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Research Article

Effect of peer and cross-age tutoring on mathematics achievement and interest of underachieving gifted students

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Abstract

Underachievement in the mathematics of gifted students is a disturbing issue that calls for urgent intervention. This study, therefore, investigates the effects of peer and cross-age tutoring as intervention strategies on the mathematics achievement and interest of gifted students. The pretest-posttest control group experimental research design was adopted and three null hypotheses were tested. Fifty underachieving gifted students participated in the study. The study lasted for 12 weeks. Analysis of Covariance (ANCOVA) was used to analyze the data collected. Findings show that peer tutoring and cross-age tutoring are both effective in enhancing the achievement and interest in mathematics of underachieving gifted students. There is also a significant differential effect between peer and cross-age tutoring. Based on the findings, it was recommended that Mathematics teachers should adopt peer and cross-age tutoring to enhance interest and achievement in mathematics of gifted students.

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Introduction

Gifted students can achieve the peak of their potential in Mathematics if well exposed to appropriately differentiated instruction. Their interest in Mathematics could be skyrocketed come adequately challenged, developed critical solution providers and inventors of improved technology if given the opportunity to develop through appropriate instructional experiences. Gifted and talented students have special abilities and aptitudes, which when harnessed and developed make them great instruments of positive change in society (Dada & Ani, 2019). But if the gifted and talented students are not well nurtured they become underachievers, less productive, and waste their potential. This perhaps is the reason for global concern in evolving ways of nurturing gifted and talented individuals in various subjects and disciplines (Dada & Fagbemi, 2014).

One key subject that cannot be overemphasized in the education of gifted and talented students is Mathematics because it is the basis for all disciplines in the fields of science, technology, engineering, commerce, and economics. This

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is mainly because studying mathematics helps students develop their capacity for problem-solving and analytical thinking while also fostering their logical, practical, and aesthetic thinking. Generally, people use mathematics every day, and this encourages the brain to express ideas, problems, and solutions that are necessary for the survival of the human race. (Awofala & Lawani, 2020; Dada & Akpan, 2019). Many countries in Africa remain underdeveloped because they do not nurture their gifted and talented individuals for strong mathematical and scientific literacy that is capable of turning around their natural endowment. Students' achievement in Mathematics is at low ebb in Nigeria despite the fact that Mathematics is a compulsory subject for all students at both primary and secondary levels of education (Obi & Dada, 2015; Dada & Meremikwu, 2021) and a compulsory requirement in technology, engineering, science and Mathematics careers at the university level.

Scientific and technological advancement is one of the major focuses of Nigeria's National goal and Policy on gifted education (Federal Republic of Nigeria [FRN] 2015) so efforts are channeled towards sustainable Mathematics in the gifted education program. Differential learning in Mathematics for underachieving gifted and talented students should be targeted at increasing interest, providing appropriate and adequate challenges, and developing critical thinking in Mathematics. For the best Mathematics achievement to be recorded for these special students, there a is need for alternative pedagogy and a diversified instructional approach. Unfortunately, many Mathematics teachers in Nigeria are not aware of learning strategies for the gifted and talented for effective teaching and learning of Mathematics but rely absolutely on the conventional methods (Dada & Dada, 2014). This tends to affect the interest and performance of students, especially the underachieving gifted, and talented ones in Mathematics. The inability of Mathematics teachers to differentiate learning for the gifted has resulted in poor learning, underachievement, and threat to interest in the Mathematics of gifted and talented students in (Dada & Ogundare, 2016). The classroom environment is a critical consideration in teaching and learning Mathematics, particularly for underachieving gifted, and talented who require specialized learning intervention (Orim, Dada & Igwe, 2017). Therefore, it is expedient for teachers to provide appropriate intervention by ensuring effective classroom administration and learning optimization.

Among the favourite learning interventions for the gifted and talented are peer tutoring and cross-age tutoring (Dada, 2010) to motivate their interest and increase their achievement. Peer tutoring, according to Topping (2005), is the active process of acquiring knowledge and skills through mutual support and assistance among peers who are equal in status and have similar ages and social groups. The concept originated from the recognition that students can learn better when they teach each other. Peer tutoring involves non-professional teachers, who are learners themselves, helping one another to learn. The peer tutors may be of the same or different ability levels but are of the same learning grade and similar age. Golding, Lisa, and Tennant (2006) further explained that peer tutoring is a technique in which students, with guidance from their teacher, teach one or more peers to acquire new skills or concepts. This approach emphasizes the use of peers to solve problems and can be effective in promoting creativity, experimentation, problem-solving skills, and deep learning of concepts.

One significant advantage of peer tutoring is that it can be easily implemented in an inclusive classroom of diverse abilities (Dada, 2016). Peer tutoring has been recognized by Nathern and Liz (2007) as a useful tool for teachers to address the diverse needs of learners and enhance academic achievement across various subjects and skill levels. Additionally, Miller and Miller (1995) suggest that peer tutoring is an effective and cost-efficient intervention that can benefit both struggling and high-achieving students by boosting both the tutor and the tutee's social and educational development and motivation to learn. When peer tutoring is skilfully supervised by a teacher, it can promote interaction among individuals and groups in the classroom, resulting in a more comprehensive understanding of scientific concepts among the students.

Cross-age tutoring involves pairing students of different grade levels, with the older student serving as a tutor for the younger student(s). This approach is similar to other peer learning programs, which are considered a form of differentiated instruction for both struggling and high-achieving students. In cross-age tutoring, an older student who has already mastered certain mathematics concepts facilitates learning through small group interactions. Specifically, cross-age tutoring employs an older student who has previously mastered specific mathematical concepts to facilitate and promote learning through small group interactions. While some studies have examined the academic outcomes of cross-age tutoring, others have focused on psychological effects such as changes in self-esteem, self-concept, and feelings of academic efficacy among learners. By employing a cooperative learning model, cross-age tutoring fosters communication, cooperation, independence, and responsibility, as both the tutor and tutee engage with the course content and employ appropriate and useful study strategies (Arendale, 2014). There is abundant evidence supporting the benefits of cross-age tutoring, including increased grades and pass rates and decreased withdrawal and failure rates (Dawson, Vander-Meer, Skalicky, & Cowley, 2014). However, its effects on mathematics achievement and interest among gifted and talented students are not yet fully understood.

Early research and meta-analysis on peer and cross-age tutoring programs found that they were effective in improving student outcomes (Britz, Dixon, and McLaughlin, 1989; Cohen, Kulik & Kulik, 1982). A more recent meta-analysis examining the impact of peer-assisted learning on elementary school students also found evidence supporting the efficacy of such learning strategies (Rohrbeck, 2003). Although the aforementioned meta-analysis highlighted significant academic gains, particularly for minority students (Rohrbeck, 2003), the effects of peer and cross-age tutoring programs involving gifted and talented students at the secondary school level in Nigeria have yet to be documented. The study is therefore motivated to investigate the differential effects of peer and cross-age tutoring on Mathematics achievement and interest of underachieving gifted and talented students in Nigeria.

Hypotheses

- There is no significant effect of peer tutoring on Mathematics achievement and interest of underachieving gifted students.
- There is no significant effect of cross-age tutoring on Mathematics achievement and interest of underachieving gifted students.
- There is no significant differential effect of peer and cross-age tutoring on Mathematics achievement and interest of underachieving gifted students.

Method

Research Model

The **p**retest-posttest experimental design was adopted. Participants were from Junior Secondary School classes with the age range of 9-12 years who have been earlier identified by experts to be underachieving gifted but are not doing so well in Mathematics as expected. Their Mathematics underachievement was revealed by their school records.

Sampling

There were 50 participants in the study. The participants were randomly assigned into two experimental groups according to their age range: those who were within the same age bracket (9-10) in the peer tutoring group and those who are older (above 10 years) in the cross-age tutoring. The participants were divided into three groups in the study: Group A for peer tutoring, Group B for cross-age tutoring, and Group C as the control group. Group A and B were offered the treatment based on peer and cross-age tutoring interventions respectively. The control group is not given any special intervention but a placebo of conventional teaching. The study took 12 weeks including the pre-test, treatment, and post-test.

Data Collection

The data for the study was collected via two validated instruments namely, Mathematics Achievement Test (MAT: Reliability estimate = .92) and Mathematics Interest Scale (MIS: Reliability estimate = .89). The MAT was developed from the Mathematics curriculum for Junior Secondary School and based on the treatment package by the researchers to measure Mathematics achievement of the participants. The MAT has 25 multiple-choice objective questions and four essay questions with a total scoring point of 50 marks. The MIS is a scale of 10 items with four response options to indicate the Mathematics interest of the participants.

Data Analysis

Data collected were analyzed using Analysis of Covariance (ANCOVA) and Independent Sample t-test.

Results

The result of the descriptive data analysis is presented in table 1. Table 1 provides the post-test mean and standard deviation of each group. The findings from the descriptive results indicate.

Table 1. Mean and standard deviation of post-test scores in Mathematics achievement and interest

Group		Mean	Std. Deviation	N
Peer tutoring	Mathematics Achievement	41.19	2.064	21
Cross-age tutoring	Mathematics Achievement	40.63	3.451	19
Peer tutoring	Mathematics Interest	35.10	3.208	21
Cross-age tutoring	Mathematics Interest	34.32	4.110	19
Control	Mathematics Achievement	36.70	1.567	10
	Mathematics Interest	30.00	2.211	10
Total	Mathematics Achievement	40.08	3.089	50
	Mathematics Interest	33.78	3.882	50

Table 2 revealed that there is a statistically significant effect of peer tutoring on Mathematics achievement and interests of underachieving gifted students (p = .00) when adjusted for pre-test and pre-assessment scores respectively. The calculated $F_{(1, 28)} = 46.709$ and 19.734 for Mathematics achievement and Mathematics interest respectively, at p= .00; < .05. The result of the analysis indicates that there was a significant mean difference between control and experimental groups in their post-test scores on both achievement and interest in Mathematics while adjusting for the pre-test. The partial Eta Squared (η^2) value if compared with Cohen's guidelines (0.2 – small effect, 0.5 – moderate effect, 0.8 – large effect) indicated that the calculated η^2 on the treatment groups was .625 and .413 on Mathematics achievement and interest respectively. This indicates a moderate and small effect but significant. The η^2 revealed that 62.5% and 41.3% of the variance in the post-test scores on Mathematics achievement and Mathematics interest are explained by peer tutoring.

Hypothesis 1. There is no significant effect of peer tutoring on Mathematics achievement and interests of underachieving gifted students.

Table 2. ANCOVA result of the effect of peer tutoring on Mathematics achievement and interest

Mathematics achievement						
Source	Type III Sum of Squares	Df	Mean Square	F-ratio	p-value	Partial Eta Squared
Corrected Model	155.220[a]	2	77.610	24.495	.000	.636
Intercept	117.071	1	117.071	36.950	.000	.569
Pre-test	18.623	1	18.623	5.878	.022	.173
Peer Tutoring	147.994	1	147.994	46.709	.000	.625
Error	88.715	28	3.168			
Total	49206.000	31				
Corrected Total	243.935	30				
Mathematics interest						
Source	Type III Sum of Squares	Df	Mean Square	F-ratio	P-value.	Partial Eta Squared
Corrected Model	180.220[a]	2	90.110	10.279	.000	.423
Intercept	1050.867	1	1050.867	119.875	.000	.811
Pre-test	4.352	1	4.352	.496	.487	.017

Interest	172.996	1	172.996	19.734	.000	.413
Error	245.458	28	8.766			
Total	35115.000	31				
Corrected Total	425.677	30				

The result of the analysis was significant at .05 because the calculated p-value of .00 on Mathematics achievement and Mathematics interest was less than .05, hence the null hypothesis which states that there is no significant effect of peer tutoring on Mathematics achievement and interest of underachieving gifted students was rejected. This implies that there is a significant effect of peer tutoring on underachieving gifted students' interest and achievement in Mathematics.

Table 3 indicates that the calculated $F_{(1, 28)}$ = 11.158 and 6.909 for Mathematics achievement and Mathematics interest respectively at p= .00; < .05. The result revealed that there is a statistically significant effect of cross-age tutoring on Mathematics interests and achievement of underachieving gifted students when adjusted for pre-test scores for Mathematics achievement and Mathematics interest respectively.

Hypothesis 2. There is no significant effect of cross-age tutoring on Mathematics achievement and interest of underachieving gifted students.

Table 3. ANCOVA result of the effect of cross-age tutoring on Mathematics achievement and interest

Mathematics achievement						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	102.103[a]	2	51.052	5.632	.009	.302
Intercept	219.916	1	219.916	24.260	.000	.483
MAT pre-test	.831	1	.831	.092	.764	.004
Treatments	101.149	1	101.149	11.158	.003	.300
Error	235.690	26	9.065			
Total	45073.000	29				
Corrected Total	337.793	28				
Mathematics interest						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	123.719[a]	2	61.860	4.643	.019	.263
Intercept	728.544	1	728.544	54.680	.000	.678
MIS Pre-assessment	1.686	1	1.686	.127	.725	.005
Treatments	92.051	1	92.051	6.909	.014	.210
Error	346.419	26	13.324			
Total	31722.000	29				
Corrected Total	470.138	28				

This reveals that there is a significant mean difference between the control and experimental groups in their post-test scores on both Mathematics achievement and Mathematics interest while adjusting for the pre-test. The partial Eta Squared (η^2) were .300 and .210 for MAT and MIS respectively which indicate a small effect size but significant. The η^2 values show that 30% and 21% of the variance in the post-test scores on MAT and MIS are explained by cross-age tutoring. The null hypothesis which states that there is no significant effect of cross-age tutoring on Mathematics achievement and interests of underachieving gifted students was rejected. This implies that there is a significant effect of cross-age tutoring on underachieving gifted students' interest and achievement in Mathematics.

Hypothesis 3. There is no significant differential effect between peer and cross-age tutoring on Mathematics achievement and interest of underachieving gifted students

The result of the analysis as presented in Table 4 revealed that there is a statistically significant effect of peer tutoring and cross-age tutoring on Mathematics achievement and interests of underachieving gifted students (p= .00) when adjusted for pre-test and pre-assessment scores respectively. From the result, the calculated $F_{(2, 46)}$ = 10.882 and 7.358 for Mathematics achievement and Mathematics interest respectively, p= .000 and .002; < .05. The result of the analysis indicates that there was a significant mean difference between control and experimental groups in their post-test scores on both Mathematics achievement and Mathematics interest while adjusting for the pre-test. The calculated η^2 on the treatment groups (experimental and control groups) was .321 and .242 for Mathematics achievement and Mathematics interest respectively which indicate a small but significant effect size. Furthermore, η^2 revealed that 32.1% and 24.2% of the variance in the post-test scores on Mathematics achievement and Mathematics interest are explained by both peer tutoring and cross-age tutoring. The result of the analysis was significant at .05 because the calculated p-value of .000 and .002 on Mathematics achievement and Mathematics interest was less than the p-value of .05, hence both peer tutoring and cross-age tutoring have a significant effect on Mathematics achievement and interests of underachieving gifted students after control for the pre-test. Meanwhile, considering the significant difference between the two groups for Mathematics achievement and Mathematics interest, at .05 and df of 38there is no significant difference in the effect between peer tutoring and cross-age tutoring in Mathematics achievement(t= .0629; p>.05) and Mathematics interest (t= .672; p>.05).

Table 4. ANCOVA result of the effect of peer and cross-age tutoring on Mathematics achievement and interest

Source	Type III Sum of Squares	Df	Mean Square	F-ratio	P-value.	Partial Eta Squared
Mathematics Achievement						
Corrected Model	153.156[a]	3	51.052	7.467	.000	.327
Intercept	295.748	1	295.748	43.254	.000	.485
Pre-test	7.236	1	7.236	1.058	.309	.022
Treatments	148.812	2	74.406	10.882	.000	.321
Error	314.524	46	6.837			
Total	80788.000	50				
Corrected Total	467.680	49				
Mathematics interest						
Source	Type III Sum of Squares	Df	Mean Square	F-ratio	P-value.	Partial Eta Squared
Corrected Model	186.304[a]	3	62.101	5.173	.004	.252
Intercept	1467.512	1	1467.512	122.232	.000	.727
Pre-test	1.639	1	1.639	.136	.713	.003
Treatments	176.685	2	88.343	7.358	.002	.242
Error	552.276	46	12.006			
Total	57793.000	50				
Corrected Total	738.580	49				

Table 5. Independent t-test of the effect of peer and cross-age tutoring on Mathematics achievement and interest

Group	Variable	Mean	Std. Deviation	N	T	Df	p-value
Peer tutoring	Mathematics Achievement	41.19	2.064	21	.629	38	.533

Cross-age tutoring	Mathematics Achievement	40.63	3.451	19			
Peer tutoring	Mathematics Interest	35.10	3.208	21	.672	38	.506
Cross-age tutoring	Mathematics Interest	34.32	4.110	19			

This result implies that the two interventions do not differ significantly in their effects. So the null hypothesis that there is no significant differential effect between peer and cross-age tutoring on Mathematics achievement and interest of underachieving gifted students is accepted.

Discussion and Conclusion

The researchers investigated the effects of peer and cross-age tutoring in Mathematics achievement and interest of underachieving gifted and talented students in the Ibarapa Division of Oyo State. It was found that there is a significant effect of peer tutoring on underachieving gifted student interest in Mathematics and Mathematics achievement. This present finding has implications for Mathematics instruction. The separate findings of Topping (2004) and White (2000) which reported that peer tutoring as a differentiated instruction strategy enhances Mathematics achievement and the interest of students lend credence to this finding. Topping (2004) reported that students are able to ask questions and develop more interest in any concept taught to them by their peers because of the level of rapport and freedom

A significant effect of cross-age tutoring on students' interest in Mathematics and the Mathematics achievement of the participants was also found. This finding supports that of Topping and Whiteley (1993) who found that although tutors academic performance improved regardless of whether they tutored peers, younger or older tutees in reading. However, older tutors experienced greater academic improvements when they tutored younger tutees. Ehly and Bratton (1981) reported significant achievement and interest in older tutees when cross-age tutoring was used. This interest extended to perceptions of competence, with well-liked tutors being perceived as more competent, though it remains unclear whether there were any real differences in competence among the tutors. However, Fogarty and Wang (1982) noted that mixed-age pairs had the potential to produce negative attitudes toward tutoring, particularly among female tutors working with male tutees. Therefore, further research is needed to explore the effects of cross-age tutoring outcomes and the mechanisms underlying them.

There is a significant differential effect of peer tutoring and cross-age tutoring on students' interest in Mathematics. This finding is in alignment with that of Nazzal (2002), Topping (2004), and Heller and Fantuzzo, (1993) who reported significant improvement in the Mathematics achievement of the participants when exposed to peer tutoring and cross-age tutoring. It also tallies with that of Torrado, Manrique and Ayala (2016) who reported a significant effect of both strategies on Mathematics performance and Mathematics interest of underachieving gifted and non-gifted high school students. In a study of mathematics students, Melero and Fernandez (1995) found that students who received peer tutoring performed significantly better than those who did not. Rudland and Rennie (2014) found that cross-age tutoring, in which older students tutor younger students, was also effective in improving academic performance in biology and mathematics. In addition to academic benefits, peer tutoring can also help students develop important social skills, such as communication, cooperation, and empathy. Durán (2009) found that students who participated in peer tutoring programs were more likely to report feeling motivated to study, having higher average grades, and valuing solidarity and communication. They were also more likely to report feeling responsible and having high self-esteem. Additionally, peer tutoring has been shown to promote responsibility and self-esteem, especially among students who take on the role of tutors (Rudland & Rennie, 2014; Durán, 2009).

It is concluded that both peer tutoring and cross-age tutoring are effective interventions for enhancing Mathematics achievement and Mathematics interest of underachieving gifted and talented students. The effect of the two interventions is relatively the same.

Recommendations

Based on the findings, it is imperative to recommend as follows:

- Teachers should adopt peer and cross-age tutoring in teaching Mathematics to enhance interest and boost the self-esteem of gifted students in Mathematics instruction.
- Mathematics teachers should be trained in the use of appropriate techniques to organize peer and cross-age tutoring for effective classroom delivery to gifted students in an inclusive setting.

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