize that deep learning does not always begin with the teacher at the front of the room. Sometimes, it begins when students take the lead, when they grapple with errors together, support each other, and find joy in their shared struggle. My role shifted from being the sole source of knowledge to becoming a facilitator, guiding students as they constructed their own understanding.

This experience reaffirmed a powerful truth: learners are not empty vessels waiting to be filled; they are thinkers, collaborators, and potential problem-solvers. When given the right tools, space,

and trust, even the most discouraged students can rise to the challenge. And as a teacher, witnessing that transformation is the real alchemy.

Conclusion

This unplanned intervention demonstrated that visible engagement does not guarantee deep understanding. It exposed latent misconceptions that hinder mathematical growth. Through structured remediation, visual modeling, and collaborative learning, learners reconstructed their understanding of algebraic principles and regained confidence. Going forward, diagnostic assessment and continuous formative evaluation will anchor my instructional practice. As Wiliam and Leahy (2015) affirm, formative assessment offers real-time insights into learning, enabling timely instructional adjustments that promote success for all learners.

Recommendations

- **Strengthen Foundational Learning:** Teachers should systematically revisit earlier algebraic concepts to ensure students have a firm grounding before progressing to advanced topics.
- **Promote Critical Thinking:** Encourage a classroom culture where learners question, critique, and justify their solutions, viewing errors as learning opportunities rather than failures.
- **Emphasize Conceptual Understanding:** Shift focus from rote memorization to deep conceptual comprehension through modeling, visualization, and guided exploration.
- **Adopt Diagnostic and Formative Assessment:** Integrate continuous, low-stakes assessments to identify misconceptions early and provide timely feedback for correction (Wiliam & Leahy, 2015).
- **Intentionally Scaffold Instruction:** Use step-by-step teaching sequences that move from simple to complex problems, ensuring mastery at each stage before progression.
- **Sustain Collaborative Learning:** Build structured peer-learning systems that empower students to take leadership roles in problem-solving while fostering teamwork and accountability.
- **Institutionalize Reflective Practice:** Encourage teachers to continuously reflect on classroom experiences, document interventions, and share insights through professional learning communities.

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Influence of Virtual Laboratory Simulations on Junior School Learners' Attitudes and Performance in Integrated Science

By Muhenje Injila Faith

Abstract This paper reflects on the influence of virtual laboratories on learner's attitudes and performance in integrated science. Ideally, many learners in junior schools in Kenya are finding it challenging to understand abstract concepts from integrated science that encompasses Biology, Chemistry and Physics. Unfortunately, most primary schools are unable to afford well-equipped laboratories that can enable better understanding of science concepts. This paper explores how virtual laboratories can be a solution to this problem. With improved performance and positive attitude by junior school learners, we can realize the intention of having 60% of the learners taking up the Science, Technology, Engineering and Mathematics (STEM) pathway as they transition to senior school. A total of 30 grade 9 learners from Kakamega Junior school in Kakamega county participated in this study. The learners were divided into two groups; an experimental group with 15 learners and a control group with 15 learners. All the 30 learners were exposed to a virtual simulation on the test for starch from grade 9 integrated science. The experimental group was additionally allowed to interact with the content on the LabXchange platform. Survey method was used to determine the attitudes and performance of the two groups. The results indicated a positive shift in the attitudes and performance. The experimental group had 80% of the learners getting above 60% in the assessment while 40% of the control group learners got above 60%. The findings in this study indicate that use of virtual labs have a positive effect on learners' attitudes and performance and therefore should be adopted in the learning of Integrated science.

Keywords: *Virtual labs, fostering positive attitudes, LabXchange, Performance*

Introduction

Integrated science is a learning area that encompasses Biology, Chemistry and Physics. Virtual labs are generally defined as computerized models, simulations and instructional technologies that are used in place of face-to-face activities in the laboratory. Learners experience challenges challenging to understand integrated science especially when they do not take an active role in the learning process (Putri, *et al.*, 2021). Most junior schools are yet to have well-equipped laboratories thereby making it challenging for learners to comprehend concepts that require practical experiences during learning. In such cases, learners are only taught theoretically due to the absence of physical laboratories. This approach of learning makes it challenging for learners to grasp the concepts and reduces their capability of developing competencies through practical experiences (Rosli & Ishak, 2024). It is necessary to embrace virtual labs simulations in junior schools as an alternative or complimentary to physical laboratories. However, this can only be used in some areas since there are still a good number of schools in Kenya which do not have access to basic ICT resources as well as weak internet connectivity. According to Halonyere, *et al.*, (2025), most schools in Kenya lack sufficient ICT infrastructure and the few that have the resources rarely use them in learning science. This calls for an urgent action by the government to ensure that all schools have adequate access to ICT resources and that these resources are efficiently used in the teaching process. Additionally, with the government anticipating 60% of the learners to undertake the STEM pathway at senior school, there is a growing need to adopt virtual lab technology which could improve the attitudes of the learners and therefore their performance in science.

Integration of virtual laboratories in learning has aroused the interest of learners enhancing their understanding of scientific concepts (Edali, *et al.*, (2024). There is no doubt that young learners like those in junior school, prefer a method that provokes and stimulates their imagination and critical thinking. Literature shows that important skills such as creativity and critical thinking are developed through the use of simulations and videos that are found in these virtual laboratories. Alhashem and Alfaiakawi (2023) in their study noted that when virtual labs are used to support

other methods of content delivery, they promote a heightened engagement from the learners. In this century where scientific knowledge is emphasized, it therefore makes sense to embrace virtual labs as a means of improving attitude and performance in science and guiding learners through the STEM pathway.

Methodology

This study focused on 30 Grade 9 learners from a selected school in Kakamega county. All the 30 learners were exposed to a virtual simulation on the procedure for testing of starch, under Grade 9 integrated science. Some fifteen learners were used as the control group. The other fifteen of these learners were used as an experimental group and were exposed to an additional LabXchange virtual lab simulation. Through guided inquiry, the learners accessed the virtual lab simulation through <https://www.labxchange.org>. In this case, the learners were able to interact with the virtual lab and walk through the test procedure themselves. Thereafter, all the 30 learners from both the control and the experimental groups were given a common 30 minutes test. The following were the test questions;

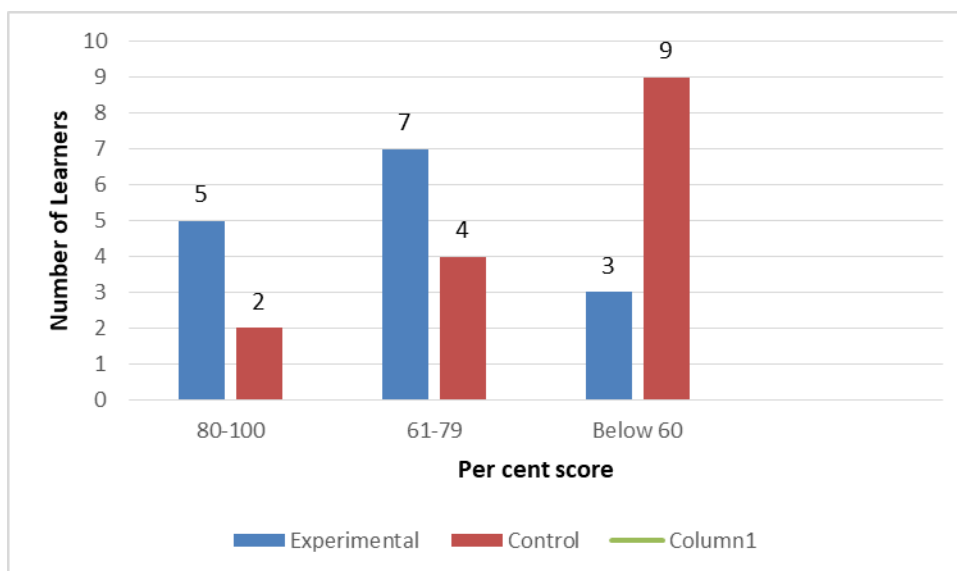
- a) Name three commonly used reagents when testing for starch (3 marks)*
- b) Describe the procedure for testing for starch (7 marks).*

Results and Discussion

The results of the study indicated a clear difference between the experimental group and the control group. While the experimental group handled the assessment in a shorter time and with impressive scores, the control group experienced some challenges. Most of the learners from the control group had already forgotten key steps in the procedure and took time to tackle the question. The results obtained from the two groups are as shown in the Figure 1.

Figure 1

Performance for both the Experimental Group and the Control Group



From the Figure 1, 80% of the learners in the experimental group were able to get above 60% in the test compared to 40% of the control group. In the contrary, while 20% of the experimental group learners garnered 60% and below, 60% of the control group learners scored below 60% of the test. Perhaps these results can be attributed to a positive attitude shift by the experimental group learners after conducting test of starch using the virtual lab. Some verbatim expressions from the experimental group learners include;

“I was able to see the color change to blue-black after I added iodine solution to the boiled leaf. This made it easy for me to describe this procedure.”

“I find it more fun to have these simulations to support the theories we have been taught. I love learning science this way because I understand the concepts better.”

The findings of this study clearly indicate that using virtual laboratories such as LabXchange can indeed make learning integrated science more engaging and fun for learners. Allowing learners to interact and explore these virtual lab platforms on their own, makes it possible for them to discover and understand concepts at their own pace. If such a method is embraced in the learning of integrated science, it can indeed help shift learners’ attitudes positively leading to improved performance. With improved attitudes and performance, learners can comfortably take up the STEM pathway which will precipitate in them pursuing STEM related careers. This will be in line with the government policy expectations that requires 60% of junior school learners to pursue STEM pathway at senior school. This is also in line with the global market landscape that emphasizes on scientific knowledge.

Conclusion

Teachers, especially in junior school, need to realize that fostering learner engagement in the learning process can have a significant impact on attitudes and performance of learners in a subject. Advancements in technology have enabled easy access to virtual labs such as LabXchange which can improve learners' experiences in the classroom. As learners interact with these virtual platforms, their understanding is enriched enabling them to apply classroom knowledge in solving real-life challenges. This is important in ensuring that many learners get interested in Integrated Science. Future studies can focus on the impact of these virtual labs on other learning areas like pre-technical studies and agriculture, where practical knowledge is required.

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VISION

An empowered, creative and innovative STEM society in Africa

MISSION

To continuously develop capacity in STEM education for sustainable development through training, research, innovation and partnerships with related ecosystems

