Can Teacher Collaboration Improve Students' Academic Achievement in Junior Secondary Mathematics?

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Abstract: The unsatisfactory academic performance of students in Nigerian secondary schools has been blamed on the quality of teachers, and professional development has been identified as a remedy. Hence, this study examined the effects of teacher collaboration as a form of professional development on students' academic achievement in mathematics. The research adopted a pretest-posttest-control group quasi-experimental design involving a 2x2 factorial matrix. The population comprised all the mathematics teachers and students of junior secondary school 1 (JSS 1) in the nineteen (19) public junior secondary schools in Ijebu-North Local Government Area of Ogun State. The sample consisted of one hundred and thirty-five (135) students and five mathematics teachers from the two junior secondary schools purposively selected for the study. Mathematics Achievement Test (MAT), a researcher-developed instrument with a reliability coefficient of 0.86 was used to collect data. The collected data were analyzed using both descriptive and inferential statistics. The results indicated students taught by the teacher that collaborated performed significantly better than those taught by the isolated teacher. Also, the findings indicated no significant effect of age on students' academic achievement in Mathematics. Additionally, the outcomes revealed no significant interaction effect of teacher's group and students' age on academic achievement in Mathematics. The results of this research imply that collaboration among teachers can account for an improvement in students learning. Therefore, school authorities should restructure the school hours to cater for teacher collaboration activities. Also, workshops should be organised for teachers on the importance of teacher collaboration as a means of professional development.

Keywords: Collaborated Teacher, Isolated Teacher, Students' Age, Teacher collaboration, Mathematics Achievement

1. Introduction

Every nation is desirous to provide functional education to its citizens. Functional education equips individuals with the skills required to participate effectively in societal affairs and bring about national development.

Teachers are pivotal to raising citizens capable of contributing to the societal and national development as no education system can rise above the quality of its teachers (Federal Republic of Nigeria [FRN], 2004). This means that quality teachers will produce learners with requisite skills, knowledge and attitudes to compete favourably in the 21st-century digital economy. Also, Mat-Salleh, Md-Nasir and Ismail (2020) opined that teachers should strive to sustain students' interest and motivation towards learning and give persuasive answers to questions posed during teaching and learning process.

However, the quality of teachers in Nigeria is worrisome. The Federal Ministry of Education (FME, 2017) described the quality of teachers in Nigerian schools as discouraging due to their inability to successfully implement the national curriculum. This observation was a sequel to the unsatisfactory performance of students in the national assessment. Mean scores of students in the assessment ranged from 30% to 52%. Although the inadequate capacity building of teachers has been identified as a factor affecting teachers' quality, efforts to improve the situation seem not to achieve results.

For instance, Federal Republic of Nigeria (2014) through the National Policy on Education states "that efforts towards the improvement of quality education at all levels shall include improvement and regulation of career-long professional development of teachers through the provision of a wide range of programmes and multiple pathways to provide serving teachers with regular opportunities to update their knowledge and skills" (p.45). The policy also recognises the establishment of Teachers' Resource Centre across all the thirty-six states and the Federal Capital Territory (FCT) and at the Local Government levels where teachers can meet for discussions, investigations, study workshops, shorts courses and conferences. The centres are also to be used to test and develop teaching materials (p.59). These policy statements are intended to enhance the quality of teachers for effective service delivery but these resource centres are not in place as desired. This suggests that teachers' professional development using these centres has suffered.

Evidence from literature has shown many teachers work in isolation which affects the quality of their instructional delivery. They do not share their views or experiences. Rosenholtz in Goddard, Goddard and Tschannen-Moran (2007) argued that teaching in isolation constitutes an impediment to teaching and learning process. It makes teachers use less effective teaching method and dependent on previously acquired skills to produce learners that cannot positively contribute to society. Hindin, Mott and Aguilar (2007) also contended that teachers conduct teaching in isolation despite several opportunities that abound for them to work collectively about new practices and other teaching innovations. These opportunities can improve their skills, competence and resourcefulness to guarantee their continued relevance on their jobs. Moreover, education stakeholders have advocated that teachers in the same schools should be encouraged to work collectively to improve students' learning (Ronfeldt, Farmer, McQueen & Grissom, 2015). This indicates that school-level professional development exercise can advance the quality-of-service delivery by the teachers.

A school-level professional development that has been suggested in the literature is teacher collaboration. Goddard *et al.* (2007); Ronfeldt *et al.* (2015) reiterated the global calls on schools to enhance teachers' quality through teacher collaboration activities. Dufour in Graham (2007) also opined that rather than looking at professional development as unachievable without sponsors to conferences, seminars and workshops, it should be handled at the school level as part of daily activities. Teachers can collaborate to share knowledge to develop a curriculum that identifies the vital knowledge and skills relevant for the learners. They can also create common assessment methods to monitor students' progression during learning, collectively use the results to identify strengths and weaknesses; exchange ideas to assist one another to develop and thus improve the quality of students' learning. Teacher collaboration also affords participants to discuss theories and teaching methods that can ensure good instructional delivery (Goddard *et al.*, 2007).

Teacher collaboration can take several methods. These methods range from one-on-one or small group interactions within the school to inter-school collaboration to exchange ideas with other professionals (Darling-Hammond *et al.*, 2017). The study of Graham (2007) suggested that collaboration activities that involve teachers of the same subject and grade-level can lead to a significant improvement in teaching effectiveness and improve students' learning. Reeves, Pun and Chung (2017) also noted that well-conducted teacher collaboration encompasses activities and interactions that can lead to teachers and students' gains. However, the success of teacher collaboration is determined by the school leadership, organizational practices, details of collaboration activities and the development of community among collaborating teachers (Graham, 2007), time and the school working conditions, training of teachers on collaboration, motivation and personal difficulties (Forte & Flores, 2014).

Studies have found that teacher collaboration can improve teachers' quality and subsequently improve students' learning achievement. Noting the dearth of literature on the influence of teacher collaboration on students' achievement, Moolenaar, Sleegers and Daly (2012) examined the relationship between teacher collaboration network and students' achievement and also the mediating roles of teacher collective efficacy beliefs. The researchers analysed the teachers' survey and

students' achievement data. The findings showed that effective teacher collaboration was associated with stronger teacher collective efficacy and improved students' achievement. Similarly, Mora-Ruano, Heine and Gebhardt (2019) analysed the 2012 Programme for International Student Assessment (PISA) data in Germany and found that teacher collaboration effectively improved students' achievement. Likewise, Ronfeldt *et al.* (2015) examined the individual teacher-level and school-level collaboration to understand the nature and effects of teacher-to-teacher collaboration in instructional teams using survey data. The study found that when teachers involved in an all-embracing and supportive collaboration, they benefited individually and collectively and that high-quality collaboration translated to improved students' learning achievement. The study of Reeves, Pun and Chung (2017) also examined the difference in the effects of teacher collaboration by the type and frequency of collaborative activities. The Trend in International Mathematics and Science Study (TIMSS) data was analysed to determine which of the five predictors of collaboration predicted students' achievement, teacher job satisfaction and teacher confidence in Japan and United States. The results revealed that the collective lesson planning by the teachers significantly predicted students' achievement while the time used teach gave the teachers higher job satisfaction rating in the United States.

Furthermore, Akiba and Liang (2016) examined the effects of six types of teacher professional learning activities on students' achievement growth over four years using state-wide longitudinal survey data collected from 467 middle school mathematics teachers in 91 schools in Missouri, United States. The results showed that teacher-centred collaborative activities which focused on mathematics teaching and learning improved students' achievement. The study also established that many districts and schools benefitted from the teacher-focused collaboration and research-based learning activities. Jao and McDougall's (2016) study examined the influence of collaborative teacher inquiry (CTI) on students' achievement. The participants were Grade 9 Applied Mathematics teachers from 11 schools across four neighbouring public schools' boards in the same geographic area of a large urban city in Southern Ontario, Canada. The study reported that teacher collaborative improved the quality of the teachers which led to more students' engagement and enhanced learning achievement. The results also illustrated that teachers were able to remove impediments to their interaction.

Apart from teaching in isolation which is a teacher factor, studies have also reported that students' factor such as age affects learning achievement especially in the developing nations (Ishiguro, 2014). Federal Republic of Nigeria (2014) stipulates that the compulsory basic education (primary one to junior secondary three) which is for nine (9) years is for children aged 0-15 years. Primary education is the education given to children aged 6-12 years whereas junior secondary education starts immediately after the primary education. This implies that the entry age to junior secondary education is 12 years. However, students of lower or higher age may be in the JS 1 class depending on the year of entry/enrolment in the primary school or the type of schools attended. Public primary schools in Nigeria allowed pupils to proceed to junior secondary school from primary six whereas pupils from most privately own primary schools either proceed from primary four or primary five based on the belief that schools would have laid a good foundation for their students. Hence, many younger students in secondary schools may be products of private primary schools. Unlike in the public primary schools, it is rare to see primary six pupils in private primary schools. Navarro, Carcia-Rubio and Olivares (2015) argued that the age difference in a particular class affects academic performance due to maturation. Besides, Zhang, Zhong and Zhang (2017) observed that one-year delay in school entry could lower students' learning achievement. This is also similar to the submission of Onuekwusi (2015) that students age influences their cognitive development, motivation and readiness to learn.

However, mixed reports abound on how students' age affect their academic performance. Aransi (2018) explored the impact of age on high school students' academic performance in Economics in Osun State, Nigeria. The finding revealed a positive but weak linear relationship between age and academic performance in the subject. That is, an increase in age leads to improvement in learning. Also, Momanyi, Too and Simiyu (2015) investigated the effect of students' age on academic motivation and academic performance among day students of secondary schools in Nakuru, Municipality in Kenya and reported that age had a significant effect on students' academic performance. The research of Nam (2014) which also analysed the Korean students' panel survey data found that monthly difference in age had a significant influence on academic achievement until middle school (junior secondary). However, this age effect would not persist when the students' transit to high school (senior secondary).

The outcomes further revealed that younger students discourage any activity that could affect their performance when in schools. This indicates that they study hard and behave responsibly to maintain good academic standing. Ishiguro (2018) determined the influence of age on learning achievements in seven Cambodian primary schools. The results revealed that the age of students had a significant negative influence on learning achievement. It also established that older students in the class obtained lower marks than the younger students. Moreover, the findings showed that older students due to delay entry scored higher marks than older students whose ages were due to repeating the class.

Conversely, Ogwero, Kathuri and Obara (2014) determined the influence of students' characteristics such as students career choice, age, gender, study times and class attendance on students' academic performance in Agriculture. The results showed that the influence of students' age on performance in Agriculture was not significant. Relatedly, the study of Onuekwusi (2015) which investigated the main and interaction effects of age and content area on students' academic achievement in Chemistry reported no significant effect of age on students' achievement. The outcomes of the research of Amuda, Bulus and Joseph (2016) on the influence of age on students' academic performance in the colleges of education in North-eastern Nigeria also revealed that age did not significantly predict academic performance in the colleges.

At the secondary education level in Nigeria, mathematics is one of the core subjects in the curriculum to equip individuals with requisite skills to contribute to societal development. Its knowledge is useful in the day-to-day activities of humanity. Ambali (2014) reiterated that Mathematics is vital for today and also for future exploration. Mathematical skills have applications in fields such as analytic, technology, science, security, politics and economics. The knowledge of mathematics can also serve as a foundation for individuals' success in other disciplines.

However, students' performance in Mathematics at the junior secondary school level in Nigeria is worrisome. The latest study on National Assessment of Learning and Performance in Basic Education (NALABE) conducted by Universal Basic Education Commission (UBEC) in 2011 revealed that the junior secondary school one (JS 1) students recorded a national mean performance of 41.08 in mathematics (UBEC, 2013). This mean performance is low when compared to 51.63, 50.63 and 52.94 recorded by students of primaries four, five and six respectively. The national mean performance index of 41.08 for JS 1 students is below expectation Moreover, the 2011 NALABE's identified teachers' quality as the factor that affected students' performance and suggested professional development to boost their quality for effective service delivery.

As exemplified above, teacher collaboration can lead to improved students' academic achievement. Nevertheless, Ronfeldt *et al.* (2015) observed that despite calls for teacher collaboration as a form of professional development, there is a paucity of studies on the effects of teacher collaboration on students' achievement. Also, Goddard *et al.* (2007) had earlier observed the unavailability of evidence to ascertain the causal relationship between teacher collaboration and students' achievement. Also, there are no empirical studies on which components of teacher collaboration that impact students' learning. Goodard et al. further sought investigation on how teachers could achieve and sustain professional development with less expectation from the governments and the school proprietors. To address some of these observations, this study examined the effects of teacher collaboration on students' learning achievement in junior secondary school mathematics in Ijebu-North Local Government Area of Ogun State with students' age as a moderating variable. To this end, teachers were grouped either as a collaborated teacher (teacher that met with other teachers at a given time to discuss their professional development) or an isolated teacher (teacher that did not meet with other teachers at a designated period to discuss professional development). The students' ages were classified either as younger (10-12 years) or older (Above 12 years.)

1.1 Objectives of the Study

This study examined the effects of teacher collaboration on students' academic achievement in Mathematics in junior secondary schools in Ijebu-North Local Government Area of Ogun State. Specifically, the study

1. Examined the effectiveness of teacher collaboration on students' achievement in junior secondary school mathematics;

2. determined the moderating effects of students' age on academic achievement in junior secondary school mathematics.

1.2 Research Questions

The following research questions were raised for the study:

1. What are the students' mean achievement gains in Mathematics when taught by collaborated or an isolated teacher?

2. What are the students mean achievement gains in Mathematics across the age groups?

1.3 Statement of the Hypotheses

This study was guided by the following hypotheses:

1. There is no significant difference in the effect of teachers' group (collaborated and isolated) on students' academic achievement in junior secondary school mathematics.

2. There is no significant difference in the effect of students' age on academic achievement in junior secondary school mathematics.

3. There is no is significant interaction of teachers' group and students' age on achievement in junior secondary school Mathematics.

2. Methods

This section presents the methods employed to conduct this study. These include the research design, population, sample and sampling technique, instrumentation and method of data collection

2.1 Research Design

The study adopted pretest-posttest-control group quasi-experimental research design involving a 2x2 factorial matrix. Two groups participated with one designated as the experimental while the second served the purpose of comparison. Also, students' ages were classified into two levels: younger (10 to 12) and older (13-16). The normal secondary school age in Nigeria is 12 years. Hence, students with ages above 12 years were classified as older students. The design layout is as shown below:

$O_1\ X_G\ O_2$	Collaborated Teacher Group (Experimental)
$O_1\ X_I\ O_2$	Isolated Teacher Group (Comparison)

Where: O_1 represents the pretest observation
O_2 represents the posttest observation
X_G represents collaborated the teacher's group
X_I represents the isolated teacher's group

2.2 Target Population

The population for this study comprised all the mathematics teachers and students of junior secondary 1 (JS 1) in the nineteen (19) public junior secondary schools in Ijebu-North Local Government Area of Ogun State. Ogun State has twenty (20) local government areas. Ijebu-North was selected due to its proximity to the workplace of the researcher.

2.3 Sample and Sampling Procedure

The participants consisted of one hundred and thirty-five (135) junior secondary one (JS 1) students and five mathematics teachers selected from two (2) out of the nineteen (19) public junior secondary schools in Ijebu-North. The two schools were selected based on the approvals of the authorities to conduct the study and the teachers' willingness to participate. A school was randomly selected and designated as an experimental group as the second one served as the control group. Since each school had more than a JS 1 class, a randomly selected class from each school was used without modification i.e., without random assignment of students. The experimental group had 69 students and four mathematics teachers. Although all the mathematics teachers participated in the collaboration exercise, only teacher handing JS 1 students taught the students. The control group had 66 students and a teacher as participants. Although there were three teachers in the control group, only one participated because of no collaboration among them.

2.4 Instrumentation

This study used Mathematics Achievement Test (MAT) developed by the researcher to measure students' mathematics achievement. The MAT had sections A and B with section A on demographic information such as the student's age and gender while Section B contained 50 items which primarily tests students' knowledge of mathematics topics schemed for this work.

For content validity, the instrument was given to experts in mathematics education and mathematics teachers in junior secondary schools to critique. Their observations led to the adjustment of some of the test items before producing a final copy. The test was then administered on 30 students of a school that did not participate in the study but share similar attributes with the selected schools using test-retest reliability method within two weeks. This was to ensure the reliability of the test, i.e., its ability to stand the test of time in measuring the students' knowledge of mathematics. The scores obtained at the two intervals were analysed using the Pearson Product Moment Correlation Statistics and yielded a reliability coefficient of 0.86.

2.5 Method of Data Collection

First, the researcher discussed the research purpose with the authorities of the experimental for approval to conduct the study using the period allocated for the literary and debating society for teacher collaboration. Later, the researcher interacted with the mathematics teachers on the use of the weekly periods scheduled for the debating and literary activities to gather all the four teachers for collaborative activities. They accepted to participate and make the experiment a success. Coincidentally, the four teachers are on the same grade level but different years of promotion. Graham (2007) suggested that collaboration activities that involve teachers of the same subject and grade-level can achieve significant improvement in teaching effectiveness. Thereafter, the four teachers were exposed to the principles of teacher collaboration and to apply them for their professional growth given the dwindling efforts from school authorities and governments to sponsor teachers to training and retraining programmes.

During the first meeting, the teachers in the experimental group discussed the curriculum, jointly developed a scheme that arranged the topics for easy acquisition of knowledge and skills. They also resolved to collaboratively plan the weekly lessons and design instructional materials for mathematics teaching in their school. Subsequently, lesson plans and instructional materials were brought to the meeting by each teacher for others to critique. The teachers also observed one another in the classroom and discussed their observations during the following collaborative meetings. Issues of

subject mastery, teaching methods and similar assessment methods that could improve students' learning were extensively discussed and implemented.

Similarly, the authorities of the control school were contacted for approval. The support of the mathematics teacher for JS 1 was then requested to make the study a success. The teacher taught the JS 1 students the same topics taught in the experimental group. While the study lasted, the researcher usually visited to ensure no collaboration among the teachers in the control group.

Meanwhile, before the commencement of teaching in both groups, the researcher administered the MAT on the students as a pretest. The scores obtained from the pretest were used as covariates. During the experiment, the teachers in both groups taught the topics outlined in the approved scheme of work by Ogun State Government, Nigeria. Throughout the eight (8) weeks of the study, the researcher moderated the activities of the collaborating teachers in the experimental group and was also on ground to ensure no collaboration among the teachers in the control group. In the ninth week, the researchers re-administered the MAT as posttest but reshuffled items to prevent the threats of history and maturation on the parts of the learners.

2.6 Method of Data Analysis

The data analysis involved the use of descriptive and inferential statistics. The descriptive statistics used means and standard deviations as inferential statistics used the Analysis of Covariance (ANCOVA). The pre-test scores served as covariates to determine the effects of the teachers' group and students' ages on students' achievement in Mathematics. The hypotheses generated were tested at 0.05 level of significance.

3. Results and Discussion

3.1 Results

The results of the analyses are presented according to the research questions followed by hypotheses testing.

Research question 1: What are the students' mean achievement gains in Mathematics when taught by collaborated or an isolated teacher?

Table 1. Mean Achievement Gains in Mathematics by students according to teachers' group

Teachers' Group	N	Test	Mean	S.D.	Mean Gain
Collaborated	69	Pretest	22.29	2.590	14.01
		Posttest	36.30	4.282	
Isolated	66	Pretest	23.00	2.474	7.27
		Posttest	30.27	5.482	
Total	**135**	**Pretest**	**22.64**	**2.550**	**10.72**
		Posttest	**33.36**	**5.748**	

Table 1 indicates that the students taught by a teacher that engaged in collaboration recorded mean achievement gain of 14.01 but students taught by the isolated teacher recorded mean achievement gain of 7.27. This finding suggests that students taught by the collaborated teacher recorded higher achievement gain in mathematics than those taught by the isolated teacher.

Research question 2: What are the students' mean achievement gains in Mathematics across the age groups?

Table 2. Students' Mean Achievement gain by age

Age Group	N	%N	Test	Mean	S.D.	Mean Gain
Younger (10-12)	76	56	Pretest	22.70	2.838	11.23
			Posttest	33.93	5.786	
Older (Above 12)	59	44	Pretest	22.56	2.144	10.05
			Posttest	32.61	5.660	
Total	**135**	**100**	**Pretest**	**22.64**	**2.550**	**10.72**
			Posttest	**33.36**	**5.748**	

Table 2 shows that the younger students (10-12) in the JS 1 class recorded mean achievement gain of 11.23 while the older students (above 12) in the same class obtained the mean achievement gain of 10.05. This finding indicates that the younger students recorded a higher mean achievement gain than their older counterparts in the same class. The table also revealed that the majority are younger students (56%) compared to the older students (44%)

Test of hypotheses

Hypothesis 1: There is no significant difference in the effect of teachers' group (collaborated and isolated) on students' academic achievement in junior secondary school mathematics.

Table 3. Summary of Analysis of covariance of students' achievement in Mathematics according to teachers' group and students' age

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1250.873	4	312.718	12.800	0.000
Intercept	1814.097	1	1814.097	74.253	0.000
Covariates	.012	1	0.012	0.001	0.982
Teachers' Group	1166.180	1	1166.180	47.733	0.000
Students' Age	18.881	1	18.881	0.773	0.381
Teachers' Group * Students' Age	4.734	1	4.734	0.194	0.661
Error	3176.060	130	24.431		
Total	154627.000	135			
Corrected Total	4426.933	134			

a. R Squared = .283 (Adjusted R Squared = 0.260)

Table 3 reveals that there is a significant difference in the effect of teachers' group (collaborated or isolated) on the students' achievement in mathematics ($F_{(1,130)} = 47.733$, $p<0.05$). This means that the posttest mean achievement scores of students in the group taught by the collaborated teacher and those taught by the isolated teacher differ significantly. Thus, the hypothesis which states that there is no significant difference in the effect of teachers' group on students' academic achievement in junior secondary school mathematics is rejected.

To obtain the magnitude of the effect of teachers' group (collaborated and isolated) on students' achievement in mathematics, multiple classification analysis was conducted. The results are as presented in Table 4.

Table 4. Multiple classification analysis of students' achievement in mathematics by in teachers' group and students' age-group

Grand mean= 33.63								
			Predicted Mean		Deviation			Beta
		B	Unadjusted	Adjusted for Factors	Unadjusted	Adjusted for Factors	Eta	Adjusted for factors
Teachers' Group	Collaborated	69	36.30	36.27	2.949	2.914	0.527	0.520
	Isolated	66	30.27	30.31	-3.083	-3.047		
Age-Group	Younger	76	33.93	33.69	0.579	.331	0.115	0.066
	Older	59	32.61	32.93	-0.745	-.427		

Table 4 shows that with the grand mean of 33.63, students taught by the collaborated teacher recorded higher adjusted posttest mean achievement score of 36.27 in mathematics than the 30.31 recorded by the students taught by the isolated teacher. This difference of 5.95 is statistically significant according to the result in table 3. The table further depicts that teachers' group accounted for 52% of the variances in the students' achievement in junior secondary school mathematics.

Hypothesis 2: There is no significant difference in the effect of students' age on academic achievement in junior secondary school mathematics.

Table 3 indicates no significant difference in the effect of students' age on academic achievement in mathematics ($F_{(1,130)} = 0.773$, $p>0.05$). This implies that the posttest mean achievement scores of younger and older students do not differ significantly. Thus, the hypothesis which states that there is no significant difference in the effect of students' age on academic achievement in junior secondary school mathematics is retained. However, the adjusted posttest mean achievement in mathematics of the younger JS 1 students is 33.69 while that of older students in the same class is 32.93 (Table 4). This suggests that younger students recorded higher adjusted posttest mean achievement score than their older counterparts. The difference in their mean scores (1.38) is however not statistically significant as depicted in table 3. The outcomes further illustrate that students age accounted for 6.6% of the variances in the students' achievement in mathematics.

Hypothesis 3: There is no significant interaction effect of teachers' group and students' age on academic achievement in junior secondary school mathematics.

Table 3 shows no significant interaction effect of teachers' group and students' age on academic achievement in mathematics ($F_{(1,130)} = 0.194$, $p>0.05$). This finding means that the posttest mean achievement scores of younger and older students either taught by the collaborated or isolated teacher do not differ significantly. Hence, the hypothesis which states that there is no significant interaction effect of teachers' collaboration and students' age on academic achievement in junior secondary school mathematics is retained.

Meanwhile, to obtain information about students' achievement in mathematics by teachers' group and students' age, *posthoc* analysis was conducted and the results are as indicated in Table 5

Table 5. Students' Achievement in Mathematics across age-group and teachers' groups

Teachers' Group	Age group	Mean	Std. Error
Collaborated	Younger	36.451	0.766
	Older	36.073	0.952
Isolated	Younger	30.826	0.855
	Older	29.688	0.874

Covariates appearing in the model are evaluated at the following values: covariate = 22.64.

Table 5 indicates that younger students in the group handled by the collaborated teachers recorded the highest posttest mean achievement score of 36.451 (S.E.= 0.766) followed by older students in the same group with posttest mean achievement score of 36.073 (S.E.=0.952) and then younger students taught by the isolated teacher with posttest mean achievement score of 30.826 (S.E.= 0.855). The older students taught by the isolated teacher recorded the least posttest mean achievement score of 29.688 (S.E.=0.874). The findings show that regardless of the students' age, students taught by collaborated teacher performed better than those taught by the isolated teacher.

3.2 Discussion

The need to enhance the teachers' quality for effective service delivery through professional development has been suggested in the literature. Consequently, this study investigated the effect of teacher collaboration as a means of professional development on the students' achievement in mathematics in junior secondary schools. This study found that students taught by the teacher that engaged in collaboration obtained higher mean achievement gain in mathematics than those taught by the isolated teacher. This finding supports that of Ronfeldt *et al.* (2015) that high-quality teacher collaboration could improve students' learning. The results of this study also indicated that younger students obtained higher mean score compared to the older students in their class. This finding also corroborates that of Navarro *et al.* (2015) that age affects students' academic performance in different proportions.

On the hypothesis that teachers' group do not significantly affect students' achievement in mathematics. This study revealed a teachers' group (collaborated and isolated) had a significant effect on students' achievement in mathematics. Multiple classification analysis showed that students whose teacher engaged in collaborative activities performed better than those taught by a teacher that did not engage in collaboration (isolated teacher). This means that teacher collaboration appears to be effective in improving students' achievement. This finding resounds that of Mora-Ruano *et al.* (2019) that teachers' collaboration can be effective in improving students' achievement if their learning needs are discussed during the collaborative activities. It also resonates with the finding of Ronfeldt *et al.* (2015) that high-quality collaboration among teachers is associated with an increase in students' achievement in mathematics and reading. It can also culminate into improvement in the teachers' job performance. A plausible reason for these results is that during collaboration, teachers worked together to arrange the mathematics scheme of work to make it easier for students to acquire the skills and knowledge that improve their mathematics learning. The teacher also planned lessons collectively and observed one another during active classroom teaching. The observations from the teaching activities were discussed in their follow-up meetings for improvement in teaching and learning process. Besides, the collaborating teachers developed assessment methods that helped them identify the strengths and challenges of their learners. All these efforts might have manifested as the improvement in students' mathematics learning.

The findings on the effectiveness of teacher collaboration imply that teachers of the same subjects in the same school can work collectively to boost the quality of their services to improve students' achievement in mathematics rather than wait for governments' sponsorship for professional development programmes.

The results of this study also revealed that academic achievement in mathematics in junior secondary school did not differ significantly between the younger and the older students. This finding corroborates the report of Onuekwusi (2015) which found no significant effect of age on students' achievement. The discussion about cognitive development and how to motivate students to learn during collaborative exercise might have reduced the age-divide in learning mathematics. Onuekwusi (2015) asserts that cognitive development, motivation and readiness to learn are all age-related factors and teacher should consider them when planning classroom instructions to the learners. It is thus possible that the collaborating teachers noticed the imbalance in the students' response to mathematics learning due to their age and discussed the solutions in the collaboration meetings.

However, another outcome of this study indicated that the younger students performed better than older students in this same class. This finding corroborates that of Nam (2014) that when younger students enrolled in junior school, they pursue academic activities with rigours and discourage distractions. This may have translated into the learning improvement. The finding also reinforces the report of Ishiguro (2018) that older students in a class scored lower marks on the test than the younger students in the same class. Majority of the younger students might be products of private primary schools believed to have an educational advantage over their older counterparts especially those from the public primary schools. These results may also be due to the number of younger students in the sample which outnumbered the older students.

Although the results revealed no significant difference in the effect of students' age on students' academic achievement, older students need remedial activities from mathematics teachers to close the achievement gap. This is against the fact that the older students may be from public primary schools with fewer educational advantages or perhaps class repeaters.

On the interaction effect of teachers' group and students' age, the results indicated no significant interaction effect of teachers' group (collaboration and isolation) and students' age on academic achievement in mathematics. However, students whose teacher engaged in collaboration recorded higher adjusted posttest mean achievement score regardless of their age group compared to their colleagues taught by the isolated teacher. This finding resonates with the study of Amuda *et al.* (2016) that age did not significantly predict academic performance in colleges of education in northeast Nigeria. The non-significant interaction outcomes may be consequent upon the deliberation on age-related matters and agreement on how to solve the problems.

Thus, findings of this study have revealed that professional development in form of teacher collaboration at the school level can enhance teachers' delivery of quality instruction to the learners as manifested in the improved performance in mathematics. It was also found that teacher collaboration activities may reduce the gap in mathematics learning by due to the age difference among the students of the same class.

4. Conclusion

This study examined how collaboration among teachers can affect students' achievement in Mathematics with age as a moderating variable. The results showed that teacher collaboration is an effective means of improving teachers' quality which manifested in improvement of students' achievement in mathematics across the age groups. These results can serve as the basis for encouraging collaboration among teachers at the school level by their respective authorities. The information can also help teachers to boost their quality through collaboration without waiting for government arrangement. They will be able to come together at the school level to discuss their teaching and learning challenges as well as that of the students. This will also provide an avenue for them to improve their knowledge, skills, resourcefulness and guarantee success in their teaching endeavours.

The study also revealed that age is not a significant factor in learning of mathematics in junior secondary school. However, younger students performed better than the older students in the same class. This information is a prompt to the teachers to pay more attention to the older students in the class contrary to the belief that their maturity will help them to learn hitch-free.

5. Recommendations

Since teacher collaboration as a means of professional development has been found to improve teachers' quality which ultimately improved students' mathematics learning, the study recommends that government should structure the school time-table to accommodate periods for teacher collaborative activities. This is to enable teachers teaching the same subjects to meet and discuss their strengths and challenges with other colleagues to arrive at common solutions. It is also recommended that the school authorities should encourage teachers to collaborate by providing enabling environment and logistics that will make the collaboration a success.

The government should organize workshops for teachers on the importance of professional development through teacher collaboration activities in their respective schools.

The study also revealed that age is not a significant factor in learning of mathematics in junior secondary school. However, the results showed that younger students performed better than the older students in the same class. Thus, it is recommended that teachers should provide remedial activities when needed to the older students in their classes.

5.1 Limitations

The study used four teachers for collaboration and only one of them taught mathematics in the selected JS 1 class in the experimental group. The small sample size may affect the generalization of the findings. Hence, further studies should be conducted involving more teachers and classes. Also, qualitative research is needed to collect information on the teachers' perception of collaboration exercise. The information will help to strengthen the collaborative activities among the teachers for optimum performance in their teaching practice.

Similarly, this research work did not examine the composition of the students according to the primary schools attended. Therefore, it is difficult to empirically link students' age to the type of primary schools attended. It thus suggested that further study on teacher collaboration and students' age should link the students' age to the school types. This will extend the findings of this study.

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References

Akiba, M. & Liang, G. (2016). Effects of teacher professional learning activities on student achievement growth. *The Journal of Educational Research, 109*(1), 99-110. https://doi.org/10.1080/00220671.2014.924470

Ambali, A. A. (2014). Mathematics is key to national development. Retrieved from http://www.unilorin.edu.ng/index.php/fnews/3744-mathematics-is-key-to-national-development-ambali

Amuda, B. G., Bulus, A. K., & Joseph, H. P. (2016). Marital status and age as predictors of academic performance of students of colleges of education in the North-East, Nigeria. *American Journal of Educational Research, 4*(1), 896-902. doi:10.12691/education-4-12-7

Aransi, W. O. (2018). Impact of age and gender on high school students' academic performance in Economics. A case study analysis. *International Journal for Innovative Research in Multidisciplinary fields, 4*(1), 8-15.

Darling-Hammond, L., Hyler, M. E., & Gardener, M. (2017). Effective teacher professional development. Retrieved from https://learningpolicyinstitute.org/product/effective-teacher-professional-development-report

Federal Ministry of Education. (2017). Education for change: A ministerial strategic plan (2018-2022). Retrieved from https://education.gov.ng/wp-content/uploads/2019/03/FINAL-UPDATED-MSP-WITH-COSTING.pdf

Federal Republic of Nigeria. (2004). National Policy on Education (4th Edition). Nigerian Educational Research & Development Council (NERDC), Lagos, Nigeria.

Federal Republic of Nigeria. (2014). *National Policy on Education*. Nigerian Educational Research & Development Council (NERDC). Abuja, Nigeria.

Forte, A. M. & Flores, M. A. (2014). Teacher collaboration and professional development in the workplace: A study of Portuguese teachers. *European Journal of Teacher Education, 37*(1), 91-105. Doi:10.1080/02619768.2013.763791

Goddard, Y. L., Goddard, R. D. &Tschannen-Moran, M. (2007). A theoretical and empirical investigation of teacher collaboration for school improvement and student achievement in public elementary schools. *Teacher College Record, 109*(4), 877-896.

Graham, P. (2007). Improving teacher effectiveness through structured collaboration: A case study of a professional learning community. *RMLE Online, 31*(1), 1-17. https://doi.org/10.1080/19404476.2007.11462044

Hindin, A., Morroco, C. C., Mott, E. A. & Aguilar, C. M. (2007). More than just a group: Teacher collaboration and learning in the workplace. *Teachers and Teaching, 13*(4), 349-376. Doi:10.1080/13540600701391911

Ishiguro, K. (2018). Determinants of learning achievements: Empirical Analysis of seven schools in Cambodian primary schools. *Journal of Education and Learning, 7*(2), 174-183. http://doi.org/10.5539/jel.v7n2p174

Jao, L. & McDougall, D. (2016). Moving beyond the barriers: Supporting meaningful teacher collaboration to improve secondary school mathematics. *Teacher Development, 20*(4), 557-573. https://doi.org/10.1080/13664530.2016.1164747

Kong, Y. (2016). Problems and solutions to professional development of novice college English teachers: A case study on Chinese local HEIs. Canadian Social Science, 12 (10), 56-51. doi:10.3968/8852.

Mat Salleh, M., Md Nasir, N., & Ismail, M. (2020). STEM facilitators training programme: Trainee teachers' perceptions of the impact on their personal growth as future teachers. *Asian Journal of University Education, 16*(3), 281-291. doi:10.24191/ajue.v16i3.11091

Momanyi, J. M., Too, J., &Simiyu, C. (2015). Effect of age on academic motivation and academic performance among high school students in Kenya. *Asian Journal of Education and e-learning,3*(5), 337-342.

Moolenaar, N. M., Sleegers, P. J. C. & Daly, A. J. (2012). Teaming up: Linking collaboration networks, collective efficacy and student achievement. *Teacher and Teacher Education, 28*(2), 251-262. https://doi.org/10.1016/j.tate.2011.10.001

Mora-Ruano, J. G., Heine, J., & Gebhardt, M. (2019). Does teachers' collaboration improve students' achievement? Analysis of the German PISA sample. *Frontier in Education, 4*(Article85). Doi:10.3389/feduc.2019.00085. Retrieved from https://www.frontiersin.org/articles/10.3389/feduc.2019.00085/full

Nam, K. (2014). Until when does the effect of age on academic achievement persist? Evidence from Korean data. *economics of Education Reviews, 40*(2014). 106-122. https://doi.org/10.1016/j.econedurev.2014.02.002

Navarro, J., Garcia-Rubio, J., & Olivares, P. R. (2015). The relative age effect and its influence on academic performance. *PLoSOne, 10*(10). e0241895. doi: 10.1371/journal.pone.0141895.

Ogwero, P. O., Kathuri, N. N. &Obara, J, (2014). Influence of students' characteristics on academic performance in secondary school Agriculture in Rachuonyo North Sub County, Kenya. *International Journal of Education and Research, 2*(3), 1-12

Onuekwusi, C. N. (2015). Influence of Age and content area on students' achievement in Chemistry. *Researchjournali's Journal of Education, 3*(1), 1-6.

Reeves, P. M., Pun, W. K & Chung, K. S. 92017). Influence of teacher collaboration on job satisfaction and student achievement. *Teaching and Teacher Education, 67*(2017), 227-236. https://doi.org/10.106/j.tate.2017.06.016

Ronfeldt, M., Farmer, S. O., McQueen, K., & Grissom, J. A. (2015). Teacher collaboration in instructional teams and student achievement. *American Educational Research Journal 52*(3), 475-514. doi:10.3102/002831215585562

Universal Basic Education Commission (2013). Final Report of 2011 National Assessment of Learning Performances in Basic Education (NALABE). Retrieved from https://ubeconline.com/Pre/2011%20National%20Assessment%20of%20Learning%20Achievement%20in%20Basic%20Education%20(NALABE)%20Report.pdf

Zhang, S., Zhong, R. & Zhang, J. (2017). School starting age and academic achievement: Evidence from China's junior high schools. *China Economic Review*, *44*(2017), 343-354. https://doi.org/10.1016/j.chieco.2017.03.004