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A Universal Design for Learning Framework for Inclusive Primary Mathematics in Ghana: Adaptation and Implementation

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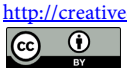

Abstract

This study proposes a Universal Design for Learning (UDL)-based framework to enhance inclusivity, engagement, and accessibility in Ghana's Primary 3 Mathematics curriculum. Although Ghana's Education Strategic Plan (2018-2030) emphasizes equity and quality, current instructional practices often rely on lecture-heavy methods that limit participation for students with diverse linguistic, cognitive, and sensory needs. Drawing on UDL's principles of multiple means of representation, action and expression, and engagement [1], this paper conceptually evaluates the existing curriculum and outlines strategies for its redesign. Literature from Ghanaian classrooms, UNICEF pilots, and international UDL applications informs the framework, which integrates culturally relevant pedagogy, locally sourced manipulatives, low-bandwidth digital tools, and co-teaching models. A phased implementation plan is proposed, including curriculum alignment, teacher training, pilot testing in diverse districts, and eventual scale-up with policy integration. Anticipated barriers such as limited resources, overcrowded classrooms, and insufficient teacher preparation are addressed through low-cost instructional materials, professional learning communities, and targeted professional development. Findings highlight UDL's potential to transform mathematics classrooms into inclusive spaces that promote equity, motivation, and deeper conceptual understanding. The framework provides curriculum developers, teacher educators, and policymakers with a practical model for embedding UDL in low-resource contexts while advancing Ghana's commitments under Sustainable Development Goal 4.

Subject Areas

Education, Curriculum Studies

Keywords

Universal Design for Learning (UDL), Inclusive Education, Primary Mathematics Curriculum, Culturally Relevant Pedagogy, Rural and Low-Resource Education, Ghanaian Education

1. Introduction

Policies that prioritize quality, accessibility, and inclusivity shape education in Ghana [2]. The Primary 3 Mathematics curriculum plays a key role in early education, introducing young learners to essential topics like arithmetic, geometry, measurement, and fractions. These foundational concepts are vital, as they not only build students' numeracy skills but also set the stage for their future academic growth. However, standardized, lecture-heavy approaches to teaching can sometimes limit engagement, comprehension, and inclusivity, especially for diverse learners [3] [4].

The Universal Design for Learning (UDL) framework provides a well-researched approach for developing flexible and inclusive learning environments that respond to a variety of learning styles and needs. Built around three guiding principles—offering multiple means of representation, action and expression, and engagement [1], UDL encourages diverse teaching methods, assessment techniques, and ways to engage students. Studies suggest that applying UDL in curriculum design can significantly enhance learning outcomes for students from different backgrounds [5].

According to the Ministry of Education [2], policies that provide the highest emphasis to quality, accessibility, and inclusiveness contribute to the development of education in Ghana. Primary 3 Mathematics is a curriculum that exposes young pupils to essential topics such as arithmetic, geometry, measurement, and fractions. Early education is heavily dependent on this curriculum. This set of basic notions is very important since they not only assist students in becoming more numerate but also prepare them for the academic progress that they will experience in the future. However, standardized, lecture-heavy teaching may often impede engagement, knowledge, and inclusion, especially for a varied student population [3] [4]. This is especially true for the inclusion of students from different backgrounds.

Even though Ghana is committed to providing an education that is equitable, there is still a significant gap between the goals of the legislative process and the actual classroom practices, particularly in the area of mathematics instruction for lower primary students [2]. It is still the case that many classrooms do not have a variety of teaching methods, resources that are sensitive to other cultures, and assessment techniques that are flexible enough to accommodate children who have varying linguistic, cognitive, and sensory needs [2]. This discrepancy has a disproportionately negative effect on students who have disabilities, children who

come from multilingual households, and children who need alternatives to traditional forms of participation. Without the implementation of inclusive frameworks that drive curriculum delivery, these children face the risk of becoming disengaged, underachieving, and experiencing long-term academic marginalization [2]. The framework known as Universal Design for Learning (UDL) provides a strategy that has been thoroughly investigated for the purpose of developing learning environments that are both inclusive and adaptive, and that cater to a variety of learning styles and requirements. The Universal Design for Learning (UDL) framework is based on three guiding principles: providing many forms of representation, action and expression, and engagement [1]. It offers a wide variety of instructional tactics, assessment methods, and ways to include students. Studies have shown that including UDL into the design of a curriculum has the potential to significantly enhance learning outcomes for students that come from a variety of different backgrounds [5].

In this study, we evaluate the Primary 3 Mathematics curriculum in Ghana using the UDL framework to identify ways it could better support students with different abilities, languages, and learning styles. By proposing a UDL-based redesign, this study aims to create a more inclusive, engaging, and accessible learning environment that aligns with Ghana's educational goals and meets the diverse needs of all students.

1.1. The Purpose of the Study

This study has three main objectives.

1) To Evaluate the Current Curriculum**:** The study scrutinizes the current Primary 3 Mathematics curriculum with a view to the challenges that need attention in order for the design to make mathematics inclusive, engaging, and accessible to all students.

2) To Propose UDL-Based Strategies for Enhancement: With the UDL framework in perspective, the study outlines concrete strategies on how to enhance multiple means of representation, action and expression, and engagement. These techniques address a number of learning styles, cultural backgrounds, and sensory needs and help make the curriculum more accessible and captivate a wider range of students.

3) Integrating a Co-Teaching Model: This study illustrates how a co-teaching model, which consists of educators with diverse strengths who complement each other, can enhance both the development and delivery process with the UDL principles. This model allows for a number of options for flexible instruction and individualized support for further enhancing curriculum inclusivity.

This study addresses the following objectives with a view to making the Primary 3 Mathematics curriculum more inclusive, dynamic, and effective in tackling the diverse needs of Ghanaian students. Ghana's educational goals of equity and quality inform the proposed redesign, which utilizes research-based best practices to create a learning environment that is both enabling and engaging.

1.2. Research Questions

1) How does the application of UDL principles in the Primary 3 Mathematics curriculum improve the inclusivity and engagement of diverse learners?

2) What specific strategies in content representation, student expression, and engagement can be effectively implemented to support students with varied learning preferences?

3) How can a co-teaching model facilitate the successful integration of UDL principles in Ghana's Primary 3 Mathematics curriculum?

1.3. Significance of the Study

This study is significant for policymakers, educators, and curriculum developers in Ghana as it provides a structured framework for embedding Universal Design for Learning (UDL) principles into the Primary 3 Mathematics curriculum. By prioritizing flexibility, cultural relevance, and inclusivity, the framework addresses the persistent gap between Ghana's policy goals of equity and quality education and the realities of classroom practice. Specifically, it responds to the needs of learners with diverse linguistic, cognitive, and sensory profiles, including children with disabilities, multilingual backgrounds, and those from low-income households.

Beyond supporting mathematics instruction, the study highlights the broader implications of UDL for teacher professional development and collaborative practice. The proposed co-teaching model strengthens teacher capacity by encouraging peer support and differentiated instruction, while Professional Learning Communities (PLCs) offer sustainable structures for sharing best practices. These innovations not only improve learner engagement and achievement but also provide educators with practical strategies for inclusive teaching in resource-constrained settings.

The findings contribute to both policy and practice by offering a research-informed model that aligns with Ghana's Education Strategic Plan (2018-2030) and global Sustainable Development Goal 4 commitments. In doing so, the study positions UDL as a viable pathway to transform Ghana's mathematics classrooms into inclusive spaces that advance educational equity and long-term academic success.

2. Literature Review

2.1. Universal Design for Learning: Theoretical Background

The UDL framework, thus far informed by cognitive neuroscience, has evolved as an inclusive instructional approach presumed to promote flexible pathways to support the diverse needs of learners [5] [6]. Recent research has demonstrated that UDL principles embedded in curriculum design enhance engagement for students and promote access to content through the provision of multiple means of representation, action and expression, and engagement [1] [7]. Indeed, as re-

flected by the meta-analysis conducted by [8], UDL has been effective in improving student results and catering to learner variability at every grade level.

Furthermore, the flexibility that UDL assures of can be of special help in mathematics, given that learners usually require some differentiation in approach so as to comprehend viewpoints that are sometimes complex and abstract. For those reasons, UDL is increasingly combined with emerging technologies in a way that further expands flexibility in learning contexts. According to [9], digital tools aligned with UDL principles promote interactive, engaging, and personalized learning experiences that address a wide range of learners' cognitive and sensory preferences. The flexible nature of UDL makes it an inclusive approach that solves not only disabilities but also sustains students with diverse cultural and linguistic backgrounds, hence suitable for an international setting such as Ghana [10].

2.2. Application of UDL in Mathematics Education

Given UDL's broad applicability, mathematics education provides a particularly valuable case for its integration. Mathematics education has also received effective applications of UDL in increasing engagement and enhancing understanding through multiple ways of engaging with the content. A study by [11] summarized that applying various instructional methods, which may include manipulative tools, visual aids, and interactive simulations, may answer the diversity of learning needs in mathematics classes. A study by [12] has documented that mathematics instruction using UDL, especially through hands-on activities and technology integration, increases the accessibility and attainment of students in foundational math skills. In practice, UDL emphasizes flexibility in the mode of instructional delivery, which matches recommendations by the [13] to connect abstract notions with real-world applications [13]. These include the use of manipulatives such as fraction bars, digital simulations, and word problems relevant to them. The students will be able to go at their own pace with a format that is more applicable to real life for them [14]. Digital platforms can also play a major role in UDL mathematics instructions. Online math games and graphing tools present side-by-side abstract ideas that can reinforce student learning where a purely text-based explanation has proven difficult. In fact, the incorporation of such tools into the curriculum demonstrated an increase in student motivation and promoted individualized learning opportunities for the students themselves.

2.3. Challenges and Opportunities toward UDL Implementation in Ghanaian Classrooms

It is expected that with the increasing emphasis on inclusivity and equity in the Ghana Education Strategic Plan of 2018-2030, the Ghanaian education system is becoming inclusive; however, all sorts of practical realities make the implementation of UDL principles difficult in Ghana. A study conducted by [15] listed some of the challenges which include limited resources, inadequately trained teachers, and overcrowding of students in classrooms in Ghana that may finally affect the

chances of UDL strategies being embraced indeed. Moreover, teachers usually lack the technical know-how and support needed in using technologies aligned with UDL, which provide diverse representation in mathematics education, such as interactive whiteboards and digital math manipulatives [16]. While these are valid challenges, the studies indicate that embedding UDL in a gradual manner, first dealing with low-resource strategies like using culturally relevant examples and peer collaboration, has the potential to make UDL more viable in resource-poor contexts [7]. A recent study by [17] show that co-teaching models, whereby teachers jointly design and deliver lessons, could be an effective solution to bridge the gap in teacher preparedness and implement UDL in Ghana. Co-teaching also allows differentiated support in classrooms where one teacher may deal with direct instruction, while the other provides support to pupils who need it more [9].

2.4. Proposed UDL-Based Framework for Primary 3 Mathematics Curriculum

Drawing from the literature, this study proposes a UDL-based framework to inform the design of Ghana's Primary 3 Mathematics curriculum in an inclusive and engaging way. This framework is embedded in the three essential UDL principles of multiple means of representation, multiple means of action and expression, and multiple means of engagement [1]. This approach aims to improve access to mathematical content, diversify the ways knowledge is represented, and enhance motivation through culturally relevant and personalized learning experiences.

2.4.1. Multiple Means of Representation

Providing diverse methods of content representation addresses the sensory, cognitive, and cultural differences in diverse learners, enabling them to engage with material in ways that suit their needs [5]. Research supports the use of visual, interactive, and concrete aids to make mathematical concepts both accessible and meaningful [8] [18].

1) Visual and Interactive Models

Research in cognitive science suggests that visual representations, including diagrams, pictorial aids, and interactive models, enhance mathematical understanding by helping learners visualize complex relationships [11]. Tools like number lines and pictorial representations can simplify operations such as addition and subtraction, while interactive digital simulations can dynamically model concepts such as fractions and geometric properties, benefiting visual and kinesthetic learners [12].

2) Concrete Manipulatives

The Concrete-Representational-Abstract (CRA) approach is widely validated as an effective method for mathematics instruction [19]. Concrete manipulatives, such as blocks, beads, and fraction tiles, offer students hands-on learning, building a strong foundation before moving to symbolic representations. Studies indicate that manipulatives enhance retention and comprehension, especially for kinesthetic learners [20].

3) Culturally Relevant Examples

Culturally responsive pedagogy helps students contextualize math problems in culturally familiar, real-world contexts [21]. Framing exercises within relevant contexts, such as examples from local markets, farming, or community activities—connects academic content to everyday life, which increases engagement and motivation [22] [23]. Research supports culturally rooted examples as a bridge between abstract concepts and students lived experiences, enhancing both coherence and relevance [24].

2.4.2. Multiple Means of Action and Expression

Incorporating varied methods for students to express knowledge allows them to communicate understanding in ways that align with their strengths, fostering inclusivity and minimizing barriers to participation [17]. This principle also promotes the development of critical thinking and communication skills essential for comprehensive mathematics education [14].

1) Diverse Assessment Options

UDL promotes diverse assessment formats beyond traditional tests, enabling students to demonstrate learning through visual models, oral explanations, and creative projects [1]. Research indicates that assessments aligned with students' strengths enhance engagement and retention [6]. For example, students might create a poster to illustrate subtraction steps or use visual storytelling to convey understanding of measurement concepts. Such assessments foster deeper understanding by offering multiple ways to demonstrate knowledge [25].

2) Project-Based Learning (PBL)

PBL aligns well with UDL by placing students in real-world problem-solving situations, promoting collaboration and critical thinking. Studies show that PBL enhances engagement and helps students apply mathematical concepts to real-life scenarios [9] [26]. In mathematics, students might plan a classroom event budget or measure items around the school, applying addition, subtraction, or measurement skills in practical contexts. PBL reinforces learning and prepares students for everyday mathematics applications [8].

3) Digital Portfolios

Digital portfolios enable students to document and reflect on their learning over time, capturing growth and understanding in a flexible format [27] [28]. Research suggests portfolios are an inclusive assessment model, accommodating diverse expression styles and allowing teachers to track progress more comprehensively than single test scores [28] Portfolios may include photos of completed work, audio recordings, and digital artifacts, offering a flexible and supportive approach to assessing learning outcomes.

2.4.3. Multiple Means of Engagement

UDL's principle of multiple means of engagement shows that students have to be provided with numerous ways of connecting and finding motivation in learning. Research supports that by providing choices and integrating culturally relevant

and goal-oriented activities, the students are motivated to work more autonomously and being more interested in their learning process [3] [29].

1) Gamification: Gamification or the integration of game-based elements like reward and challenge has proved to enhance motivation and persistence in math learning. By introducing gamification into Primary 3, math-based puzzles may incorporate points systems and progress badges to offer interactive and engaging learning opportunities for regular practice towards the core abilities in mathematics. Gamified learning experiences appeal to students' intrinsic motivations and build foundational math skills in an appealing and very low-pressure environment.

2) Choice Boards: Choice boards allow students to choose activities based on their interests, learning preferences, and readiness levels fostering a sense of autonomy and ownership over their learning. For example, a measurement unit might involve a choice board that requires students to measure objects in the classroom, estimate playground distances, or generate a graph using collected data. As with this choice board example, options are consistent with UDL's flexibility, where students are allowed to access content through means with which they feel comfortable and confident due to their personal interests and strengths

3) Setting Goals and Self-reflection: The literature on self-regulated learning and motivation supports encouraging students to set learning goals and to reflect on their progress. According to [29], goal setting enhances both motivation and performance because students have clear, personal objectives for which to strive. In the UDL-enhanced curriculum, students may set short-term goals in math, master addition in a week—developing reflections on one's progress each week. A growth mindset will be fostered in this manner, along with self-efficacy regarding mathematics.

2.5. Hypothetical Implementation of the Curriculum and Expected Results

In this session, we try to give a hypothetical application and expected results of how the re-designed curriculum can be implemented and what are the likely outcomes.

Hypothetical Scenario: A Primary 3 Mathematics teacher incorporates UDL-based approaches by creating learning stations with manipulatives, digital tools, and examples that are highly relevant to students' cultures. A co-teacher enters to facilitate smaller group work and offer extra support to students who may need it. Students rotate through centers, engaged in cooperative, project-based exercises that model how math is used in the real world.

2.5.1. Engaging

Promotes higher levels of engagement due to multiple means of accessing content and demonstrating knowledge either through hands-on activities or through interactive lessons.

2.5.2. More Accessible

Use of culturally relevant examples and multiple assessment formats will allow students of diverse backgrounds and abilities to feel that they are reflected and supported throughout their learning.

Improved Understanding: Visual, concrete, and digital tools facilitate students' learning of abstract concepts, further deepening their understanding of mathematics.

2.5.3. More Teacher Collaboration

The co-teaching model helps teachers to work to their strengths, making the learning environment more dynamic and supportive.

Empirical Support for UDL in Low-Resource and Ghanaian Contexts

While the present paper is conceptual in nature, the proposed framework is grounded in a growing body of empirical research that demonstrates the feasibility and impact of Universal Design for Learning (UDL) principles in low-resource educational settings, including Ghana.

A notable example is the UNICEF-led pilot of UDL implementation in Ghana between 2019 and 2021, conducted in the Ada West and West Gonja districts. The project involved 15 first-grade schools and 693 pupils, with a focus on training teachers to apply UDL principles through low- and no-cost instructional materials, such as cardboard and locally sourced manipulatives. The intervention resulted in the creation of a national cadre of over 200 trainers and produced measurable shifts in teacher practice, including increased use of multiple means of representation and culturally relevant examples. Importantly, the initiative also documented a positive shift in community attitudes toward disability and inclusive education, suggesting that UDL-based professional development can generate both pedagogical and socio-cultural benefits in Ghanaian schools [30].

Comparable evidence from other sub-Saharan contexts supports the transferability of UDL-based approaches to under-resourced mathematics classrooms. For example, a multiple case study in rural primary schools in South Africa examined five mathematics teachers' integration of UDL strategies. Data collected through classroom observations, focus groups, and lesson documents revealed improved student engagement, greater instructional flexibility, and more equitable access to mathematical content for learners with diverse needs [31]. These findings suggest that UDL can effectively address variability in learners' cognitive, sensory, and linguistic profiles even in settings with significant material constraints.

At a broader level, a meta-analysis of 18 empirical studies conducted between 2013 and 2016 provides quantitative evidence of UDL's positive impact on learning outcomes across general and special education contexts. The review reported consistent gains in student performance and engagement when instructional design incorporated multiple means of representation, action and expression, and engagement [8]. Although the meta-analysis spans multiple countries and contexts, its findings affirm the underlying pedagogical logic of the framework pro-

posed in this paper.

Evidence from Ghana's higher education sector further reinforces the applicability of UDL principles in the national context. In a mixed-methods study involving 122 students enrolled in an "Introduction to the History of Global Art" course, the application of UDL strategies, such as flexible assessment formats, collaborative activities, and multimodal content delivery, was associated with enhanced student motivation, improved collaborative learning, and strengthened critical thinking skills [32]. While this study was conducted at the tertiary level, it demonstrates the adaptability of UDL to Ghanaian educational settings and its capacity to foster inclusive learning outcomes.

Finally, while not a UDL-specific intervention, an AI-powered mathematics tutor pilot ("Rori"), delivered through WhatsApp to nearly 1000 Ghanaian students in grades 3 - 9, yielded a statistically significant improvement in mathematics scores (effect size = +0.37, $p < 0.001$) [33]. The success of this low-bandwidth, scalable technology intervention underscores the feasibility of integrating digital tools into mathematics instruction in Ghana, a key feature of the proposed UDL-based framework. Taken together, these studies offer robust empirical justification for the proposed application of UDL principles to Ghana's Primary 3 Mathematics curriculum. They collectively demonstrate that UDL-based strategies, particularly when adapted to local contexts, supported by teacher training, and augmented with low-cost or digital resources, can enhance student engagement, support diverse learning needs, and promote equitable access to mathematical learning in both Ghanaian and comparable low-resource environments.

2.6. Proposed Implementation Scenario and Plan

2.6.1. Pilot Scenario

Drawing upon empirical evidence from Ghana and other low-resource educational contexts [8] [30] [31], the proposed Universal Design for Learning (UDL)-based framework for Primary 3 Mathematics instruction is envisioned as a phased, contextually responsive intervention. In the pilot phase, the framework would be introduced in a small number of diverse districts—urban, peri-urban, and rural, to capture variability in infrastructure, resources, and learner needs. In a representative classroom, mathematics concepts would be presented through multiple modalities aligned with UDL principles of representation, action and expression, and engagement [1]. Instruction would combine locally sourced manipulatives such as bottle caps, sticks, and seeds to support the Concrete–Representational–Abstract (CRA) progression [19], culturally relevant examples from markets, farming, and crafts to enhance motivation [21], and low-bandwidth digital tools where feasible, following recent Ghanaian models [34]. A co-teaching model, adapted from [30], would enable one teacher to deliver core instruction while the other provides differentiated support. Learners would rotate through stations emphasizing tactile exploration, interactive simulations, and real-world problem-solving.

2.6.2. Implementation Phases

Implementation would unfold in three sequential stages. Phase 1: Preparation and Capacity Building (0 - 6 months) would focus on curriculum audits, teacher professional development workshops, and the creation of a locally adapted UDL toolkit. Phase 2: Pilot Implementation (6 - 18 months) would involve embedding UDL strategies into routine classroom practice through co-planning, co-teaching, and monthly Professional Learning Community (PLC) meetings, while teachers document lesson plans, maintain reflection logs, and integrate low-cost digital applications. Phase 3: Evaluation and Scale-Up (18 - 36 months) would combine quantitative and qualitative assessments to evaluate impact on learner engagement, comprehension, and inclusivity. Findings would guide refinement of the UDL toolkit and inform professional development modules, while policy briefs, developed in collaboration with the Ministry of Education, would support broader curriculum adoption.

2.6.3. Anticipated Challenges and Mitigation

Potential challenges include resource limitations, high teacher workload, and resistance to pedagogical change [15]. To mitigate these, the framework emphasizes gradual scaling to reduce teacher burden, reliance on existing PLC structures to avoid creating parallel systems, and the use of low-cost, high-impact materials validated in prior pilots. Recognition incentives and peer mentoring are also proposed to strengthen teacher buy-in and sustain momentum. By grounding the intervention in empirical precedents, strategically phasing activities, and anticipating systemic constraints, this UDL-based framework positions itself as both pedagogically robust and contextually feasible. Its design aligns with Ghana's Education Strategic Plan (2018-2030) and advances Sustainable Development Goal 4 by promoting equitable and quality mathematics education for all learners.

3. Discussion

This proposed framework of UDL in Ghana's Primary 3 Mathematics certainly provides a promising approach toward inclusion, engagement, and accessibility. By bringing together multiple means of representation, action, and engagement into one framework, it addresses diverse learners' needs and, therefore, supports Ghana's commitment to achieving equitable quality education. It has also been revealed that instructional tools and variations, such as manipulatives and examples relevant to students' cultural backgrounds, significantly enhance the performance of students in mathematics and deepen the level of engagement in mathematics classes. It helps students correlate the abstract concept with reality.

However, UDL is hard to be implemented in the Ghanaian context due to several resource limitations and the need for teacher training. Most consultations have, however, pointed out that a few of these digital tools and manipulatives are not widely available in Ghanaian classrooms, which could be a barrier to effective full use of UDL strategies. In this case, it may be useful to consider more gradual strategies: low-cost, culturally relevant materials could be introduced into the

classroom, such as local artifacts for measurement and counting, that make the use of Universal Design for Learning feasible.

Second, the partnership with NGOs and educational technology providers could promote digital resource access, which is a key component for interactive and flexible learning environments. For this reason, teacher training becomes a crucial condition for the realization of UDL's success; educators need to be guaranteed in confidence and skill for sustaining various teaching strategies. Training programs related to UDL and co-teaching models, as well as professional development, can offer a teacher the capability of differentiated instruction and hence build collaborative effort while giving support to learners individually. Co-teaching has been proven hopeful within the settings of inclusive practices when resources are at a minimal, for this approach splits the responsibilities among the teachers and hence supports the students more specifically. This framework will help mathematics education in Ghana, while also serving as a model for others, scalable to other subjects and grade levels to help achieve national goals for inclusive, quality education. Longitudinal studies might be used in the future to measure the long-term effects of UDL in early mathematics education, such as how inclusive strategies contribute to academic success in later years. Addressing these challenges and opening the door to UDL principles would bring Ghana closer to an inclusive and effective education system to address a wide range of students' needs.

4. Conclusions

The integration of Universal Design for Learning (UDL) principles into Primary 3 Mathematics instruction in Ghana represents a crucial step toward creating classrooms that are inclusive, engaging, and accessible to all learners. By employing multiple tools of instruction, leveraging culturally relevant examples, and diversifying assessment methods, UDL ensures that teaching is responsive to the diverse needs of learners while aligning with the Government of Ghana's broader agenda for equity and inclusion in education. Importantly, this framework not only enhances mathematical understanding but also fosters learner motivation, participation, and confidence, thereby shifting the classroom from a space of rote learning to one of active exploration and problem-solving.

Nevertheless, successful implementation requires confronting practical challenges such as resource constraints, teacher workload, and limited exposure to inclusive pedagogical strategies. While these barriers are significant, they are not insurmountable. Low-cost locally available materials, targeted teacher professional development, and partnerships with government agencies and NGOs provide pathways for scaling implementation in resource-constrained contexts. Furthermore, positioning Professional Learning Communities (PLCs) as a platform for peer mentoring and collaborative problem-solving offers a sustainable means of embedding UDL principles into everyday practice.

The potential of UDL in mathematics extends beyond a single subject or grade

level. Effective integration in Primary 3 can serve as a model for other curricular areas, supporting a systemic shift toward more inclusive pedagogy across Ghana's basic education system. This has implications for national policy, as UDL can be embedded within curriculum reforms, teacher education programs, and strategic initiatives outlined in Ghana's Education Strategic Plan (2018-2030). Beyond practice and policy, the framework also opens a critical research agenda.

Future research directions should focus on empirically testing the effectiveness of UDL-based mathematics instruction on learner outcomes across different contexts in Ghana, including rural and under-resourced schools. Longitudinal studies could track the impact of UDL on students' mathematical achievement, confidence, and long-term retention of concepts, while also assessing its influence on teachers' professional growth and instructional design. Comparative studies between UDL-integrated and traditional classrooms would provide deeper insights into how inclusive pedagogy shapes equity outcomes, particularly for learners with disabilities, multilingual backgrounds, or from low-income communities. Additionally, policy-oriented research examining how UDL can be formally embedded into teacher education curricula and national assessment frameworks would provide evidence to inform systemic adoption.

Ultimately, UDL offers a transformative opportunity to reimagine mathematics education as a space where every learner can participate fully, regardless of background, ability, or context. Its integration in Primary 3 mathematics is not only a pedagogical innovation but also a step toward fulfilling Ghana's commitments under Sustainable Development Goal 4, ensuring inclusive and equitable quality education for all. By addressing barriers pragmatically and building on local strengths, Ghana has the potential to lead the way in demonstrating how UDL can be adapted and scaled in low-resource contexts, setting an example for other nations pursuing equity-driven education reform.

Conflicts of Interest

The authors declare no conflicts of interest.

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