Journal of Research and Advances in Mathematics Education

Volume 7, Issue 2, April 2022, pp. 64-76
DOI: 10.23917/jramathedu.v7i2.16863
p-ISSN: 2503-3697, e-ISSN: 2541-2590

In-service mathematics teachers' knowledge of differentiated instruction

Patrick Kyeremeh[1*], Nixon Saba Adzifome[2], Emmanuel Kojo Amoah[3]

[1] *Department of Mathematics/I.C.T, St. Joseph's College of Education, Bechem, Ghana*
[2] *Department of Basic Education, University of Education, Winneba, Ghana*
[3] *Department of Mathematics Education, University of Education, Winneba, Ghana*

Citation: Kyeremeh, P., Adzifome, N. S, & Amoah, E. K. (2022). In-service mathematics teachers' knowledge of differentiated instruction. *JRAMathEdu (Journal of Research and Advances in Mathematics Education), 7*(2), 64-76. https://doi.org/10.23917/jramathedu.v7i2.16863

ARTICLE HISTORY:
Received 25 December 2021
Revised 19 March 2022
Accepted 21 March 2022
Published 30 April 2022

KEYWORDS:
Differentiated instruction
Mathematics teachers'
Content
Process
Product

ABSTRACT

This study sought to investigate in-service mathematics teachers' knowledge of differentiated instruction in junior high schools in Tano South Municipality of Ghana. The study adopted an explanatory sequential mixed method design. We employed a sample of 50 JHS mathematics teachers comprising 41 general in-service teachers and 9 special in-service teachers in the quantitative study through a proportionate stratified sampling technique. In the qualitative phase, 6 JHS mathematics teachers comprising 4 general in-service teachers and 2 special in-service teachers were purposively selected and interviewed. In line with the design adopted, the quantitative data obtained through a questionnaire was first collected and analysed. This was followed by the qualitative data obtained through semi-structured interviews. The quantitative data were analysed using both descriptive statistical tools (such as frequency counts, percentages, mean, standard deviation, and average per item rating), and inferential statistical tools (independent samples t-test). Qualitative data used inductive content analysis. Among the findings, we found no statistically significant difference in the knowledge scores on differentiated instruction for general in-service teachers and special in-service teachers ($t = -0.80$, $df = 48$, $p > 0.05$). We, therefore, recommend teacher education institutions review their mathematics curriculum to reflect the use of differentiated instructional approaches among mathematics teachers.

INTRODUCTION

Throughout the years, the Ghanaian Government has stressed inclusion in education by using various policies such as the Accelerated Development Plan in 1951, the Education Act of 1961 and the Inclusive Education Policy to facilitate discussions on how to include all learners irrespective of one's ability (MoE, 2015). This inclusive education policy acknowledges the diverse learning needs of students, and requires all stakeholders in the sector of education to address these needs under the universal design for learning (UDL) programme in a conducive learning environment (Kyeremeh, Amoah & Sabtiwu, 2021). This policy seeks to realise the nation's goal for creating the enabling environment to address the varied educational needs of individuals within the country. Differentiated instruction, therefore, provides a vehicle for attaining this goal (Ireh & Ibeneme, 2010).

Differentiated instruction, according to Tomlinson (2001, 2015), is a philosophy of teaching that empowers teachers to meet the diverse needs of students in the classrooms by employing varied instructional approaches. In the quest to differentiate instruction, teachers first need to recognize

*Corresponding author: pkyeremeh@joscobechem.edu.gh

students' relevant previous knowledge, their readiness, learning profile and interests, and tailor instruction responsively. There are key elements that frame differentiated instructional practices in education. Tomlinson (2001) identifes content, process, and products as the main elements of the school curriculum that can be modified. It is hypothesized that teachers who are familiar with students' varied learning need such as readiness, learning profile and interests will be more likely to differentiate them (Santangelo & Tomlinson, 2012). Tomlinson (2005b) explained content to be the material being learned by a student. Content differentiation, therefore, requires teachers to adapt their teaching to enable learners to access these materials. Process differentiation, according to Tomlinson (2014), refers to the way in which students access the material. This presents instructional activities in a way that validates students' process of learning in the classroom. When teachers differentiate the process, they teach the same concept or skill to each student; however, how each student makes sense of the topic or skill can vary. Product refers to how a student shows what he or she has learned (Tomlinson, 2005a). In differentiating product elements, students are allowed to select their own way of showing mastery of the content taught (Richards-Usher, 2013; Watts-Taffe *et al.,* 2012). They argue that effective product differentiation offers learners clear and appropriate criteria for success; focuses on real-world relevance and application; promotes creative and critical thinking; and allows for varied modes of expression.

The new Ghanaian primary school mathematics curriculum emphasizes inclusion and sees differentiation of instruction as one of the strategies to achieve the goal of ensuring that "all learners have the best possible chance of learning" (National Council for Curriculum and Assessment (NaCCA), 2019: 16) and for scaffolding learners to gain a stronger understanding and greater independence in the learning process. The document indicates that in a case where a learner fails to attain readiness for the next phase of education "a compensatory provision through differentiation should be provided to ensure that such a learner is ready to progress with his/her cohort" (p. 15).

Differentiation is thus defined in the new curriculum as:

> "a process by which differences (learning styles, interest, and readiness to learn) between learners are accommodated so that all learners in a group have the best possible chance of learning. Differentiation could be by content, tasks, questions, outcome, groupings and support" (NaCCA, 2019, p. 16).

The documents, for the purpose of emphasis, further elucidate the different ways of implementing differentiation. Differentiation by task-where the teacher sets different tasks for learners of different abilities to attain the same academic goals, differentiation by support- where teachers refer learners to the Guidance and Counselling Unit for academic support and differentiation by outcome, which "involves the teacher allowing learners to respond at different levels. Weaker learners are allowed more time for complicated tasks" (NaCCA, 2019, p. 16).

The success of differentiated instructional practices as an effective methodology for teachers is established in the literature. Earlier studies (e.g., Subotnikl, Olszewski-Kubilius & Worrell, 2011; Welsh, 2011) have established that differentiation of instructions supports all students learning, however, there are few evidence in the literature that show teachers' knowledge of differentiated instruction. Joseph (2013) in his study among pre-service and in-service teachers in Trinidad revealed similar findings. The findings indicated that most teachers showed a fair understanding of the concept of differentiation. In Ghana, the situation might not be different as some studies have revealed that teachers in our schools have a fair knowledge of differentiated instruction. Abora's (2015) study found that the majority of teachers had at least fair knowledge of major concepts and practices of differentiation (even though they were not aware that those were concepts and practices of Differentiated Instruction). Whipple (2012) in a study explored teachers' understanding of differentiated instruction and how they implement it at the elementary level through to the sixth grade. From the findings, teachers put content in first place for understanding. Overall, teachers were found to have possessed a high level of knowledge of differentiated instruction.

In Ohio, Schwarber (2006) in a study compared general education and special education teachers' knowledge, concerns, and confidence in adapting instructions to meet students with special needs. A sample of 166 comprising 105 general education teachers, 29 special education teachers, and 32 other educational professionals were recruited for the study. From the findings, it was revealed that special education teachers had more knowledge and high self-efficacy in structuring

teaching to meet the varied needs of individuals especially children with autism than their general education teacher counterparts. Consistently, Cambell-Whatley, Obiakor and Algozzine (1995) in their study found that special educators' skill levels in differentiating instruction to meet students' diverse needs were found to be higher than their general education counterparts irrespective of ones' years of experience in the field of teaching. Usually, general education teachers do not take special courses that focus on adapting instructions to meet the varying needs of students including those with special educational needs. And so, they are usually overwhelmed when students with special educational needs who should have been taught by special education teachers are placed in their classrooms (Kyeremeh *et al*., 2021).

Contrary to the findings of this study, a mixed study conducted by James (2009) to investigate teachers' perceptions of differentiated instruction and its implementation in day-to-day teaching within the classroom confirms the opposite. According to James (2009), the findings support the premise that teachers have adequate knowledge of differentiated instruction. Consistent with James's (2009) findings is that of Abora (2015) which revealed primary school teachers possessed adequate knowledge in differentiated instruction. Abora (2015) also conducted a mixed-method research design to investigate Ghanaian primary school teachers' knowledge and practice of differentiated instruction. The findings of Abora indicated that primary school teachers possessed a higher level of knowledge on the aspects of differentiation in general. However, there was variability in terms of their level of knowledge. The process was rated the highest element followed by product with content been the least. In contrast to these findings, Melesse (2015) indicated that the majority of primary teachers have a low perception of differentiated instruction. Melesse conducted a descriptive survey to assess primary school teachers' perceptions, practices, and challenges associated with the implementation of differentiated instruction. The findings from the study revealed teachers' low perception of differentiated instruction. Teachers attributed this low perception to the lack of adequate training on how to employ differentiated instruction in the classroom. This could be due to the fact that differentiated instruction was a new concept.

Zelalem, Melesse, and Seifu (2022) in their study examined teacher educators' self-efficacy and perceived practices of differentiated instruction in Ethiopian primary teacher education programs. Their findings revealed that most of the teacher educators have not had any training in differentiated instruction and therefore had low knowledge about differentiated instruction to be able to implement it effectively. Mengistie (2020) also in a study explored primary school teachers' knowledge, attitude, and practice of differentiated instruction in the Amhara Region. From the findings, it was revealed that basic school teachers apparently had an adequate level of understanding of differentiated instruction; however, they showed a lack of knowledge of specific strategies that can be employed to manage students in mixed ability classrooms.

It is obvious from literature that how knowledgeable teachers are about differentiation and its practice has ramifications for implementation and ultimately the impact on the learners. Hence, further studies that add information to the weight of evidence on this subject are considered worthwhile. In contemporary times, the diversity of students in classrooms is soaring. In view of this, meeting the needs of individual students in a classroom has become one of the major challenges (Melesse, 2015; Owusu, 2016). Teachers are always beset with the challenge on how to accommodate students' differences in the classroom in order to maximise their success. Alhassan and Abosi (2014) assert that the Ghanaian educational system has not adequately addressed the learning needs of students with learning difficulties in regular classrooms. Alhassan and Abosi's attributed this anomaly to teachers' incompetence in adapting instruction to meet the learning demands of students.

Undeniably, it is implausible for teachers to effectively and efficiently implement differentiation without an adequate understanding of differentiated instruction and the skills needed to do so. This study brings to bear the extent to which in-service mathematics teachers understand differentiated instruction and how that informed their practices of differentiated instruction in the Ghanaian basic school classrooms as revealed in Kyeremeh *et al.* (2021) study.

Even though there are numerous studies of the concept of differentiated instruction and its use among educators in Ghana (e.g., Abora, 2015; Kyeremeh *et al*., 2021; Owusu, 2016), there are very few studies discussing JHS mathematics teachers' knowledge of differentiated instruction. Moreover,

it appears no study has been conducted in the Tano South Municipality highlighting teachers' knowledge of this philosophy. There exists gap in literature concerning the in-service mathematics teachers' knowledge regarding differentiated instruction and how their experiences with the approach influences instructional practices at the junior high school in Tano South Municipality. It is against this backdrop that the study sought to investigate in-service mathematics teachers' knowledge of differentiation of instruction in the junior high schools in Tano South Municipality.

As society evolves, the content and pedagogical knowledge of teachers ought to be changed to be able to meet the demands of the 21st-century educational economy. Many countries including Ghana are in the midst of educational reform with the heart of this reform revolving around changes in the curriculum and teacher instructional behaviour through teacher education. Therefore, investigating the knowledge level of mathematics teachers about differentiated instruction might provide educational administrators and policymakers with some fair idea about the level of mathematics teachers' knowledge of differentiation, and how these could be utilised to the benefit of all students in Ghanaian basic school classrooms. To this end, the findings of this study could help inform Colleges of Education and Universities on the need to restructure their mathematics curricula by giving peculiar attention to pedagogical content (such as Differentiated Instruction) so as to be able to produce mathematics teachers who understand and are capable of employing multi-directional approaches (such as differentiation) to effect the desired change. Also, this study contributes to the scholarly community and mathematics education in Ghana as it adds to the body of knowledge of differentiated instruction. Teachers' knowledge in this phenomenon adds significantly to the advancement of instructional practice in basic mathematics.

The purpose of this study was to investigate in-service mathematics teachers' knowledge of differentiated instruction at junior high schools in Tano South Municipality of Ghana. It sought to answer the research question: What knowledge do in-service mathematics teachers at junior high school have about differentiated instruction? In other to determine if there are differences in relation to teacher type, the hypothesis below was tested:

H_0: There is no statistically significant difference between general in-service teachers and special in-service teachers in relation to their knowledge of differentiated instruction

H_A: There is a statistically significant difference between general in-service teachers and special in-service teachers in relation to their knowledge of differentiated instruction.

METHODS

Research design

The study employs the explanatory sequential mixed method design of the mixed-method approach. Research design is an overall plan for gathering and analysing data including steps taken to enhance both internal and external validity (Locke, Spirduso & Silverman, 2013). Pragmatism undergirds mixed methods and allows the collection of both qualitative and quantitative data. In sequential explanatory design, quantitative is dominant and collected first and analysed after which qualitative data is collected and analysed to support or clarify the quantitative findings (Creswell & Creswell, 2018). This study followed this procedure as data was first collected from the respondents and analysed after which interviews were collected to support the quantitative findings.

Sample and sampling technique

The study was conducted in Tano South Municipality of Ghana among public junior high school mathematics teachers and data was collected. We employed a proportionate stratified sampling technique for the sampling of in-service mathematics teachers for the study. In the determination of sample size for the study, we employed Cohen, Manion, and Morrison's (2018) sample size determination table with confidence level and interval of 99% and 3% respectively. As a result, a sample size of 50 JHS mathematics teachers comprising 41 general teachers and 9 special education teachers was sampled for the quantitative study. Proportionate stratified sampling, according to Avli (2016), is used when the population is heterogeneous. This technique is considered advantageous as the sample was more representative of the population than if taken from the population as a whole. Based on the nature of the study, we considered the type of training teachers received at the universities and colleges of education. We believe that mathematics teachers who were trained to

instruct students with special educational needs might have more knowledge in adaptive instructions than those who have been prepared to instruct in the general classroom.

In view of this, we grouped the JHS mathematics teachers within Tano South Municipality into general in-service teachers and special in-service teachers with a population size of 48 and 10 respectively. These teachers were derived from 27 general schools and 2 special schools respectively. Using the proportional allocation technique, the sample size of 50 is made proportional to the number of elements present in each of the two strata. The proportional representation technique which is meant to allocate a sample from the strata brought the sample size of JHS mathematics teachers which comprises general educators and special educators to 41 and 9 respectively. Following that, teacher participants with sample sizes of 41 and 9 were selected from among general in-service teachers and special in-service teachers respectively through simple random sampling. Teachers were assigned with numbers on pieces of paper. These numbers were folded up and selected randomly without replacement. The general in-service teachers were teachers who had the training to teach mathematics and thus studied mathematics as their major area while special in-service teachers are those who were trained in special education but studied mathematics as a minor area and thus teach mathematics at junior high schools in the Municipality.

In the qualitative phase, a segment of 6 in-service mathematics teachers comprising 4 general in-service teachers and 2 special in-service teachers were drawn using the purposive sampling technique. Researchers recommend at least six sources of evidence in a qualitative study (Yin, 2014). The basis for using the purposive sampling technique was that we want to obtain rich and accurate data from the respondents for the study. This corroborates Rossman and Rallis's (2012) assertion that researchers who employ purposive sampling have special knowledge about some selected subjects who represent this population.

Demographic characteristics of respondents

The demographic characteristics of 50 participants (teachers) involving general in-service teachers and special in-service teachers included class level, type of teacher, gender, highest educational qualification, and range of years of teaching. Details of these are depicted in Table 1. The analysis of data in Table 1 showed that out of the 50 respondents selected across all levels of JHS, 82% (41) were general in-service teachers whereas the remaining 18% (9) were special in-service teachers. With regards to the highest educational qualification, it was observed that 53.7% (22) of the general in-service teachers had a Diploma in Education while the remaining 46.3% (19) had Bachelor's Degree. No one holds Master's Degree at that level. Among special in-service teachers, it was discovered that 88.9% (8) of the special in-service teachers had Bachelor's Degree while only 11.1% (1) hold Master's Degree. Inferably, none of the respondents holds a Diploma in Education at these levels. The reason is that colleges of education in Ghana, with the primary mandate for training and supply of basic schools with professional teachers, do not offer special education programs as done in the universities.

Data collection procedure

In gathering the required data for both the study, a self-administered close-ended questionnaire with a 4-point Likert-type scale, and a semi-structured interview guide were used. These instruments were adapted from the study by Whipple (2012) and Santangelo & Tomlinson (2012) with a few additions to suit the study purpose. We considered the questionnaire an appropriate instrument for the study due to the fact that it serves as a means of minimizing bias and requires less time to administer. The in-depth interview also helped to solicit extensive and detailed information that can be used to explain the in-service mathematics teachers' knowledge of differentiated instruction. The interviews were done through a face-to-face approach. The interview guide included a series of questions, probes, and follow-up questions on key themes.

In determining the content validity of the questionnaire, drafts were given to two Professors in Mathematics Education at the University of Education, Winneba for their expert judgement. The questionnaire and the interview guide were pilot tested on 8 in-service teachers who teach mathematics at the junior high schools in Tano South Municipality to determine their reliability. Using the Cronbach Alpha, a reliability coefficient of a=0.74 was obtained on the questionnaire items.

This indicates a good internal consistency in the scale (Taber, 2018). Also, in ensuring trustworthiness of the qualitative data, we ensured that there was accurate reflection on the interview by cross-checking with the participants regarding what had been experienced during the interview. Again, we had a prolonged and concentrated engagement with the participants on phone during the interview.

Prior to the early study, research authorization from the Tano South Municipal Directorate of Ghana Education Service was sought to seek permission to carry out the study in the junior high schools within the municipality. We then made a visit to the schools from which in-service mathematics teachers were sampled to acquaint them with the study and address any concerns that they could have concerning the study. We created a good rapport so as to have the confidence of the participants to respond to the questionnaire without any fear. Afterward, we sought their consent and fixed the date for the administration of the instruments. The questionnaires were retrieved after 5 days. The final visit to the school was made to solicit qualitative data through the interviews.

Data analysis

Primary quantitative data were collected using a closed-ended questionnaire measured on a 4-point Likert scale whereas qualitative data was garnered using a semi-structured interview guide. We employed both descriptive (such as frequency, percentage, mean and standard deviation) and inferential statistics (independent samples t-test) to analyse the quantitative data using SPSS version 23. In the inferential analysis, an independent t-test at a 0.05 level of significance was used to compare means of knowledge about differentiation among general in-service mathematics teachers and special in-service mathematics teachers. On the other hand, we used an inductive content analysis procedure to analyse the qualitative data. From the study, interview responses obtained were coded whereby similar patterns were categorised into themes.

FINDINGS

Findings from the quantitative phase of the study

Research Question: What knowledge do in-service mathematics teachers at junior high school have about differentiated instruction in Tano South Municipality?

Participants' average per item rating scores for the three major elements of differentiated instruction that fall below 1.40 were considered to have low knowledge, those between the range of 1.40 to 1.60 as having average knowledge, and those above 1.60 as having high knowledge. Table 2 shows the results from the field. Overall, the process was rated the highest understood element of differentiated instruction among the general in-service teachers and special in-service teachers. In Table 2, the general in-service teachers' process category yielded a mean and standard deviation of 7.44 and 0.78 respectively with an average per item rating of 1.86 whereas, the special in-service teachers' process category recorded a mean and standard deviation of 7.56 and 0.73 respectively with an average per item rating of 1.89. For the process category to yield average per item rating of 1.86 and 1.89 implies that in-service teachers in their response to the questionnaire selected agree or strongly agree on average, and put the process in first place for knowledge. This indicates that the participants (general in-service teachers) had high knowledge in process differentiation.

The statistics of the questionnaire items measuring in-service teachers' knowledge of differentiated instruction in relation to the process element is presented in Table 3. Among the general in-service teachers, Table 3 shows a mean range and standard deviation scores of 1.68 to 1.98 and 0.16 to 0.47 respectively with an average per item rating of 1.86. This implies that general in-service mathemayics teachers at junior high schools have high knowledge in the process differentiation. In the case of special in-service teachers, the responses attracted a mean range and standard deviation of 1.67 to 2.00 and 0.00 to 0.50 respectively with an average per item rating of 1.89. This reveals that special in-service mathematics teachers at junior high schools had high knowledge in differentiation of process.

Table 1
Summary of demographic characteristics of respondents

		General Education Teacher		Special Education Teacher	
Variable	Category	*f*	%	*f*	%
Class Level Taught	JHS 1	14	34.1	4	44.4
	JHS 2	12	29.3	3	33.3
	JHS 3	15	36.6	2	22.2
Gender	Male	35	85.4	8	88.9
	Female	6	14.6	1	11.1
Highest Educational Qualification	Diploma	22	53.7	0	0
	Bachelor's Degree	19	46.3	8	88.9
	Master's Degree	0	0	1	11.1
Range of years for teaching	1-10 years	23	56.1	5	55.6
	11-20 years	15	36.6	4	44.4
	21-30 years	3	7.3	0	0
	Total	41	82	9	18

Key: ***f***-Frequency, **%-**Percentage

Table 2
In-service mathematics teachers' knowledge of differentiated instruction in relation to the three major elements

Elements of Differentiation	General In-service Teachers			Special In-service Teachers		
	APIR	*M*	*SD*	APIR	*M*	*SD*
Content	1.50	5.98	0.99	1.56	6.22	0.67
Process	1.86	7.44	0.78	1.89	7.56	0.73
Product	1.49	7.44	1.72	1.58	7.89	1.90

Key: *M*=Mean, ***SD*=**Standard Deviation, **APIR=**Average Per Item Rating

Table 3
In-service mathematics teachers' knowledge of process differentiation

	General In-service Teachers				Special In-service Teachers			
Process	Agree *f* (%)	Disagree *f* (%)	*M*	*SD*	Agree *f* (%)	Disagree *f* (%)	*M*	*SD*
1. Teachers must collaborate with students about their learning in classroom	40 (97.6)	1 (2.4)	1.98	0.16	9 (100)	0 (0)	2.00	0.00
2. Teachers must assess each student's readiness level, interest level, and learning profile/style in DI	28 (68.3)	13 (31.7)	1.68	0.47	6 (66.7)	3 (33.3)	1.67	0.50
3. Contents, processes and products must constantly be modified in classroom	33 (80.5)	8 (19.5)	1.80	0.40	8 (88.9)	1 (11.1)	1.89	0.33
4. In DI, teachers must show respect for their learners' commonalities and differences	40 (97.6)	1 (2.4)	1.98	0.16	9 (100)	0 (0)	2.00	0.00

Key: ***f***–Frequency, **%–**Percentage, ***M***–Mean, ***SD***–Standard Deviation

Table 4
In-service mathematics teachers' knowledge of content differentiation

	General In-service Teachers				Special In-service Teachers			
Content	Agree *f* (%)	Disagree *f* (%)	*M*	*SD*	Agree *f* (%)	Disagree *f* (%)	*M*	*SD*
1. The curriculum is based on major concepts and generalizations.	36 (87.8)	5 (12.2)	1.88	0.33	7 (77.8)	2 (22.2)	1.78	0.44
2. Teachers must use a variety of materials other than the standard text.	7 (17.1)	34 (82.9)	1.17	0.38	2 (22.2)	7 (77.8)	1.22	0.44
3. In DI, it is mandatory for teachers to clearly articulate what they want students to know, understand and be able to do.	15 (36.6)	26 (63.4)	1.37	0.49	4 (44.4)	5 (55.6)	1.44	0.53
4. Teachers must provide a variety of support mechanisms (e.g., organizers, study guides, study buddies) in DI.	23 (56.1)	18 (43.9)	1.56	0.50	7 (77.8)	2 (22.2)	1.78	0.44

Key: ***f***–Frequency, **%–**Percentage, ***M***–Mean, ***SD***–Standard Deviation

Table 5
In-service mathematics teachers' knowledge of product differentiation

	General In-service Teachers				Special In-service Teachers			
Product	Agree *f* (%)	Disagree *f* (%)	*M*	*SD*	Agree *f* (%)	Disagree *f* (%)	*M*	*SD*
1. Every assignment must offer students clear and appropriate criteria for success; focus on real-world relevance and application.	23 (56.1)	18(43.9)	1.56	0.50	5(55.6)	4 (44.4)	1.56	0.53
2. Using DI in the classroom prepares students to take standardized tests	22 (53.7)	19(46.3)	1.39	0.51	5(55.6)	4 (44.4)	1.56	0.53
3. When teachers differentiate instruction, they don't create unfair workloads among students	16 (39.0)	5 (61.0)	1.39	0.49	4(44.4)	5 (55.6)	1.44	0.53
4. DI prepares students to compete in the real world	23 (56.1)	18(43.9)	1.56	0.50	6(66.7)	3 (33.3)	1.67	0.50
5. Teachers use whole group instruction in differentiation	16 (39.0)	25(61.0)	1.39	0.49	6(66.7)	3 (33.3)	1.67	0.50

Key: ***f***–Frequency, **%–**Percentage, ***M***–Mean, ***SD***–Standard Deviation

Table 6
Group statistics of in-service mathematics teachers' knowledge of differentiated instruction

	Type of teacher	N	Mean	Std. Deviation	Std. Error Mean
Teachers' Knowledge	General in-service teacher	41	20.85	2.83	0.44
	Special in-service teacher	9	21.45	2.45	0.82

Table 7
Independent samples t-test of in-service mathematics teachers' knowledge of differentiated instruction

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	*Df*	Sig. (2-tailed)	Mean Diff.	Std. Error Diff.	95% Confidence Interval of the Difference	
									Lower	Upper
Knwl	Equal variances assumed	0.38	0.54	-.080	48	0.43	-0.60	1.02	-2.87	1.24

Key: **Knwl** = Knowledge

Increasingly, both general in-service and special in-service teachers seemed to have average knowledge of content differentiation. From the statistical analysis, general and special in-service teachers attracted an average per item rating of 1.50 and 1.56 in content respectively. Table 4 presents the statistics of the questionnaire items measuring in-service teachers' knowledge about differentiated instruction in relation to the content element. In Table 4 under the content category, general in-service teachers' scores yielded a mean range and standard deviation of 1.17 to 1.88 and 0.33 to 0.50 respectively with an average per item rating of 1.50. The implication is that general in-service mathematics teachers at junior high schools have average knowledge of content differentiation. In the same vein, special in-service teachers' responses attracted a mean range and standard deviation of 1.22 to 1.78 and 0.44 to 0.53 respectively with an average per item rating of 1.56. The indication is that, special in-service mathematics teachers at junior high schools have average knowledge in the differentiation of content.

Both general in-service and special in-service teachers seemed to possess an average knowledge of product differentiation. From the statistical analysis, general and special in-service teachers attracted an average per item rating of 1.49 and 1.58 in product respectively. Table 5 presents the statistics of the questionnaire measuring in-service teachers' knowledge of differentiated instruction in relation to the product element. From Table 5 under the product category, general in-service teachers' scores yielded a mean range and standard deviation of 1.39 to 1.56 and 0.49 to 0.51 respectively with an average per item rating of 1.49. It, therefore, implies that general in-service mathematics teachers at junior high schools have average knowledge in product differentiation. Similarly, special in-service teachers' responses to product differentiation attracted a mean range and standard deviation of 1.44 to 1.67 and 0.50 to 0.53 respectively with an average per item rating of 1.58. This showed that special in-service mathematics teachers at junior high schools have average knowledge in product differentiation.

H_0: There is no statistically significant difference between general in-service teachers and special in-service teachers in relation to their knowledge of differentiated instruction

This hypothesis looked for a difference between two groups: general in-service teachers' knowledge and special in-service teachers' knowledge. Tables 6 and 7 illustrate variability between the general in-service teachers' knowledge and special in-service teachers' knowledge in differentiated instruction. From the observation of the group means in Table 6, it could be indicated that special in-service teachers (M = 21.45, SD = 2.45) showed slightly higher knowledge of differentiation than than their general in-service teacher counterparts (M = 20.85, SD = 2.83). An independent samples t-test was conducted to examine whether there was a significant difference between general and special education teachers in relation to their knowledge in differentiated

instruction. The t-test results in Table 7 revealed no statistically significant difference between general in-service teachers and special in-service teachers (t = -0.80, *df* = 48, *p* > 0.05). Special in-service teachers reported slightly high knowledge of differentiation than their general in-service teacher counterparts. Therefore, we fail to reject the null hypothesis and conclude that there was no statistically significant difference between general and special in-service teachers in relation to their knowledge of differentiated instruction.

Findings from the qualitative phase of the study

We present a qualitative account of respondents for the study. Six (6) individual interviews were conducted on 4 general in-service teachers (G1, G2, G3 and G4) and 2 special in-service teachers (S1 and S2). These interviews explored issues in the first phase of the study based on results obtained after analysing the questionnaire data on in-service mathematics teachers' knowledge about differentiation. On the question 'What is differentiated instruction?', teachers exhibited fair knowledge of the meaning of differentiated instruction. For example, G2 defined differentiated instruction as (T: Tano. II: Individual Interview):

> *"[A kind of instruction that helps students to have a fair share in the learning process]"* II with G2, T

S2 also said:

> *"Differentiated instruction is a way of structuring instruction to suit the individual student needs…."* II with S2, T

The findings corroborates the earlier findings obtained from the quantitative phase of the study that general and special education teachers have fair knowledge of differentiated instruction. The focus of differentiated instruction has to do with teachers ensuring that all students reach the same instructional objective or goal with unique learning process. In simple terms, differentiated instruction could be described as a process of adapting instruction to suit the needs of individual students in the classroom.

In order for teachers to effectively tailor their instructions to cater for the varied learning needs of individual students, they ought to first and foremost pre-assess students. In view of this, paticipants were asked in the interview whether the pre-assessment of students during classroom instructions forms part of the differentiated instruction principles. All respondents interviewed indicated that teachers who employ differentiated instruction at all times assess students before the introduction of a new concept/topic. This is captured in the excerpts below:
S2 noted that:

> *"Differentiated instruction requires teachers to pre-assess their students in order to know their readiness level before beginning to teach new topic. It [pre-assessment] is very important."* II with S2, T

G3 also stated that:

> *"Yes, they [teachers] need to do that [pre-assess students]. As we all know, differentiated instruction should help us [teachers] to address students' needs; therefore, they should be assessed so that we may know their readiness level."* II with G3, T

Moreover, we also asked respondents in what manner do their students learn best in the classroom and how they did come to know? From the interview, it was revealed that students make significant learning gains when instruction is designed to connect with students' relevant previous knowledge and also engage in active social classroom This is captured in the comments below:

> *G2: "The students that I handle in class learn best when I link-up new concept with concepts that they already know. I came to this realisation in their response to questions that trigger such thinking."* II with G2, T

> *S1: "What I know is that these students learn well when I make them active in class through group activities. I notice their excitement through the smiles I see in their faces anytime they are given the opportunity to interact with them about a learning."* II with S1 T

DISCUSSION

Knowledge, according to Nonaka (2006), is a dynamic human process of justifying personal beliefs towards truth which is normally gained through experience or education. In our contemporary world today, the knowledge teachers possess still proves to be the most critical factor in their effectiveness or otherwise in their professional endeavours. This is because, teaching has historically been a profession in search of knowledge that could inform classroom practice. This affirms the assertion that the extent of teachers' knowledge of differentiated instruction is consequential to its practice by them (Whipple, 2012). In effect, teachers who are in the best position to differentiate instruction in their classrooms operate from strong and grown knowledge base (Tomlinson, 2015). However, the practice of differentiated instruction requires deep knowledge of its process, theoretical framework, and ways through which the theory is translated into action. It is in relation to these underpinnings that the JHS mathematics teachers' knowledge and practice of differentiated instruction was deemed necessary and explored.

Tomlinson (2001) identified *content*, *process* and *product* as three main elements of differentiation. In-service mathematics teachers comprising general and special teachers took part in this study that explored their knowledge regarding the 3 components. The findings showed that general in-service teachers had a high level of knowledge of differentiated instruction with *content* differentiation (M = 5.98, SD = 0.99, APIR = 1.50), *process* differentiation (M = 7.44, SD = 0.78, APIR = 1.86), and *product* differentiation (M = 7.44, SD = 1.72, APIR = 1.49). From the general in-service teachers' responses, it could be concluded that the participants on the average have high knowledge in differentiated instruction. This indicates that general in-service mathematics teachers at junior high schools in Tano South Municipality are knowledgeable in the differentiation of instruction. This is inconsistent with what Mengistie (2020) study findings revealed that basic school teachers apparently had adequate level of understanding of differentiated instruction; however, they showed lack knowledge of specific strategies that can be employed to manage students in mixed ability classrooms.

The findings from the study also revealed that special in-service mathematics teachers had a high level of knowledge in differentiated instruction with content differentiation (M = 6.22, SD = 0.67, APIR = 1.56), process differentiation (M = 7.56, SD = 0.73, APIR = 1.89), and product differentiation (M = 7.89, SD = 1.90, APIR = 1.58). From the qualitative data analysed on special education teachers' responses, it could be stated that respondents on average had some fair knowledge in differentiated instruction. The indication is that special in-service mathematics teachers at junior high schools are knowledgeable in the differentiation of instruction. This is affirmed by the definitions some of the respondents gave to differentiated instruction when they were asked in an interview: "Differentiated instruction is a way of structuring instruction to suit the individual student needs." Tomlinson and Moon (2013) similarly noted differentiated instruction to be an approach to instruction that systematically takes student differences into account in designing opportunities for each student to maximise learning.

In comparison, it could be mentioned that there was no statistically significant difference in the knowledge of differentiation among the two groups of mathematics teachers. This is consistent with the findings of Whipple (2012) which revealed special in-service teachers possess high knowledge in differentiation than general in-service teachers. This disparity may be as a result of the kind of training special educators received from universities which may provide them knowledge in instructional adaptation to meet diversity of students' needs in the classroom as compared to that of general education teachers. This corroborates what Zelalem, Melesse and Seifu (2022) study's findings revealed that most of the teacher educators have not had any training on differentiated instruction, and therefore had low knowledge about differentiated instruction to be able to implement it effectively. In addition, special education teachers typically have students with varied abilities and disabilities thereby compelling them to differentiate instruction quite often. As a result, their hands-on experience could be a factor in the results of the data.

CONCLUSIONS

Based on the study results, we concluded that in-service teachers who teach mathematics at junior high schools in Tano South Municipality on average possess high knowledge of differentiated instruction. There was no statistically significant difference in the knowledge about differentiation among the two groups of mathematics teachers. This means that our teacher education institutions need to expose prospective teachers to more differentiation strategies through professional development programmes. In the quest to achieve this feat, we recommend that teacher education institutions review their mathematics curriculum in a way that ensures prospective teachers maximum exploration of differentiated instructional approaches to teaching at basic levels of our education system.

As the diversities among students in the classroom increase, teachers' failure to understand these diversities and how to respond to them in classroom may have a lasting impact on the successes of students in mathematics education (Richards-Usher, 2013). In view of this, the direction for future research may look at the situation at different settings including private institutions since this study focused on in-service mathematics teachers at the public basic school system.

ACKNOWLEDGMENT

The researchers would like to extend their profound gratitude to all in-service teachers who teach mathematics in junior high schools in Tano South Municipality for their participation in this research work.

BIBLIOGRAPHY

Abora, S. O. (2015). *Investigating teachers' knowledge and practices of differentiated instruction in Ghanaian primary schools*. (Unpublished M.Phil thesis). Winneba: University of Education, Winneba, Ghana.

Alhassan, A. R., & Abosi, C. K. (2014). *Teacher effectiveness in adapting instruction to the needs of pupils with learning difficulties in regular primary schools in Ghana*. Retrieved from http://sgo.sagepub.com/content/spsgo/4/1/2158244013518929.full.pdf on 18/09/2017.

Alvi, M. H. (2016). *A manual for selecting sampling techniques in research*. Karachi, Pakistan: University of Karachi, Iqra University.

Cambell-Whatley, G. D., Obiakor, F., & Algozzine, B. (1995). Perceptions of competencies for including students with disabilities in elementary and secondary school classrooms. *Special Services in the Schools, 10*, 79-93.

Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education* (8th ed.). New York: Routledge.

Creswell, J. W. & Creswell, J. D. (2018). *Research design: Qualitative, quantitative and mixed methods approaches (5th ed.)*. Thousand Oaks, CA: Sage.

Ireh, M., & Ibeneme, O. T. (2010). Differentiating instruction to meet the needs of diverse technical/technology education students at the secondary level. *African Journal of Teacher Education, 1* (1), 106-114.

James, D. (2009). Differentiated instruction: One school's survey analysis. *The Corinthian, 10* (13), 169-190.

Joseph, S. (2013). Differentiating instruction: Experiences of pre-service and in-service trained teachers. *Caribbean Curriculum, 20*, 31–51.

Kyeremeh, P., Amoah, E. K., & Sabtiwu, R. (2021). Junior High School Mathematics Teachers' Practice of Differentiated Instruction and Associated Challenges in Tano South Distict. *Journal of Mathematics and Science Teacher, 1,* em001. https://doi.org/10.29333/mathsciteacher/10914

Locke, L. F., Spirduso, W. W., & Silverman, S. J. (2013). *Proposals that work: A guide for planning dissertations and grant proposals (6th ed.)*. Thousand Oaks, CA: Sage.

Melesse, T. (2015). Differentiated instruction: Perceptions, practices and challenges of primary school teachers. *Science, Technology and Arts Research Journal, 4* (3), 253-264.

Mengistie, S. M. (2020). Primary school teachers' knowledge, attitude and practice of differentiated instruction: The case of in-service teacher-trainees of Debre Markos College of Teacher Education, West Gojjam Zone, Amhara Region, Ethiopia. *International Journal of Curriculum and Instruction 12*(1), 98–114.

Ministry of Education (2015). *Inclusive education policy*. Accra, Ghana: MoE.

National Council for Curriculum and Assessment (NaCCA) (2019). *Mathematics curriculum for primary schools*. Accra: Ghana: MoE.

Nonaka, I. (2006). *Creating sustainable competitive advantage through knowledge-based management.* California, Berkeley: The Graduate School of International Corporate Strategy Hiotsubashi University.

Owusu, O. K. (2016). *Differentiated instruction: Practice and challenge in an elementary schoo*l. MA thesis. Kumasi: Kwame Nkrumah University of Science and Technology, Kumasi-Ghana.

Richards-Usher, L. (2013). *Teachers Perception and Implementation of Differentiated Instruction in the Private Elementary and Middle Schools* [Unpublished doctoral dissertation]. Capella University.

Rossman, G., & Rallis, S. F. (2012). *Learning in the field: An introduction to qualitative research (3rd ed.)*. Thousand Oaks, CA: Sage.

Santangelo, T., & Tomlinson, C. A. (2012). Teacher educators' perceptions and use of differentiated instructional practices: An exploratory investigation. *Action in TeacherEducation, 34* (4), 309-327. https://doi.org/10.1080/01626620.2012.717032

Schwarber, L. A. (2006). *A comparison of general education and special education teachers' knowledge, self-efficacy, and concerns in teaching children with autism* [Bachelor's thesis], Miami University in Oxford, Ohio.

Subotnik1, R., Olszewski-Kubilius, P., & Worrell, F. (2011). Rethinking giftedness and gifted education: A proposed direction forward in relation to psychological science. *Psychological Science in the Public Interest, 12* (1), 3-54.

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Res Sci Educ, 48*, 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Tomlinson, C. A. (2001). *How to differentiate instruction in mixed-ability classrooms*. Alexandria, VA: ASCD.

Tomlinson C. A. (2004). The mobius effect: Addressing learner variance in schools. *Journal of Learning Disabilities, 37* (6), 516-524.

Tomlinson, C. A. (2005a). *How to differentiate instruction in mixed-ability classrooms*. Upper Saddle River, NJ: Pearson Education.

Tomlinson, C. A. (2005b). *The differentiated classroom: Responding to the needs of all learners*. Upper Saddle River, NJ: Pearson Education.

Tomlinson, C. A. (2014). *The differentiated classroom: Responding to the needs of all learners (2nd ed.)*. Alexandria, VA: ASCD.

Tomlinson, C. A. (2015). *Differentiation does, in fact, work*. Education Week. Retrieved from http://www.edweek.org/ew/articles/2015/01/28/differentiation-does-in-fact-work.htm

Tomlinson, C. A., & Imbeau, M. (2010). *Leading and managing a differentiated classroom*. Alexandria, Virginia: ASCD.

Tomlinson, C. A., & Moon, T. R. (2013). *Assessment and student success in a differentiated classroom*. Alexandria, VA: Association for Supervision and Curriculum Development.

Watts-Taffe *et al.* (2012). Differentiated instruction: Making informed teacher decisions. *Read, Teach, 66* (4), 303-314.

Welsh, M. E. (2011). Measure teacher effectiveness in teacher education: Some challenges and suggestions. *Journal of Advanced Academics, 22* (5), 750-770.

Whipple, K. A. (2012). *Differentiated instruction: A survey study of teacher understanding and implementation in a Southeast Massachusetts School District* [Unpublished Ed.D thesis]. Massachusetts: Northeastern University Boston, U.S.A.

Yin, R. K. (2014). *Case study research: Design and methods (5th ed.)*. Thousand Oaks, CA: Sage.

Zelalem, A., Melesse, S., & Seifu, A. (2022). Teacher educators' self-efficacy and perceived practices of differentiated instruction in Ethiopian primary teacher education programs: Teacher education colleges in amhara regional state in focus. *Cogent Education, 9*(1), 2018909, https://doi.org/10.1080/2331186X.2021.2018909