Journal of Educational Sciences Vol. 4 No. 1 (Jan, 2020) 1-19

Journal of Educational Sciences

Journal homepage: https://jes.ejournal.unri.ac.id/index.php/JES

P-ISSN 2581-1657

E-ISSN 2581-2203

Increasing Mathematics Achievement of Senior Secondary School Students through Differentiated Instruction

Adeneye O. A. Awofala[1*], Abisola O. Lawani[2]

[1]*University of Lagos, Faculty of Education, Department of Science and Technology Education*

[2]*Tai Solarin University of Education, College of Science and Technology Education, Department of Mathematics*

ARTICLE INFO

Article history:

Received: 12 August 2019
Revised: 26 October 2019
Accepted: 26 September 2019
Published online: 06 Jan 2020

Keywords:

Differentiated Instruction
Achievement
Mathematics
Conventional Teaching Method

A B S T R A C T

This study examined the effect of differentiated instruction on senior secondary school students' achievement in mathematics in Nigeria within the blueprint of the pre-test, post-test non-equivalent control group quasi-experimental research design. The sample comprised 220 students in which three research questions and three null hypotheses guided the study. The experimental group was taught with the differentiated instruction while the control group received instruction with the conventional teaching method for eight weeks. Three valid and reliable instruments, Mathematics Achievement Test (KR-20=0.89), Felder-Soloman Index of Learning Styles (Cronbach α=0.92), and McKenzie Multiple Intelligences Inventory (Cronbach α=0.90), were used for data collection. Results revealed that students in the differentiated instruction group performed significantly better than students in the conventional teaching method group. Also, male students performed slightly better than female students with differentiated instruction, although no significant difference existed between the achievement of male and female students taught mathematics using differentiated instruction. There was no significant main effect of gender on students' achievement in mathematics. Also, there was no significant interaction effect of treatment and gender on students' achievement in mathematics. The differentiated instruction made lesson more fascinating, stress-free and created co-operation among students. It was thus, recommended that differentiated instruction be adopted by mathematics teachers in teaching mathematics at the senior secondary school level in Nigeria.

1. Introduction

Mathematics is as old as mankind in that God being the greatest mathematician ever framed the world with the idea of mathematics. As such mathematics plays an

* Corresponding author. Tel./Fax.: +6281371311801
E-mail: aawofala@unilag.edu.ng

Doi: https://doi.org/10.31258/jes.4.1.p.1-19

indispensable role in the lives of people and the world at large, for a person can go on well in life without being literate but cannot go on well without being numerate.

Mathematics not only enhances problem solving and analytical skills of students but promotes their logical, functional and aesthetic skills. In general human beings engage in daily usage of mathematics and this daily application of mathematics induces the human brain to articulate problems, theories and their solutions for the survival of human race. There is no gainsaying that mathematics at school prepares students to acquire functional and coping skills for adult life. Mathematical skills serve as catalyst for genuine invention, improved productivity, and expansion in social well-being of citizens. For any nation to be globally competitive, its citizens must display high mathematical and scientific literacy as a strong base for technological prowess. Many countries remain underdeveloped because they lack strong mathematical base cum scientific literacy. In these countries students' achievement in mathematics is at low ebb when compared to high achieving countries despite their adoption of mathematics as a filter of students into science, technology, engineering, and mathematics careers at the university level. Arresting this negative trend in mathematics calls for a renew interest in curricula and instructional approaches that will bring equity in mathematics classrooms. Equity in mathematics classroom can be attained by recognizing students' level of readiness, interest, and learning profile during teaching and exploiting their prospects for personal learning and growth.

In general mathematics educators crave for a homogeneity of students in respect of abilities, creativity, skills and capacity in order to achieve uniform progress in learning. Despite this urge, enormous differences seem to exist among students in mathematics classrooms in the area of knowledge, skills, experiences, habits, cognitive capabilities, process of cognition, interests, pace of learning, learning style, language proficiency, motivation for learning and development. Regardless of these individual differences in mathematics classrooms, students are expected to engage in the learning of concepts, principles, and skills under the tutelage of a teacher. When a teacher delivers his/her teaching without recourse to students' individual differences in a classroom, students' learning of mathematics may suffer. This is typical of the Nigerian mathematics classrooms in which teachers are preoccupied with dishing out of facts and information in an undifferentiated way. One way of engendering equity in mathematics classroom is for teachers to locate an approach that taps into the diversity of their students and this can be achieved through differentiated instruction.

Differentiated instruction is a pedagogical theory founded on the principle that instructional methodologies should vary and be adjusted relative to distinct and diverse students' needs in the classrooms (Tomlinson, 2001). Differentiation is an approach to teaching in which teachers pre-emptively transform and adjust their teaching to address the varied needs of individual students and small groups of students to optimize the learning prospect for each student in the classroom by using logical procedures for academic advancement monitoring and data-based decision-making (Mulder, 2014). Differentiated instruction entails that teachers should consider numerous student features when planning and designing lessons and units (Goddard, Neumerski, Goddard, Salloum, & Berebitsky, 2010) and this clearly shows that differentiated instruction is not a single strategy, but rather an approach to instruction that integrates a range of strategies (Hayes & Deyhle, 2001; Watts-Taffe et al., 2012). The model of differentiated instruction necessitates that teachers be flexible in their approach to teaching and instruction in such a way that diverse student factors in mathematics classrooms enumerated above are taken into account when planning and delivering instruction in mathematics.

Differentiated instruction provides a structure for adapting curriculum and teaching strategies to supplement the knowledge readiness, areas of interest and learning profiles of each student (Tomlinson & Eidson, 2003). Ogunkunle and Onwunedo (2014) and Rojo (2013) gave five critical elements of differentiated instruction to include content, process, product, affect, and learning environment. The content is described as the knowledge, understanding, skills, acts, concepts, generalizations, principle, and attitudes that students need to learn in the classroom. Content deals with what is taught and how it is presented to the students and as such the teachers must focus on the concepts, principles and skills that students should learn. The disparity told in a differentiated classroom is in respect to the way in which students gain access to key learning with tasks and objectives align to learning goals. What teachers can differentiate in terms of content is the methods that students use to access key content. The content of instruction should focus on the same concepts with all students, but the extent of complexity should be attuned to suit diverse learners (Ogunkunle & Onwunedo, 2014). In this manner, teachers can engage in scaffolding of content by teaching prerequisite content to some students, allowing forward-thinking students to move ahead of the class, or even altering the content for some students based on their individualized education programmes (Tomlinson & Imbeau, 2010).

The process is the means by which students come to understand, apply, learn, and make sense of the content. By differentiating process, teachers are pre-occupied with crafting sense-making activities that aid students take ownership of the content by permitting them to see how content makes sense, and recognize how the content is valuable and applicable in the realm outside the classroom. The process is a very important stage in differentiated instruction because this is the stage where learning occurs with students and students need to work at varying speeds, with varying kinds of support, in varying groupings, and in varying modes of learning. In the process the teacher enables flexible grouping in which all students work together at their own pace, with below-average students use auxiliary materials and the teacher provides extra support/challenge to students, based on their progress during the lesson.

The products, or summative assessments, actually reveal what students have truly learned. Products are ways for students to demonstrate what they have come to know, understand, and be able to do after an extended period of learning (Tomlinson & Imbeau, 2010). Pre-, on-going, and post-assessments of students' readiness and growth are vital in that they lead to purposeful and efficacious differentiation which deliver a list of options of methods, choices, and frameworks for the different needs, abilities and interests that surface in classrooms of diverse students. While assessments may be formal or informal, a well-constructed students' product should show different ways of assessments and offer varying degrees of scoring to meet the needs of diverse learners. The learning environment relates to how time, materials, and space are organized and it is the tone of the classroom. Affect considers the affective or emotional needs of students. The effect of students' emotions and feelings on their learning constitutes another critical element of differentiated instruction. Students' emotions and feelings are created by their previous experiences and their responses to both previous and present experiences, impact their self-concept, self-efficacy, motivation to learn and ability to collaborate. Differentiating student affect connotes transforming the learning environment to take care of the emotional needs of the students. Tackling students' affective needs should be the hallmark of teachers when planning such aspects of differentiated instruction as respectful tasks and flexible grouping.

There is certainly a wide array of instructional strategies, which may be engaged to differentiate classroom elements for students' readiness, interest, and learning profile. These strategies such as group work, tiered activities, scaffolding and whole class instruction should conform to the following guiding principles of differentiated instruction (Tomlinson, 2003): (1) students are appreciated by providing them with work that focuses on the essential contents targeted for the lesson. (2) Students are kept scholastically tested while providing suitable backing so they are successful. (3) Class time includes prospects for flexible grouping, whole group work and individual work. (4) Assessments are ongoing so differentiation for individuals remains informed and responsive to changes in development. (5) Curriculum is coherent, important, inviting, and thoughtful.

Adopting differentiation for a learning profile among the five classroom elements starts with an understanding of learning style, intelligence, and culture (Tomlinson & Eidson, 2003; Sternberg, 2006). Once these aspects are pre-evaluated, one method to transforming the process for learning profile is through flexible grouping where students work in groups that have both mutual and wide-ranging learning profiles. Instruction can be differentiated based on four student qualities: readiness, a student's current proximity to specified knowledge, understanding, and skills (Tomlinson & Imbeau, 2010); interest, topics that evoke a student's attention, involvement and curiosity (Tomlinson & Imbeau, 2010); learning profile, is a preference for taking in, exploring, or expressing content (Tomlinson & Imbeau, 2010) and is how a student learns best; and affect, the way students feel about themselves (Boges, 2014). Four factors help to form a learning profile: culture, learning style, intelligence preference and gender.

Throughout the past decade differentiated instruction has become more popular in the educational research community as an instructional practice that produces a response to the ever growing diverse population of students seen in today's classrooms (Landrum & McDuffie, 2010); thus, very scanty empirical evidences though mixed or investigations of the causal mechanisms that might support such claims, particularly for mathematics are available (Mulder, 2014; Ogunkunle & Onwunedo, 2014). More so, quantitative research on the effectiveness of differentiated instruction is limited despite being a teaching approach for rectifying literacy problems (Boges, 2014).

The result of the study by Ogunkunle and Onwunedo (2014) showed that differentiated instructional strategy was more effective in promoting meaningful learning and enhancing mathematics students' achievement than the conventional method. Mulder (2014) found that differentiated instruction had no statistically significant effect on students' mathematics achievement but the relationship between differentiated instruction and mathematics achievement was positive, which meant that the more the teacher differentiated, the higher the mathematics achievement of the students was.

In Nigeria of today classrooms are becoming more culturally and academically diverse. Most classrooms comprise students of both gender with different cultural backgrounds and contain students who do not speak English as their first language, and commonly encompass students with a range of uniqueness and evidently dissimilar practical experiences. In short, these students undoubtedly learn and work at different readiness levels, have changeable interests, and acquire knowledge, understanding and doing in a diversity of ways. Teachers of mathematics will definitely find it practically challenging to steadily use only tasks that are ascetically thought-provoking for all students in a classroom that contains an array of readiness and experiential levels. The present study therefore, investigated the effect of differentiated instruction on senior secondary school students' achievement in mathematics in Lagos state, Nigeria.

Research Question One: What is the difference in the mean achievement scores of students taught mathematics with differentiated instruction and those taught with conventional teaching method?
Research Question Two: What is the difference in the mean achievement scores of male and female students in mathematics?
Research Question Three: Is there any interaction effect of treatment (differentiated instruction vs. conventional teaching method) and gender (male & female) on students' achievement in mathematics?

The following null hypotheses were formulated for this study:
H_{01}: There is no significant effect of treatment (differentiated instruction vs. conventional teaching method) on senior secondary school students' achievement in mathematics.

H_{02}: There is no significant influence of gender on senior secondary school students' achievement in mathematics.
H_{03}: There is no significant interaction effect of treatment and gender on senior secondary school students' achievement in mathematics.

2. Methodology

Research Design

The study adopted a quantitative research within the blueprint of pre-test, post-test non-equivalent control group quasi-experimental research design. Quasi-experiment is an experiment where randomization of subject of experimental and control groups is not possible (Nworgu, 2006). The researcher randomly assigned intact classes to experimental and control groups. This was necessary in order not to disrupt the normal classes of the students and the school time-table. The quasi-experimental design was used to contrast the treatment's (at two levels) scores crossed with gender (at two levels) using a 2×2 factorial matrix. The design of the study is symbolically given as follows:

$O_1\ X_1\ O_2$	$X_1 gain = O_2 - O_1$	O_1O_3 pre-tests
$O_3\ C\ O_4$	$Cgain = O_4 - O_3$	O_2O_4 post-tests

Where X_1 and C represent differentiated instruction strategy and conventional teaching method respectively. The mean gain scores between O_1 and O_2 and O_3 and O_4 were tested for statistical significance using the Analysis of Covariance (ANCOVA).

Participants

The participants consisted of 220 Senior Secondary School year two mathematics students (120 females and 100 males). Simple random sampling was used to select one intact class each from three streams each of six equivalent coeducational senior secondary schools that were distantly located from one another within the city of Lagos, Nigeria. The researcher randomly assigned three schools to the differentiated instruction strategy with 96 students (51 females and 45 males) and the remaining three schools to the conventional teaching method with 124 students (69 females and 55 males). The mean ages of the students in the differentiated instruction schools and conventional teaching method schools were 15.8 years (SD=2.1) and 15.7 years (SD=2.3) respectively.

Instrument for Data Collection

Three instruments were used for data collection in this study and they are: Felder-Soloman (ILS) Index of Learning Styles (2000), McKenzie Multiple Intelligences Inventory (MII) (1999), and Mathematics Achievement Test (MAT).

The Felder-Soloman (ILS) Index of Learning Styles (2000) of 44 items forced-choice instrument requires respondents to select one of two statements that is more like them and was used to determine the learning styles of students in this study. Students' learning styles refer to preference on how students receive and process information. The instrument was designed to process information in different ways: seeing and hearing, reflecting and acting, rational reasoning and intuitive reasoning, and analyzing and visualizing. The ILS categorizes learners into four groups, with 11 items per subscale that can be used to assess learning styles: 1. Active and reflective learners

(ACT-REF): Active learners learn better by actively participating and discussing or applying it with others. Reflective learners learn better by thinking about things, preferably alone. 2. Sensing and intuitive learners (SEN-INT): Sensing learners learn better when presented with facts, and think more in practical ways. Intuitive learners learn best when presented with the possibilities of innovation and relationships. They tend to work faster than sensing learners, who prefer to think things through more. 3. Visual and verbal learners (VIS-VER): Visual learners learn better when they see objects, pictures, diagrams, flow charts, and videos. Verbal learners, on the other hand learn better when they read words in a written fashion and when words are spoken. 4. Sequential and global learners (SEQ-GLO): Sequential learners learn better when subjects are presented in a linear manner. Each step follows another, and therefore, it forms a logical sequence. Global learners learn best when they are able to go from one area to another, to use information in a nonlinear manner. These learners will jump from one item to another, and suddenly, the concept will 'click' and they will understand it but they may not be able to explain how they came to the actualization of the product (Felder & Soloman, 1999). In the present study, the reliability coefficient of the ILS was found to be .92 using Cronbach alpha.

The Multiple Intelligences Inventory (MII) was adopted from McKenzie (1999) and contained 90 items with each intelligence type consisted of 10 statements. In this inventory, students were asked to respond to every item in relation to what they are really feeling. The responses were 0 and 1 in which 0 showed the statement that was not in accordance with the participant feeling and 1 showed the statement was in accordance with the participant feeling. Gardner (2004) strongly recommended the theory of Multiple Intelligences and suggested that all individuals have personal intelligence profiles which consist of combinations of nine different intelligence types, namely verbal-linguistic, mathematical-logical, visual-spatial, bodily-kinesthetic, musical-rhythmic, interpersonal, intrapersonal intelligence, naturalist intelligence, and existential intelligence. Verbal-linguistic thinks in words and loves reading, writing, telling stories, and playing word games. Logical-mathematical thinks by reasoning and loves experimenting, questioning, figuring out logical puzzles, and calculating. Visual-spatial thinks in images and pictures and loves designing, drawing, visualizing, and doodling. Bodily-kinesthetic thinks through somatic sensation and loves dancing, running, jumping, building, touching, and gesturing.

Musical-rhythmic thinks via rhythms and melodies and loves singing, whistling, humming, tapping feet and hands, and listening. Interpersonal thinks by bouncing ideas off other people and loves leading, organizing, relating, manipulating, mediating, and partying. Intrapersonal thinks in relation to their needs, feelings, and goals and loves setting goals, meditating, dreaming, and planning. Naturalist thinks through nature and natural forms and loves playing with pets, gardening, investigating nature, raising animals, and caring for planet earth. Existential thinks in collective consciousness and values, summative and intuitive iteration and loves seeking meaningful learning, looking for connection, synthesizing, having strong connection with family and friend, and expressing a sense of belonging to a global community (Armstrong, 2009). The MII was used to assess the students' intelligence profile in this study. In the present study, the reliability coefficient of the MII was found to be .90 using Cronbach alpha.

The MAT, which was used to test the achievement of students in mathematics was developed by the researcher. The MAT used as pretest and posttest consisted of 30 multiple choice items with options A to D selected from past West African Examinations Council question papers in mathematics and covered contents related to number and numeration, algebraic processes, geometry, probability and statistics, and introductory calculus as contained in the senior secondary year two mathematics curriculum. The initial 40–items of MAT was subjected to face and content validation by two mathematics Lecturers at the University of Lagos, Akoka, Lagos, Nigeria. The validation entailed checking the MAT items against the themes and content of the lesson plan, language editing, and appropriateness of the test to the target participants. Five items were removed based on experts' recommendation and the face validated MAT was tested for difficulty index and discrimination power. Items with difficulty power of 0.4-0.6, discrimination power of 0.2 and above, and distracter index of negative decimal were retained (Akinsola & Awofala, 2009). Based on this, five items were removed leaving the final 30 items for the MAT which was pilot tested with 80 students in one Senior Secondary School different from the study schools in Lagos State. The reliability coefficient of the MAT was found to be 0.89 using Kuder-Richardson 20 formulae. Each item on the MAT was scored 1½ marks, thus, a total score of 45 marks was obtainable. The MAT covered the first three levels of Bloom taxonomy of cognitive domain called the lower–order cognitive domain (knowledge, comprehension, and application) as contained in the table of specification (Table 1) below.

Table 1. Mathematics Achievement Test (MAT) Item Specification

Contents	**Level of cognitive domain**			
	K	**C**	**A**	**Total**
1. Number and numeration	2	2	2	6
2. Algebraic processes	2	2	2	6
3. Geometry	2	2	2	6
4. Probability and statistics	2	2	2	6
5. Introductory calculus	2	2	2	6
Total	10	10	10	30

K=Knowledge C= Comprehension A=Application

Procedure

Two sets of lesson plans were prepared by the researcher based on the topics set out for the study as contained in the test blueprint. Each set contains eight (8) lesson plans that lasted for a period of eight weeks and 80 minutes duration. One set of the lesson plan was written based on differentiated instruction and the subject teacher in the experimental group applied this lesson plan at different stages of instructional process, while the second set was prepared based on conventional teaching method in teaching mathematics. One week intensive training programme was planned for the teachers of the experimental group that were involved in the study. On the first day, before the lesson commenced, MAT was administered as pre-test to both the experimental and control groups after, which proper teaching commenced by using the prepared lesson plans.

In the experimental schools the following heuristics of differentiated instruction that involve pre-assessment, flexible grouping, tiered instruction, scaffolding, and assessment were followed to meet the needs of the students. Pre-assessment is a way to determine what students know about a topic before it is taught. Aside the MAT that was used as pre-test, students in the experimental group were pre-tested on learning style inventory and multiple intelligences inventory to ascertain the students' learning style and intelligence preference. Teachers in the experimental group used the information gained in pre-assessment to make instructional decisions about student strengths and needs. In addition, the pre-assessment enabled the teachers in the experimental group to determine flexible grouping patterns as well as which students were ready for advance instruction in mathematics. In the experimental group, flexible grouping involved matching students to skill work by virtue of readiness and not with the assumption that all students needed the same task, computation skill, writing assignment, etc. It should be noted that the flexible grouping allowed movement among groups, based on readiness on a given skill and growth in that skill.

Flexible groups allowed the teachers in the experimental classes to group students for direct instruction according to deficits in specific skills in mathematics. The teachers monitored students' progress and systematically grouped and regrouped students in an effort to maximize students' learning. The pre-assessment in the experimental group was concluded with compacting which involved giving students credit for what they already know and allowing them to move ahead in the curriculum tasks. In the experimental group, the 96 students were divided into groups of four to form teams. Each group consisted of a mixture of high and low ability students, unequal numbers of boys and girls, with varied learning style and multiple intelligences preferences. The justification for creating mixed group was to exploit strength (Asherson, 2008) and to differentiate the students according to readiness levels, interests, and learning profile.

Each group had different predominant learning styles in, which each team had a leader who was going to be responsible for instruction in mathematics in a specific area of the class. The teams rotate through work stations or centers in specific areas of the class for instruction. The team leader who had the predominant feature for the task delivered instruction and also served as a facilitator to the other team members who had different learning styles. Each group worked on the same lesson unit, but focused on different skills, based on their interests. Thereafter, students in the experimental group were engaged in tiered instruction in mathematics. The tiered instruction in mathematics used varied levels of mathematical activities to ensure that students explore ideas at a level that builds on their prior knowledge and prompts continued growth. Tiered activities provided the opportunity for the students to focus on essential skills and understandings at different levels of complexity. To this end, student groups in experimental classes used varied approaches to exploration of essential ideas in mathematics. Students were given the opportunity to work in learning centers and with scaffolding from the teacher, which assisted students in moving from one instructional level to the next by providing support systems that assisted students in succeeding. Instructional techniques that provided scaffolding included teacher modeling, peer tutoring, and hands-on activities (Tomlinson, 2003).

The following gave an overview of the differentiated instruction used in the experimental group in this study. Teachers in the experimental group set minimum goals for all students and expressed different expectations for students with different abilities by adjusting the learning objectives/expectations to relevant differences between students. The teachers enabled flexible grouping and ensured that learning materials were adjusted to the level and development of all students. The teachers in experimental group took differences among students into account with the organization of the learning environment by making differences between students in the complexity of tasks and in the number of tasks so that the below-average students were allowed to use auxiliary materials in mathematics to reinforce effective learning. The teachers adjusted the processing of the learning content to relevant differences between students and allowed all students to work at their own pace by providing the below-average students with content with more structure and extra instructional support so that the above-average students were provided with content with more depth and extra challenge during instruction. The teachers in the experimental group provided extra support/challenge to students, based on their progress during lesson as revealed by on-going assessments and at the end the teachers evaluated the learning of the students.

In the control group students were treated with the conventional teaching method. In this method, the teacher presented the information on the topics to the whole class while students listened and carry out the assignment at the end of the lesson. The topics taught in the experimental and control groups lasted for a period of eight weeks. At the end of the treatment session, the MAT items were reshuffled in order to prevent halo effect which might result from overfamiliarity with the pre-test and administered to both the experimental and control groups. The scores obtained from both groups were compared to determine the effect of the teaching strategies that were used in the study.

Method of Data Analysis

Data collected were analyzed using the appropriate descriptive and inferential statistics of the Statistical Package for the Social Sciences (SPSS) Programme version 16. In testing for the possible post-experimental difference in achievement due to treatment and between male and female students, the Analysis of Covariance (ANCOVA) was used and the hypotheses were tested at .05 level of significance.

3. Results and Discussion

Research Question One: What is the difference in the mean achievement scores of students taught mathematics with differentiated instruction and those taught with conventional teaching method?

Null Hypothesis One (H_{01}): There is no significant main effect of treatment (differentiated instruction vs. conventional teaching method) on students' achievement in mathematics.

Table 2 below showed the results of statistical analysis of pre-treatment and post-treatment achievement scores between the experimental and control groups according to gender.

Table 2. Results of statistical analysis of pre-treatment and post-treatment achievement scores based on treatment and gender

Treatment	**Gender**	**Post-test**		**Pre-test**		**Mean**	**N**
		Mean	**SD**	**Mean**	**SD**	**differ**	
Differentiated	Male	32.94	3.90	21.37	4.41	11.57	51
	Female	32.67	3.78	21.69	4.58	10.98	45
	Total	32.81	3.83	21.52	4.47	11.29	96
Conventional	Male	23.92	5.71	21.29	4.47	2.63	49
	Female	23.95	4.89	21.61	4.24	2.34	75
	Total	23.94	5.21	21.48	4.32	2.46	124
Total	Male	28.52	6.64	21.33	4.42	7.19	100
	Female	27.22	6.18	21.64	4.35	5.58	120
	Total	27.81	6.41	21.50	4.37	6.31	220

The results in tables 2 and 3 present answer to research question one and test null hypothesis one respectively. Table 2 showed that the experimental group taught mathematics with differentiated instruction had a mean score of 21.52 (SD=4.47) in the pre-test and a mean score of 32.81 (SD=3.83) in the post-test making a pre-test, post-test mean difference of 11.29. Meanwhile, the control group taught mathematics with conventional teaching method had a mean score of 21.48 (SD=4.32) in the pre-test and a post-test mean of 23.94 (SD=5.21) with a pre-test, post-test mean difference of 2.46. This showed that students in the experimental group taught mathematics with the differentiated instruction performed better than the students in the control group taught with the conventional teaching method. Hence, the differentiated instruction was effective when compared with the conventional teaching method.

Further analysis of the post-treatment achievement scores of the students in the experimental and control groups using the Analysis of Covariance as contained in Table 3 below showed that the difference in means between the two groups was statistically significant ($F(1, 219)=213.37$, $p=0.000$, $\eta 2p=0.498$). The partial eta squared ($\eta 2p$) which is the proportion of the effect + error variance that is attributable to the effect (Awofala, Fatade & Udeani, 2015) was just 0.498 in this study, which means that the factor treatment by itself accounted for only 49.8% of the overall (effect+error) variability in the senior secondary school students' achievement in mathematics score. This result suggested a large effect for treatment (Cohen, 1988). The significant result at a level of $p<0.05$ meant that there was a less than 5% chance that the result was just due to unpredictability. The flip side of this was that there was a 95% chance that the difference in post-treatment achievement scores between the two groups was a real difference and not just due to coincidence. As observed in Table 3 below, the two-tailed p value was 0.000, which meant that random sampling from identical populations would lead to a difference smaller than was observed in 100% of experiments and larger than was observed in 0% of experiment. Thus, the null hypothesis one was rejected and it was concluded that there was a significant difference in the achievement of students taught mathematics using differentiated instruction and those taught with conventional teaching method in favour of the differentiated instruction.

Table 3. Summary of Analysis of Covariance of Achievement in Mathematics Scores by Treatment and Gender

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig**	**Partial Eta Squared**
CM	4820.66[a]	4	1205.17	62.15	.000	.536
Interc	3667.52	1	3667.52	189.12	.000	.468
Pretest	554.96	1	554.96	28.62	.000	.117
T	4137.62	1	4137.62	213.37	.000	.498
G	3.054	1	3.054	.157	.692	.001
T×G	1.181	1	1.181	.061	.805	.000
Error	4169.32	215	19.392			
Total	179126.00	220				
CT	8989.982	219				

a.R Squared = .536 (Adjusted R Squared = .528); CM=corrected model; CT=corrected total; Interc=intercept; T= treatment; G= gender

Research Question Two: What is the difference in the mean achievement scores of male and female students in mathematics?

Null Hypothesis Two (H_{O2}): There is no significant influence of gender on senior secondary school students' achievement in mathematics.

The results in tables 2 and 3 present answer to research question two and test null hypothesis two respectively. Table 2 showed that male students taught mathematics had a mean score of 21.33 (SD=4.42) in the pre-test and a mean score of 28.52 (SD=6.64) in the post-test making a pre-test, post-test mean difference of 7.19. Meanwhile, the female students taught mathematics had a mean score of 21.64 (SD=4.35) in the pre-test and a post-test mean of 27.22 (SD=6.18) with a pre-test, post-test mean difference of 5.58. This showed that female students taught mathematics performed slightly lower than the male students in the post-test. Hence, there could still be slight gender difference in achievement in mathematics in favour of the male students.

Further analysis of the post-treatment achievement scores of male and female students using the Analysis of Covariance as contained in Table 3 above showed that the difference in means between the two groups was statistically not significant ($F_{(1,\ 219)}=0.16$, $p=0.69$, $\eta2_p=0.001$). Thus, it was concluded that there was no significant influence of gender on senior secondary school students' achievement in mathematics.

Research Question Three: Is there any interaction effect of treatment (differentiated instruction vs. conventional teaching method) and gender (male & female) on students' achievement in mathematics?

Hypothesis One (H_{O3}): There is no significant interaction effect of treatment and gender on students' achievement in mathematics.

The results shown in tables 2 and 3 revealed that male students taught mathematics with the differentiated instruction had a mean score of 21.37 (SD=4.41) in the pre-test and a mean score of 32.94 (SD=3.90) in the post-test making a pre-test, post-test mean difference of 11.57. Meanwhile, female students taught mathematics with the differentiated instruction had a mean score of 21.69 (SD=4.58) in the pre-test and a post-test mean of 32.67 (SD=3.78) with a pre-test, post-test mean difference of 10.98. Also, male students taught mathematics with the conventional teaching method had a mean score of 21.29 (SD=4.47) in the pre-test and a mean score of 23.92 (SD=5.71) in the post-test making a pre-test, post-test mean difference of 2.63. Meanwhile, female students taught mathematics with the conventional teaching method had a mean score of 21.61 (SD=4.24) in the pre-test and a post-test mean of 23.95 (SD=4.89) with a pre-test, post-test mean difference of 2.34. With these results both male and female students taught mathematics using the differentiated instruction gained comparably and maximally from the instruction than the male and female students taught mathematics using the conventional teaching method. Thus, the differentiated instruction could close the achievement gap between male and female students in mathematics.

Further analysis of the post-treatment achievement scores of students by treatment and gender using the Analysis of Covariance as contained in Table 3 above showed that the interaction effect of treatment and gender was statistically not significant ($F_{(1,\ 219)}$=.061, p=0.81, $\eta 2_p$=0.000). Thus, it was concluded that there was no significant interaction effect of treatment and gender on students' achievement in mathematics.

The results presented in Table 3 showed significant main effect of treatment on students' achievement in mathematics and that the 49.8% of the variance in students' achievement in mathematics could be explained by the treatment alone. This result showed that students' achievement in mathematics was greatly enhanced when they were taught with the differentiated instruction than when they were taught with the conventional teaching method. This finding supported earlier findings (Awofala, 2011a, 2011c; Akinsola & Awofala, 2008; Akinsola & Awofala, 2009; Awofala, Fatade & Ola-Oluwa, 2012; Awofala, Fatade & Ola-Oluwa, 2013; Awofala & Nneji, 2011; Awofala, 2014; Awofala, 2010; Ojaleye & Awofala, 2018) which associated improved content learning and achievement to learner-centred teaching strategies. The conventional teaching method has not only been judged for accentuating teacher activity at the expense of students' participation (Awofala, Arigbabu & Awofala, 2013) but that it could have a detrimental and negative influence on students' achievement in mathematics (Awofala, 2011a; Ojaleye & Awofala, 2018).

The differentiated instruction was found to be more effective in promoting and increasing students' achievement in mathematics than the conventional teaching method in this study because the method not only provided students with the opportunity to work together in flexible grouping but that students were taught in recognition of their individual differences which could hamper their growth in mathematics. Differences in readiness levels, interests and learning profiles were taken care of during differentiated instruction. By considering interests, the teacher gave the students the opportunity to develop skills and concepts through the mathematics topics, which students enjoy studying. A peep into students' readiness level enabled the teachers to take into account the academic needs of their students while the learning style allowed the teachers to account for the seeing and hearing, reflecting and acting, rational reasoning and intuitive reasoning, and analyzing and visualizing preferences of the students. The implementation of differentiated instruction in the experimental classes enabled teachers to modify curriculum and instruction in mathematics by selecting and organizing mathematics content on the basis of learning objectives, choosing instructional approaches for its effective transaction, designing learning activities and assessments according to students' interests, learning styles and readiness levels.

The higher achievement by the differentiated instruction group might be that students were exposed to novel experiences, which involved them in an active process of identifying links (steps) between concepts where new knowledge was reconciled, progressively differentiated and well integrated into previous knowledge already acquired by the students (Ogunkunle & Onwunedo, 2014). Similar studies have associated the effectiveness of differentiated instruction in facilitating meaningful understanding of concepts and enhancing students' achievement in mathematics (Tomlinson, 2000; Anderson, 2007). When concepts are productively learnt and internalized, students show mastery and exercise control over the content leading to significant improvement in students' achievement. However, some studies (Cummings, 2011; Kesteloot, 2011; Maxey, 2013) have shown that there was no significant effect of differentiation on students' achievement in school subjects. The underachievement of the control group students as shown in the results of the present study could be attributed to the defective nature of the conventional teaching method in, which students were only passive recipients of knowledge in the learning process, which could deprive them from taking charge of their own learning.

The non-significant main effect of gender on students' achievement in mathematics in this study (Table 3) was in agreement with the results of previous studies in mathematics (Awofala, 2017; Fatade, Nneji, Awofala & Awofala, 2012; Awofala & Anyikwa, 2014; Awofala, 2016). These studies reported that there are no significant gender differences in students' learning outcomes. The present study result on gender differences in achievement in mathematics was in contradiction with the work of researchers who believe that gender stereotyping is still prevailing in the Nigerian educational system (Awofala, 2011b; Awofala, 2008). Gender based variances are due to the individual's perception of own abilities and the sex role stereotyping (Schiefele & Csikszentmihalyli, 1995). The result of the present study suggested the non-existence of differential experiences of boys and girls within and outside the classroom and that gender differences in achievement in mathematics might be declining.

The non-significant interaction effect of treatment and gender recorded in this study was in line with previous study (Ojaleye & Awofala, 2018) which showed that gender appeared not to interrelate with instruction to produce results, meaning that the treatment conditions did not differentiate across gender in this study. Contrarily, Ogunleye, Awofala and Adekoya (2014) reported that there was a statistically significant interaction effect of treatment and gender on students' achievement in physics. The present study result implied that differentiated instruction could be used to advance learning and close the gap of gender disparity in the learning of mathematics. Thus, this teaching approach of differentiated instruction could be used as a basis for individualizing instruction for both male and female students to promote teaching effectiveness (Awofala, 2012).

4. Conclusion

The adoption of differentiated instruction as an authentic and novel teaching approach in secondary school mathematics teaching and learning is one way to guaranteeing significant learning and comprehension of mathematics concepts in contrast to learning by memorization which is the hallmark of conventional teaching method. Teaching mathematics using differentiated instruction is effective for increasing achievement in mathematics. Hence, differentiated instruction is very unique, effective and productive teaching approach for enhancing meaningful understanding of abstract and difficult concepts in mathematics. Gender was not a factor in students' achievement in mathematics in this study. Also, irrespective of the nature of gender students will record improved achievement in mathematics when differentiated instruction is employed for teaching mathematics. The result therefore showed that differentiated instruction is a viable alternative to the conventional teaching method for teaching mathematics in senior secondary schools in Nigeria. It is hoped that if the teaching approach of differentiated instruction is taken into consideration in the teaching of mathematics in senior secondary schools in Nigeria, the students will graduate with necessary social skills needed for work in the present world of work and also improve their performance in both public and internal examinations in mathematics.

The following recommendations were made from the findings of this study: Mathematics teachers should be encouraged to use differentiated instruction in the teaching of mathematics in schools in Nigeria as this will enable them to cater for diverse students' needs in terms of readiness level, interest, and learning profile in the classroom and hence, improve the academic performance/achievement in mathematics of their students.

The Federal and State Governments and other educational bodies should deem it fit to popularize the use of differentiated instruction in schools by organising technical workshops, seminars and regular in-service innovation-oriented training programs for teachers on this efficient and effective teaching approach. Mathematics educators at the tertiary education level in Nigeria should infuse element of differentiated instruction in the curricular of pre-service mathematics teachers.

Acknowledgement

The authors thank all the students, staff and principals that aided in the collection of data for the study. More power to your elbow.

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How to cite this article:

Awofala, A. O. A. & Lawani, A. O. (2020). Increasing Mathematics Achievement of Senior Secondary School Students through Differentiated Instruction. *Journal of Educational Sciences*, *4(1)*, 1-19.