

Effect of Differentiated Instruction and Assessment Strategies on Primary Four Students' Achievement in Mathematics

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Abstract

The study investigated the effect of differentiated instruction and assessment strategies on the mathematics achievement of primary school learners in the Effutu Municipality in the Central Region of Ghana. A concurrent embedded mixed-methods design was used. This comprised a quasi-experimental and semi-structured interview. The population of the study consisted of all primary four learners and teachers in Effutu Municipal. Mixed sampling was used which included a simple random sampling to select 2 private and 2 public schools. Purposive sampling was used to select primary 4 and a convenient sampling to select participants for the qualitative data. An intact class was used to obtain the sample which consisted of 204 learners and 4 teachers for the study. Mathematics test items in the form of pre- and post-test were employed to collect the quantitative data. The test items were piloted which generated a reliability coefficient of 0.73. Semi-structured interview guide was also used to collect the qualitative data. Quantitative data collected were analysed using descriptive and inferential statistics. That of the qualitative were analysed using thematic content analysis. The findings revealed that learners who were taught mathematics with differentiated instruction and assessment strategies significantly achieved higher scores than those who were taught using conventional teaching and assessment approaches. Learners were of the view that differentiation increases learners' participation in mathematics lessons. The study recommended that differentiation should be adopted in all basic schools as it has the transformative potential to support diverse learning needs.

Keywords differentiated instruction; differentiated assessment; problem-based learning; conventional instruction

Introduction

In Ghana, successive governments have attempted to improve the standard of living of citizens through education by increasing access and ensuring inclusivity (Ministry of Education, 2015; National Council for Curriculum and Assessment [NaCCA], 2020). As boldly spelt out in the sustainable development goals [SDG], specifically Goal Four, in order to promote sustainable development, gender equality,

healthy lifestyles, human rights, global citizenship, and appreciation of cultural diversity, it is imperative that all affiliated countries make sure that all children receive free, and high-quality primary and secondary education by the year 2030 (United Nations, 2015). This, therefore, advocates for equitable opportunities in our educational system where all learners, irrespective of their gender, religion, race, social-economic status, cognitive ability,

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Effect of differentiated instruction and assessment strategies on Primary 4 students' achievement in mathematics

Mills, E. D., Nugba, R. M., & Asamoah-Gyimah, K.

etc. have the opportunity to learn. Differentiation of instruction and assessment has become critical in transforming contemporary classrooms beset with diversity.

Fundamentally, differentiation is based on the knowledge that every classroom contains a variety of learners with differing cognitive capacities, skills, learning preferences and needs (Algozzine & Anderson, 2007; Coyne, Kaméenui & Simmons, 2004; Chapman & King, 2003; Tomlinson, 2001). Theoretically, the justification for differentiation is premised on the fact that individuals possess different intelligence. According to Gardner's (1993) theory of multiple intelligences (MI), each person possesses diverse skill sets to varying degrees. According to Gardner (1993), learners differ in their achievement on tasks that call for the use of various bits of intelligence, indicating that they have different intellectual profiles, strengths and weaknesses in various domains.

The justification for differentiation and hence the reason for this study is that, within the framework of ensuring equitable opportunities, mathematics and science must be recognised as critical components of quality education for everyone; given the rapid advancements in technology that define the twenty-first century (NaCCA, 2020). Hence, young people need to be well-prepared in mathematics if they want to be relevant and capable participants in the worldwide world that lies ahead of them (NaCCA, 2019).

However, achievement in mathematics at the primary and junior high school levels has been below expectation over the past years (MoES, 2004; Anamuah-Mensah & Mereku, 2005; Anamuah-Mensah, Mereku & Ghartey-Ampiah, 2008; Mills & Mereku, 2016; NaCCA, 2019 & 2020). The government, educators, parents, and

all other interested parties have expressed concern about the steadily declining standards in mathematics. Reports from the Standards-Based (2019) and Common Core Programme (2020) Mathematics Curricula for Primary and Junior High Schools respectively outline clearly that the government was worried about the decline in standards in mathematics (NACCA, 2019 & 2020).

These poor achievements are also evident in the Central Region and the Effutu Municipal where this study was carried out (MOE, 2022, Mills & Mereku 2016). WAEC data on BECE for the period of 2015 to 2023 indicate that Effutu is among the bottom four constituencies in the Central Region in terms of achievement in mathematics (WAEC, 2023). Further, report based on the 2021 Primary 4 National Standardised Test (NST) indicates that only 38% of learners achieved the necessary level of functional numeracy competence (MoE, 2022). This data provides a precise indication of the extent of mathematical learning difficulties among upper primary learners in the country. The disappointing mathematics achievement in the recent NST at the national level is mirrored in the Central Region, including the Effutu Municipal area. The 2021 NST results reveal that over 70% of learners in the Central Region scored below the proficiency score in mathematics. These poor performances, spanning over two decades, suggest that there is a clear practical gap in literature since the various interventions put in place to improve achievement seem to have not yielded satisfactory results.

NaCCA (2019) indicates that poor achievements in mathematics at both primary and JHS is, to a large extent, a reflection of the "one size fits all approach" to pedagogical and assessment strategies being used in the school system characterised by diversity. NaCCA

explains that, learners, to a large extent, are taught the same way irrespective of their unique learning needs.

Contemporary studies that have delved into the effect of differentiation in many diverse contexts including Ghana have shown that the methodology and its strategies have the potential of transforming the mathematics classroom to an engaging one and increase learners' learning gains. However, empirical studies have shown conflicting findings about the effect of differentiated instruction and assessment on learners' achievement. Thus, whereas some research studies demonstrated a substantial difference between differentiation and regular traditional instruction, (Koeze, 2007; Chamberlin & Powers, 2010; Karadag & Yasar, 2010; Stavroula, et al., 2011; Joseph, et al., 2013; Aliakbari & Haghigi, 2014; Dosch & Zidon, 2014; Melka & Jatta, 2022; Owusu-Ansah & Apawu, 2022), others showed no such difference (Ducey, 2011; Westbrook, 2011; Vincent, 2012; Williams, 2012 Gubbins, et al., 2013; Maxey, 2013). Clearly, there is a lack of adequate data on the efficacy of differentiated instruction and assessment, and other studies' results have been inconsistent leading to an empirical gap therefore, additional research is needed in this respect.

It is evident that although differentiation has the potential of helping learners in multi-ability classrooms to improve their achievement in mathematics as espoused by numerous experts and research findings, some gaps continue to exist. Hence, evidence must be gathered to address these gaps. Again, with a growing interest in differentiation in Ghana and its inclusion in all basic school curricula (NaCCA, 2019; 2020), it is perhaps the right time to delve into the model to understand how it works within the Ghanaian context.

The study was guided by the following questions:

1. How does differentiated instruction and assessment impact achievement in mathematics of primary four learners at Effutu Municipality?
2. What views do learners have about the incorporation of differentiated instruction and assessment into their mathematics lessons?

Methodology

A concurrent embedded mixed methods design (Creswell, 2009) was employed for this study. The primary method that was used is a quasi-experimental approach to generate the quantitative data. The secondary method was qualitative descriptive approach by means of interview to gather the qualitative data for the study. The mixing of the data from the two methods is to integrate the information to provide an overall composite assessment of the problem. The population for this study comprised all primary 4 learners and mathematics teachers in Effutu Municipal. The study used a mixed sampling for the selection of schools and participants. Four primary schools, comprising two public and two private schools, were selected. The sample for the study was 208 participants. The total number of learners were 204. Four (4) teachers were selected to participate in the study. Two for the experimental schools and two for the control schools. Data for the study were gathered using two instruments, comprising test items (pre-test and post-test) and semi-structured interview guides. The test items were employed for collecting quantitative data. The test was composed into two sections, A and B. Section A had 30 multiple choice items with four options and Section B had 8 essay items where learners were to work out and supply their own answers. Overall, 40% of the items covered knowledge and understanding and 60% covered

Effect of differentiated instruction and assessment strategies on Primary 4 students' achievement in mathematics

Mills, E. D., Nugba, R. M., & Asamoah-Gyimah, K.

application and reasoning. The semi-structured interview guides were used as the instrument for collecting qualitative data.

The entire duration of the study was 13 weeks. Thus, it lasted the entire third term of the basic school academic calendar. Necessary authorisation was obtained from all required institutions since the

learners' consent had been sought through their parents, their consent was orally sought again before the administration of the treatment.

Implementation of the treatment followed strictly the scheme of learning and the lesson plans designed in collaboration with the teachers in the experimental schools/groups. The four strategies

Table 1 Differentiated Activities

Key notes on Differentiated learning and assessment

Learners will be put in mixed-ability groups during the practice part of the lesson; however, learners will be given individual expectations and success criteria.

Approaching Proficiency Learners:

Content: Questionnaire with 3 questions

Process: Oral presentation of questions individually and in groups

Product: Allow learners to present at least 3 questions orally.

Proficient Learners:

Content: Questionnaire with 5 questions

Process: Oral and written presentation of questions individually

Product: Accept a combination of oral and written presentation of at least five questions.

Highly Proficient Learners:

Content: Questionnaire with 7 questions

Process: Written presentation of questions individually

Product: Accept written presentation of at least **seven** questions.

study involved minors. Before the treatment was implemented, the teachers were given a week training on the concept of differentiation and its benefits as well as the elements of differentiation (content, process, product). They were also given hands-on training on the strategies used for the treatment. They strategies included independent study, tiered activities, flexible grouping and problem-based learning. Finally, teachers were trained and supported to prepare their learning plans integrated with the elements of differentiated instruction and assessment.

Pre-testing and Treatment

Before the treatment was implemented, the pre-test was conducted involving 204 learners from all four schools. Although

employed in the treatment as stated earlier were tiered activities, flexible grouping, problem-based learning and independent study. The tiered activities were done in three ways;

Tiered Content: here the teacher made sure that the central idea of the topic being taught was the same for all learners, but varied the complexity between the tiers. Learners were assigned different tiers based on the group they belonged to. For example, during the teaching of data handling where learners were to *construct graphs by applying knowledge of one-to-one correspondence*, they were engaged in problem-based learning where they constructed their own questionnaire to collect data among their friends to construct the graph. In differentiating this

activity, the teacher maintained the central idea of “constructing a questionnaire”, however, the complexity of the content was different for different groups of learners as shown in Table 1.

Tiered Process: Under the tiered process the teacher used various approaches to achieve the learning indicator. Learners were given the opportunity to choose the procedure that best fits their learning preferences or degree of preparation. For instance, in the same example of the lesson on data handling, some groups of learners were offered the opportunity to use oral means of data collection and presentations. Others used written presentations, whereas others combined oral and written means of data collection and presentations.

Tiered Product: In the tiered products, teachers gave learners the opportunity to demonstrate their learning in different ways based on their interests, capacity, or levels of readiness. Also, in the same lesson used in the earlier examples, the teachers used different tiers for the different groups of learners. The expectations from the various groups were differentiated.

A one-hour observation each for two

two teachers and six learners from the experimental schools. The focus of the interviews was to solicit their views about the incorporation of differentiated instruction and assessment strategies in their mathematics lessons.

Data Processing and Analysis

Both descriptive and inferential statistics were used to analyse the data on research question one. However, before these inferential statistics were carried out, the normality assumption was carried out and was met. For the one-way ANCOVA, additional assumptions were tested which included measurement of covariate prior to the experimental manipulation, reliability of the covariate, correlations among the covariates, linearity and homogeneity of regression slopes. A thematic content analysis was carried out for research questions 2 & 3 following a five-step approach by Creswell and Creswell (2018). The two sources of data were integrated to offer a holistic view of the impact of differentiated instruction and assessment on primary school learners' achievement in mathematics.

Result

Table 2 *Descriptive statistics of the experimental and control groups post-test results*

Type of teaching method	Mean	Std. Deviation	N
Differentiation	52.29	21.11	108
Conventional	41.06	15.23	95
Total	47.03	19.38	203

visitations each week was scheduled at each teacher's convenience. These visitations were to ascertain whether teachers were heeding to the fidelity of implementation (FOI) as discussed and practised during the training. The post-test was administered during the 11th week of the term. The number of learners who took part in the post-test were 203. Interviews were held after the post-test involving the

Effect of differentiated instruction and assessment on the mathematics achievement of primary four learners at Effutu Municipality

Table 2 presents the means and standard deviations of the dependent variable for both set of scores for the experimental and control groups.

Effect of differentiated instruction and assessment strategies on Primary 4 students' achievement in mathematics

Mills, E. D., Nugba, R. M., & Asamoah-Gyimah, K.

Results in Table 2 indicate that learners in the experimental group obtained a mean score of 52.29 and a standard deviation of 21.11. Thus, the average achievement of participants in the experimental group on the dependent variable is approximately 52. The standard deviation gives an indication that there is a relatively high degree of variability within this group, with regards to the spread of scores around the mean. The results further show that the control group obtained a mean score of 41.06 with a standard deviation of 15.23.

subsequent ANCOVA analysis. Thus, it provided the foundation for meaningful inferences to be drawn from the effects of the two instructional methods while controlling for the influence of the covariate.

A one-way between-groups ANCOVA was conducted to compare the effectiveness of using differentiated instruction and assessment in teaching mathematics compared to the use of the conventional approach to teaching

Table 3 *One-way analysis of covariance results*

Tests of Between-Subjects Effects						
Dependent Variable: POST-TEST						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	42438.541 ^a	2	21219.27	126.95	.00	.56
Intercept	2400.18	1	2400.14	14.359	.00	.07
Pre-test	36071.51	1	36071.51	215.80	.00	.52
TOTM	9860.02	1	9860.02	58.99	.00	.23
Error	33430.22	200	167.151			
Total	524954.00	203				
Corrected Total	75868.76	202				

a. R Squared = .559 (Adjusted R Squared = .555)

This means that participants in the control group achieved an average score of 41 on the dependent variable. The standard deviation indicates a somewhat lower degree of variability around the mean score within this group compared to the experimental group. It can be inferred from the higher mean score obtained by the experimental group that, averagely, participants who received differentiated instruction and assessment achieved higher scores compared to those in the control group who received conventional instruction.

In summary, the descriptive analysis has indicated that initial differences exist between the achievement of learners in the experimental group and the control group. These findings provide a valuable information for the interpretation of the

mathematics among primary four learners. The independent variable was the type of teaching method (differentiated teaching and assessment method and conventional teaching and assessment method), and the dependent variable comprised scores on the mathematics test administered after the completion of the intervention. The analysis included the covariate which was the pre-intervention scores serving as control for any potential pre-existing differences between the groups. Again, it included the assessment of several key assumptions. These were normality, linearity, homogeneity of variances, homogeneity of regression slopes, and the reliable measurement of the covariate. It was determined that there were no violations of any of the assumptions under consideration, hence ensuring the

robustness of the ANCOVA results. Table 3 presents the ANCOVA results.

Results from Table 3 show that after controlling for the covariate, the ANCOVA produced a statistically significant difference in the post-test scores between the experimental and control groups. The significant differences can be referenced from the F-statistic which produced a value of 58.98 with 1 and 200 degrees of freedom. The p-value produced a value of 0.00 indicating a highly significant difference between the achievement of the experimental and control groups. This significance is further corroborated by the effect size, as indicated by the partial eta squared value of 0.23, indicating that approximately 23% of the variance in the post-test scores can be ascribed to the type of teaching method after taking into account, the impact of pre-intervention scores. Table 4 presents the adjusted means for both the experimental and control groups post-test scores after the effect of the covariate has been removed.

Results in Table 4 show that the

covariate (pre-test score) was held constant at a value of 39.86 when estimating the means.

The difference in means between the groups (approximately 14.05 points) suggests a substantial effect of the differentiated teaching and assessment method on the experimental group's achievement on the post-test, after controlling for the influence of pre-test scores. This provides strong evidence in support of the effectiveness of the differentiated teaching and assessment method compared to the conventional and assessment method.

What views do learners have about the incorporation of differentiated instruction and assessment into their mathematics lessons?

The major theme that emerged from the analysis of the data is positive impact of differentiated learning in mathematics which describes how learners felt about being part of differentiated mathematics lessons.

The theme is supported by four (4)

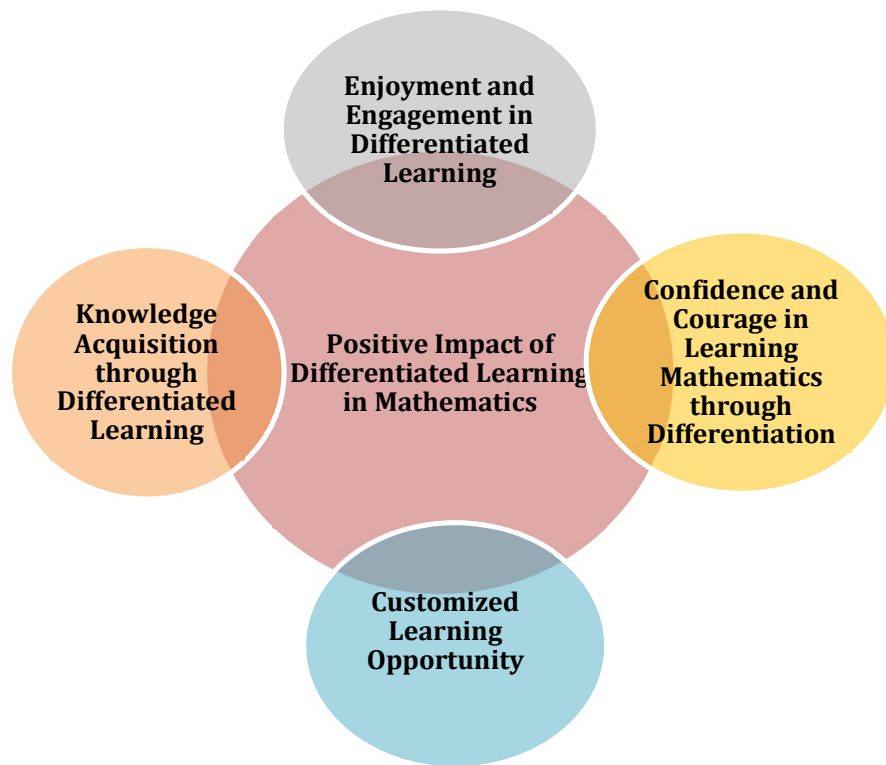
Table 4 Means and standard errors for post-test scores

Type of teaching method	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Differentiation	53.61 ^a	1.25	51.15	56.07
Conventional	39.56 ^a	1.33	36.94	42.19

a. Covariates appearing in the model are evaluated at the following values: Pre-test = 39.86.

experimental group obtained a mean score of 53.61 in the post-test. The 95% confidence interval ranged from 51.15 to 56.07. This means that, the true achievement of the experimental group lies between this interval, giving a reasonable confidence. Again, from the results, the control group recorded a mean score of 39.56. Similarly, based on the sample data, there is reasonable confidence that the true population mean score on the post-test for the control group falls within 36.94 to 42.19 at the 95% confidence interval. The

subthemes; enjoyment and engagement in differentiated learning, confidence and courage in learning mathematics through differentiation, knowledge acquisition through differentiated learning, and customised learning approach which sum up how learners perceived learning mathematics in a differentiated classroom. Figure 1 depicts the main theme as well as the four sub-themes that summarise learners' views about differentiation in their mathematics lessons.



The first subtheme which characterises the positive impact that differentiated instruction and assessment strategies had on learners in their mathematics lessons was *enjoyment and engagement in differentiated learning*. This finding has been expressed in the following responses:

*Because differentiation entertains me...
(Learner B)*

This response suggests that the learner finds differentiated learning in mathematics enjoyable and engaging. The enthusiasm expressed in the participant's response points to the importance of aligning instructional approaches to individual learning styles and preferences.

The second subtheme that explains the main theme is *confidence and courage in learning mathematics through differentiation*. It is imperative to acknowledge that most young learners perceive mathematics as a challenging subject which requires rigorous calculations and hence mostly learn the

subject by rote memorisation as opposed to developing conceptual understanding of the mathematics contents and its real-life applications in everyday situations (Mills & Mereku, 2016). It is therefore imperative to encourage learners and engage them in activities that boost their confidence and offer them the opportunity to learn mathematics irrespective of their ability, background, gender, etc. Perhaps, a differentiated approach to teaching and learning of mathematics can be said to offer such opportunities for diverse learners. This idea is captured in the following interviewee response:

Because differentiation makes me have more courage so that I can be able to learn more mathematics... (Learner D)

This response highlights differentiation's potential to boost learners' self-confidence when it comes to tackling mathematical challenges. This theme echoes the current conversation about the need to nurture a growth mind set among learners. Hence, coming to the realisation that differentiation creates the kind of

environment where learners feel encouraged to cope with mathematical concepts supports present-day conceptualisation and understanding of pedagogical strategies. It reiterates the idea that differentiated instruction not only tackles the diversity of learning styles but also develops in learners, a sense of self-belief.

The third subtheme that explains the main theme is *knowledge acquisition through differentiated learning*. Learners' responses to the interviews provided a noteworthy finding focusing on enhanced knowledge gain. The data showed that differentiated learning strategies significantly contributed to a deeper understanding of mathematical concepts among learners. This is expressed in the following learner's view:

Because it helps me. Sometimes it makes me get more knowledge in mathematics ... (Learner E)

This response demonstrates that differentiated learning provides learners the opportunity to acquire knowledge and understanding in mathematics. Clearly, learners believe that they have been given the opportunity to showcase their capabilities in solving mathematics problems through a more flexible classroom environment that takes into consideration their uniqueness and appreciates their efforts. This means that once again the idea of one-size-fits-all approach to teaching is insufficient in addressing the diverse learning needs of primary school learners.

The fourth subtheme that explains the main theme is *a customised learning approach*. The finding re-echoes the importance of targeting instruction to individual needs and abilities. The following responses corroborate this finding:

'Because differentiation makes me learn the way that I like to learn... (Learner F)

Because differentiation makes me learn my own way... (Learner A)

Because it helps me to know about what I love to learn... (Learner C)

These statements underscore the importance of individualised learning methods and the role differentiation plays in facilitating this. Indeed, being given the opportunity to learn the way one likes to learn is the hallmark of contemporary theories about learning that characterises the 21st Century.

Discussion

The findings of this study speak to the positive impact of differentiated instruction on primary school learners' achievement in mathematics. The analysis revealed clearly that participants in the experimental group, who received differentiated instruction and assessment, achieved a notably higher mean score compared to those in the control group who were taught using conventional instruction and assessment methods. Further analysis using one-way between groups ANCOVA showed that, there is a statistically significant difference between the two groups in terms of their achievement on the post-intervention mathematics test. The effect size indicated that this difference is substantial. The significant result suggests that the type of teaching method employed had a considerable impact on the post-intervention scores in the mathematics test. This finding is qualitatively corroborated by learners who are of the view that differentiated learning approaches in mathematics had a positive impact on them, making the learning process more engaging, effective, and tailored to their individual preferences and needs. This finding reinforces the pivotal role of differentiated instruction and assessment in enhancing learners' enjoyment and engagement in mathematics, ultimately contributing to improved achievement.

Effect of differentiated instruction and assessment strategies on Primary 4 students' achievement in mathematics

Mills, E. D., Nugba, R. M., & Asamoah-Gyimah, K.

These results corroborate numerous research that have consistently reported the benefits of employing differentiation in teaching multi-ability classroom. Studies by Chamberlin and Powers (2010) observed greater improvements in the learning of mathematics of tertiary-level students who received differentiated instruction and assessment, providing further verification for the positive effects of differentiation on learning at both lower and higher education levels. Additionally, Joseph, et al (2013) reported that learners reacted satisfactorily to differentiated instructional strategies, showing increase in their achievement and interest, generally, in learning. Several other studies by Kadum-Bonjak and Buri-Krianac (2012); Gavin et al. (2013); Mulder (2014) and Bal (2016) all found pieces of evidence that speak to the substantial improvements in learners' achievement in mathematics as a result of the use of differentiated instruction and assessments.

Further, the findings align with the research of Owusu-Ansah and Apawu (2022) who reported that Junior High School teachers in Effutu, Ghana indicated that differentiated instruction brought high interest among their learners and in instances where learners had not shown interest prior to the implementation of the treatment become active participants and demonstrated enthusiasm towards lessons. Again, the present study's finding corroborates that of Casa et al. (2017) who similarly found statistically significant effects of differentiated teaching and assessment on academic achievement of learners in mathematics. Hence, these studies throw weight in support of the findings of the present study, accenting to the use of differentiated instruction and assessment as a potential teaching approach to improving learners' learning, especially in mathematics and within the Ghanaian context.

It is however important to acknowledge that while the differentiated approach led to a remarkable positive impact on learners' achievement as indicated by the findings in this study and numerous other studies, the magnitude of this effect vary across different studies. Studies by Deunk et al. (2018) and Smale-Jacobse et al. (2019), recorded modest to reasonable effects on the academic achievement of learners that participated in those studies. It is therefore imperative to acknowledge that the efficacy of differentiation and its strategies may be affected by numerous factors within the context where the methodology is being implemented. Such factors may include the specific differentiated instructional and assessment strategies employed, the level of rigor with regards to the implementation activities, the peculiar challenges, and the particular subject matter.

The finding of the present study, however, is in contradiction to studies by Vincent (2012); Williams (2012); Gubbins, et al. (2013) and Maxey (2013) as they found no significant difference in achievement between learners who were taught with differentiation approach and those taught with the conventional approach to teaching and assessment.

Conclusions and Recommendations

Based on the findings, it was concluded that differentiation positively impacts on achievement of primary school learners in the learning of mathematics. That is, differentiated instruction and assessment in an effective approach to improving the learning of mathematics compared to conventional teaching methods. Further, differentiation positively influences active classroom engagements and interactions among learners. It also extends to learners facing challenges or having reservations about mathematics; thus, differentiation has the potential of significantly supporting learners who are considered to show no interest in mathematics. Hence, it

effectively bridges learning gaps and empower learners to comprehend mathematics concepts with confidence. It is recommended that differentiation should be adopted in all Ghanaian basic schools and teachers must create the kind of classroom environment that support differentiation to optimize the learning experiences of learners. Also, Ghana Education Service (GES) must continue to support teachers with resources and encourage them to engage in continuous professional development programs to enhance understanding and implementation of differentiated instruction and assessment strategies which underline that fact that true educational impact arises when learners are at the centre of the entire learning process and are met where they are to honour their preferred learning pathways.

Disclosure statement/ Conflicts of Interest

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Informed Consent Statement

Informed consent was obtained from all subjects involved in this study.

Data Availability Statement

The data presented in this study are available on request from the author since this research was conducted on students, for which their teachers gave consent.

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Effect of differentiated instruction and assessment strategies on Primary 4 students' achievement in mathematics

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