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Cross-Age Peer-Tutoring: An Effective Strategy for Enhancing Students' Retention in Mathematics

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ABSTRACT

The alarming rate of students' underachievement in mathematics as linked to short retention is calling for urgent involvement of stakeholders. In view of this, this study investigated the effects of cross-age peer-tutoring as an intervention on students' retention in mathematics. By means of multi-stage sampling technique, a total of 93 senior secondary school 2 (Grade-11) students (59-control & 34-Experimental groups) were sampled in their intact classes. The study adopted the quasi-experimental research design using the pre-test-post-test non-equivalent control group experimental approach. Three research questions and three null hypotheses guided the study, which lasted for five weeks. The self-developed students' achievement test in coordinate geometry (SATC) has Pearson-R coefficient of 0.74, while mean, standard deviation and Analysis of Covariance were used as statistical tools. The study found significant effect of cross-age peer-tutoring strategy on retention of students in mathematics [$F(3, 134)=8.15$; $p<0.05$] revealed no statistical significant influence of gender on students' retention [$F(1, 134)= 1.24$; $p>0.05$ and no statistical significant influence of age on students' retention [$F(2, 134)= 0.33$; $p>0.05$]. It concluded that cross-age peer-tutoring is an effective strategy for extending students' retention in mathematics, irrespective of gender and age. It is neither gender bias nor age sensitive. To boost learning outcome in mathematics teachers should generously teach difficult concept like coordinate geometry using a peer-tutoring strategy.

1. Introduction

Most teachers are unaware that retention is one of the predicting factors responsible for students' underachievement and frustrations in mathematics (Dada et al. 2023). Thus, the symbiotic link between students' achievement and retention in mathematics has been latent among mathematics stakeholders for decades (Ijeh, 2023; Oguegbu & Akanwa, 2024). As a matter of fact, students' achievement in mathematics is predetermined by their retention rate, which focuses on the duration of time that a piece of information is retained in the memory (Dada et al. 2023). It has been observed that mathematics knowledge acquired by most students is short-lived, as they are found wanting especially during external examination. This is because retention is connected to learning and memory as the period of time during which acquired information, skills or knowledge are retained in the memory and can be recalled for later use (Kalu-Uche & Ogbonna, 2021). In this study, retention would be seen as a concept that focusses on the duration or length of time that a piece of information is retained in the memory. It could be measured through specific tests, quizzes or assessments that evaluate students' ability to recall geometric information, it is often measured by tracking students' performance over time, using longitudinal studies or repeated case assessment techniques.

Despite effort by the Mathematical Association of Nigeria (MAN) to fight underachievement and short retention in mathematics through series of workshops organized to War Against Poor Achievement in Mathematics (WAPAM), the issue has remained unresolved across secondary schools in Nigeria particularly in Lagos State (Oguegbu & Akanwa, 2024). Other interventions are modelled towards curriculum improvement. However, a good number of students have recorded an appreciable improvement in their academic achievement as a result of the suggestions provided by these studies, but a sizable number of students still achieve below expectation in mathematics when likened to other subjects. The attainment of short or long retention by a student is evident in achievement because students' achievement is a metric used to assess success in academic activity. However, students' underachievement in mathematics may arise from failure to remember what they have been taught.

The sole aim of teaching and learning is to ensure that students retain what is learned. Retention is the ability to hold onto acquired data in long-term mental storage and recover that material when required for future tasks Merram-Webster (2020). Retention takes place whenever knowledge and capabilities are retained in long-term mental memory. The retention of learnt concepts promotes introspective thinking and, as a result, the utilization of the remembered content in an innovative way to solve daily challenges. Retention is also seen as the capacity to recall or apply already acquired information or abilities. From the foregoing, it becomes necessary to ask if teachers' methods of subject delivery affect students' academic achievement and retention in mathematics? Efforts to address this persistent failure have made researchers in mathematics education to study several factors.

Prominent among these factors is teachers' methods of subject delivery in the inability of classroom which is one of the leading causes of low achievement. For instance, the teacher centered instruction does not enhance students' achievement and retention due to the abstract nature of mathematics. Hence, the need for team oriented approach that enhances students' retention and achievement in mathematics. In order for Nigeria to develop as one of the leading tech countries globally, principles of coordinate geometry must be e mbraced right from secondary school level. Observation revealed that technological advancement is a function of in-depth knowledge and application of coordinate geometry skills. Such countries that leverage on requisite geometric skills (Nwigboj & Olo, 2017), set priorities in bequeathing students with requisite technological skills.

An aspect of mathematics that requires adequate retention rate for successful application in the tech world is coordinate geometry. The term co-ordinate geometry is an offshoot of geometry that was described by Odumosu (2002) as the most useful branch of mathematics that has its origin from measurement of farm land in early Egyptian civilization. Though, seen as a branch of Mathematics in which geometric components such as lines, curves and solids are represented algebraically (Abiola, 2004). Students are expected to have a grip of it as an indispensable concept, but rather, many seem to be underachieving due to inadequate choice of instructional strategy (Mohamed *et al.*, 2013). Mathematics teachers cannot be totally exonerated from being responsible for students' underachievement and inability to retain geometric skills for a long period, (Das & Das, 2013). This is because they have been encapsulated by the fact that output is always a product of input. Eventually, some believed that poor choice of strategies is the originator of students' consistent under-achievement in coordinate geometry.

For instance, Mohamed *et al.* (2013) revealed that choice of strategy significantly predicted students' retention as a bi-product of achievement. Essentially, the main purpose of mathematics education is to produce individuals with ability to acquire and retain specific skills for the sustainability of societal norm and standard (Federal Republic of Nigeria (FRN, 2013)). Hence, while uncovering the actual cause of mathematics underachievement, Egho (2018) underscored anxiety, gender, wrong choice of instructional strategies, parental involvement, self-efficacy and inadequate counseling service as factors that shorten retention-span in Mathematics. In fact, Fabiyi (2017) reported that out of 23 topics captured, coordinate geometry was perceived difficult to learn by students due to poor instructional strategies. All of this shows that, learning outcome is a function of multivariate instructional strategies, as evident in co-ordinate geometry and other core areas (Curry, 2016). For instance, Mohammed (2010) found that 37.5% of the teachers investigated held that lack of interactive strategies played a significant role in students' retention-span in coordinate geometry, while Mbacho (2013) believed that psychological factors such as students' ability, retention, age, and gender also influence retention-span. This is why the Federal Republic of Nigeria ((FRN), 2013) encouraged teachers to jettison the habit of sole reliance on conventional technique but rather, adopt the practice of using a combination of two or more techniques that match the audience and content delivered. The ideal situation would be a setting in which success could not be predicted by a person's gender, age, race, ethnicity or social status but equal access to opportunities and outcomes.

Personal experience has shown that mathematics knowledge acquired through conventional method does not stand the test of time. The term method refers to a particular way of presenting an instructional content to the learners, while strategy is the stepwise set of activities the teacher employs to complement a particular teaching method (Liu & BealKowski, 2018). This implies that a strategy is an embodiment of composite techniques used by the teacher to disseminate instruction. Akudo and Olaoye (2021) saw the conventional method as an instructional approach where the teacher articulates the goals of each lesson and makes presentations, illustrating how to do the assignment that is progressively assessed. It is a teacher centred way of presenting a lesson package to a large group of students. Much like the lecture approach, the conventional approach is one of the traditional methods of teaching (Oshodi, 2005), which obviously lack students' active participation and interaction, therefore, it is appropriate that teachers adopt an approach that is completely students centred. For the fact that students are usually differ in ability to handle mathematical challenges due to age and skills, there is need for students with lower age to actively mix with the average and older learners. By this, teachers could identify students with likely longer retention-span for crossbreeding with those with average or short term retention.

One such strategy that fosters crossbreeding and students' interaction is the peer-tutoring strategy. It fosters both individualized and interactive learning. Hence, some teachers prefer it to the conventional approach since it allows students of same age or cross ages with mixed abilities to share ideas about a concept. This opens opportunities for students to confidently ask questions in pairs, instead of anxiously listening to the teacher without opportunity to reveal unexpressed challenges. In a peer interactive session, students are more relaxed and ready to assimilate new ideas with friendly looking colleagues (Scruggs *et al*, 2012). It is an effective learning strategy that involves active, interactive and participatory learning process, resulting in a better and deeper understanding of concepts for both tutors and tutees (Srivastava & Rashid, 2018). It is an asymmetric relationship that transmits knowledge, skills and ability by substituting a tutoring student for the teacher (Alegre-Ansuategui *et al*., 2018). Moreover, Nobel (2005) defined the term peer as a student or partner who is approximately the same age, grade, and academic level. So the term peer refers to an individual with the same status or near status of another, while peer tutors are learners who teach colleagues in twos. In this study, the strategy would be considered as student-student instructional approach that gives opportunity for students to learn cooperatively in twos under the guidance of the teacher.

Mathematics teachers are expected to be dynamic in their choice of instructional strategies, so as to be able to stimulate students' interest in the subject to improve their understanding of key concepts. This is because the use of inappropriate instructional strategy produces a crop of math-phobic students (Mohamed *et al.*, 2013) which leads to poor class attendance and general disinterestedness in the subject, hence inattention in class and short retention. Essentially, the problem underlying this study is the inability to establish the effects that peer-tutoring strategy has on students' retention in coordinate geometry. Therefore, the main objective of the study is to examine the main effects of cross-age peer-tutoring on retention of students in coordinate geometry with respect to gender and age

(Akudo, 2022). The study employed the cross-age peer tutoring because the pre-test did not reveal any significant difference in the ability level of the respondents. This involved pairing younger students with relatively older ones. These steps were taken because it is anticipated that the results would inform teachers on how to make better choice of appropriate strategies for the teaching of coordinate geometry and thus enhance students' retention. It would also guide policy-makers and curriculum developers in recommending appropriate instructional strategies that would help in up-scaling learning outcomes. Nevertheless, students would improve in understanding of mathematical concept and develop long term retention. Consequently, parents would stop wasting their hard earn money on examination malpractices as students learn to retain experiences for longer period and become more self-reliant in external mathematics examinations (Akudo et al., 2019).

Theoretical Framework

It hinged on theory of Aptitude-Treatment Interaction (ATI) (Cronbach & Snow, 1977), and the Zone of Proximal Development (ZPD) theory (Lev-Vygotsky, 1978). ATI states that some instructional strategies are more or less effective for particular individuals depending upon their specific natural abilities. The theory suggests that optimal learning results when the instructional strategy exactly matches the aptitudes of the individuals involved. Aptitude here means students' natural ability to speak/talk, see/look, think/reason, hear/listen or move/walk. The ATI principles were hinged on the fact that: (1). Aptitudes and treatments interact in complex patterns and are influenced by task and situation variables. (2). Highly structured learning environments tend to be most successful with students of lower ability; conversely, low structure environments may result in better learning for high ability students. (3). Anxious students tend to learn better in highly structured learning environments; non-anxious or independent students tend to prefer low structure. Obviously, the usefulness of ATI goes beyond individualism to social setting. Learning in in a social process occurs through active participation and personal experience. In view of this, purposeful activity in social setting such as peer-tutoring, think-pair-square-share and jigsaw environments is the key to genuine learning and understanding. It gives the students ample opportunity to observe, initiate and subsequently develop higher mental functions (Akudo, 2022).

The ZPD states that irrespective of social setting, there is always a knowledge gap to be filled by an individual. This gap emerged as a result of three levels of task development: 1. task that an individual can perform without help moat of which are innate, 2. task that can be performed with help even when highly structured and 3. task that cannot be performed by an individual due to some level of independence. This gap is an area within which problems are too difficult to be solved alone but not too hard with the help of more competent persons. The ZPD is the distance between the zone of actual/active development and the zone of future development. In this study, ZPD would be seen as the difference between the tasks that an individual is able to perform independently and tasks that cannot be performed even dependently. For the fact that ATI is centered on developing natural ability through treatment and interaction as the key elements, ZPD focused on using the same elements to improve achievement through interaction, the study is interested in harnessing these two theories for upward development of students' aptitude which could metamorphosed into better retention in coordinate geometry with the application of the right treatment that require active listening, thinking, questioning, participation and interaction (Akudo, 2013). It is believed that the interaction within innate and acquired abilities through collaborative strategies could be a panacea to low retention and short retention-span of students in coordinate geometry (Akudo, 2022).

Retention is simply the ability of learners to keep learnt material and be able to recall it when required or the ability of an organism to store, retain and recall information (Liu & BealKowski, 2018). Retention is measured in collaboration with achievements as the ability of students to remember experiences and things learnt (Juweto, 2018). Iwuji (2012) defined retention as the ability of an individual to retain acquired experienced for use at a later time. It was seen by Isah (2015) as the ability to recapitulate knowledge gained within a period of two weeks. It was seen by Abdullahi (2017); and Samuel (2018) as the ability of an individual to retain and consequently remember acquired experiences at a later time. Okechukwu and Oyekunle (2019) defined retention as learners' ability to transfer information earlier learnt behaviour after a period of time. It further stated that retention takes place when information in the memory is successfully encoded, stored and retried. Contextually, encoding is the act of registering the received information which is expected to be retained. Although, Tarva (2015) proposed a formula for retention rate in mathematics as $\frac{\text{A's, B's and \& C's}}{\text{number of students in the entire class}}$. By this formula, students with D, E and F grades are considered to possess no retention of acquired knowledge. The formula was therefore considered deficient because it failed to differentiate categories of students with low, intermediate and long retentions. So, instead of this formula, a better rating scale was preferable for use in this study to determine retention.

Retention in mathematics refers to the duration and quality of a learner's ability to retain mathematical concepts, facts, and skills. Retention can be classified into short-term memory, where information is held briefly, and long-term memory, which allows for better retention over time and is more beneficial for learning in mathematics. Retention comes after encoding and it is the key factor responsible for successful transfer of knowledge from one subject area to another (Omotayo, 2013). It can be enhanced if teachers prioritize it as they spend most of their time reviewing basic concepts already taught or rather adopt strategies that are capable of engaging students in meaningful interaction. Dada et al. (2023) believed that learning experiences occur during peer-tutoring and can motivate students to build stronger relationship among their peers. Obviously, when students understand the benefit of peer tutoring and have the necessary materials that can make them effective tutors and tutees, they retain information longer for greater achievement than those given individualized instruction. Meanwhile, in the process of imparting knowledge to the attentive students, bits of this information are temporarily stored in the short term memory. As time passes by, on daily basis, the unimportant or poorly understood bits of the acquired knowledge tends to be discarded by the mind. The relatively useful knowledge is moved to the intermediate memory, while the important bits are clearly understood and put into use and kept in the long term memory (Akudo et al., 2019).

Information could be encoded into the memory visually, acoustically and semantically. The processing of received images is called visual encoding, the processing of sounds is known as acoustic encoding, while the processing of meaning of words is semantic encoding. Short Term Memory is stored acoustically (sound), while Long Term Memory is stored semantically (meaning). Mchealchie (1999) explains that in a cooperative setting, students have opportunity to explain the concepts being taught for clarity in order to achieve what is expected. Explanation does not only enhance the receiver' knowledge but also deepens the understanding of the one explaining. Thus, collaborative explanation of a topic usually results in long term retention of the topic taught (Chainson *et al.*, 2015). Students recall information obtained over a long period when learning is coded into their long term memory. Thus, the appropriate coding of information is key to long term retention (David, 2007). Conversely, retention is short when information is coded improperly, intermediate when coded with some level of understanding, and long when put into use. This is in tandem with the learning pyramid of Benjamin-Franklin cited in Odewunmi (2022), which stipulated that knowledge gained through lecture has only 5% retention rate, reading 10%, audio-visual 20%, demonstration 30%, discussion 50%, practice by doing 75% and teach others 90%. At best, when applied some methods result in partial understanding of basic mathematical concepts. Again, the nature of the materials to be coded also contributes to the level of retention. This implies that choice of teaching strategies that encourage immediate application of acquired skills would promote long term recall of coded information in the memory of students irrespective of gender (Akudo, 2022).

The concept of age in peer-tutoring

As described by Dada et al. (2023), cross-age tutoring involves the pairing of older students to serve as tutors to the younger ones. This approach is not dissimilar to other peer learning programs for struggling and high-achieving students, where an older student who has already mastered certain mathematics concepts facilitates 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 (Dada *et al.*, 2023). There is abundant evidence supporting the benefits of cross-age tutoring, including increased grades and pass rates and decreased withdrawal and failure rates. However, its effects on mathematics achievement and interest among gifted and talented students are not yet fully understood.

Empirically, the outcome of a quasi-experiment by Aloha and George (2022 revealed a statistically significant difference between the 114 erroneously randomized students taught algebra using a peer tutoring strategy and those taught using the teacher deductive teaching method in terms of retention. The work of Dada et al. (2023) showed that a combination of cross-age and peer-tutoring are both effective in enhancing the achievement and interest in mathematics of underachieving gifted students, although with a significant differential effect between peer and cross-age tutoring. Ijeh (2023) observed significant effect of peer-tutoring strategy on students' retention in mathematics but not with respect to gender. Oguegbu and Akanwa (2024) also reported that peer tutoring has a significant impact on students' achievement and retention in mathematics. Juweto (2018) indicated that the retention was longer with students taught using conventional method than those taught with small group and peer tutoring but not significant due to gender. Similarly, Raheem *et al.* (2017) found that gender played no role in the retention span of students taught with peer tutoring strategy favoring both male and female students as they demonstrated significant improvement in their retention span when exposed to peer tutoring. Thus peer tutoring does not only help in the improving retention of students but also increases the quality of interaction. Moliner and Alegre (2020) registered peer tutoring as beneficial tool for reducing middle school students' mathematics anxiety, regardless of their gender or grade.

Gender by Iwuji (2012) is the amount of masculinity or feminity or mixture of both found in a person. For instance, based on social expectation and orientation, women are socialized in preparation for their role as wife and mother and they are expected to fulfil this role effectively; while males are socialized and oriented in manner that stand them in a good position to fulfil their social and cultural roles as fathers and husbands. Also males are socialized and oriented to take up masculine jobs carrying high prestige, high skills and income. It has been reported by Stanley (2008) that most girls choose to be successful in those subjects considered appropriate for females as a way of being a high achiever while at the same time maintaining their feminity. Several researchers reported gender differences in subject choice and also in achievement within the subjects. School subjects by investigations are sex–stereotype. For instance, Mathematics, Physical sciences, Computer and Engineering are regarded as masculine subjects, while humanities, languages; domestic subjects (English & Home Economics) are regarded as feminine. However, Mari (1994) revealed that female students are academically superior in Mathematics and sciences. These showed that despite the discrimination that the female child faced, they are able to navigate successfully through maintaining a positive disposition.

Although peers do not gain equally from participation, but it offers an opportunity for each participant to become aware of their weaknesses. Rohrbeck *et al.* (2003) conducted a meta-analysis that evaluated the peer-assisted learning interventions and found that positive effect sizes were produced in achievement. Researchers were encouraged to develop peer-assisted learning interventions to maximize effectiveness. In another meta-analysis involving 50 studies which cut across a comparative analysis among cross-age, same-age, fixed age, reciprocal, fixed same-age and reciprocal same-age peer tutoring strategies, Alegre-Ansuategui *et al.* (2018) found that 88% of the reports have positive effects on retention but no significant moderating effects of tutors or tutees' ages and length of the sessions retention, but variables such as educational stage, design of the study, duration of the program, level of knowledge of the tutors, time of the day and sample size were significant moderators on academic achievement.

Srivastava and Rashid (2018) through an online survey, probed the effectiveness of peer tutoring on Academic achievements of the students in Oman. The tutors benefited in terms of bolstered experience, increased knowledge, skills, self-confidence and a sense of responsibility, while the tutees developed better likeness for the subject; more cooperation skills among their peers; increased motivation to study; good communication skills; effective stress management and collective confidence. However, variables such as the ages of the participants, roles, skills of the tutees, length of the sessions and frequency were not significant moderators of students' academic achievement, while variables such as educational stage, design of the study, duration of the programme, level of knowledge of the tutors, time of the day and sample size turned out to be significant moderators. Rizve (2012) exposed students peer tutoring experience fosters achievement in their zone of proximal development than exposing them to experience traditional methods of teaching in their content area. Ullah *et al.* (2018); Campit *et al.* (2015) also found that peer tutoring has significant positive effects on students' achievement.

While trying to determine relatively effective strategies for helping slow learners to retain important concepts, Abdurrahman and Garba (2014) observed that slow learners' taught through laboratory activity and peer tutoring teaching strategies have longer retention than those taught in traditional setting. It was reported that the retention of students taught geometry using cooperative learning strategy were significantly better than those taught conventionally, but recorded no significant deference between male and female students (Isah, 2015). It was also reported by Timayi *et al.* (2015) that there is an inconclusive global debates on students' performance and retention in mathematics with respect to gender. Studies conducted by Stoet and Geary (2013); Ali *et al.* (2014) observed that male students outperform their female counterpart in mathematics. Therefore, the research questions include: What is the retention of the students in coordinate geometry lessons when taught with conventional and peer-tutoring strategy? What is the retention of the students in coordinate geometry lessons when taught with conventional and peer-tutoring strategy based on gender? What is the retention of the students in coordinate geometry lessons when taught with conventional and peer-tutoring strategy based on age? While the null hypotheses tested at 5% level of significance include: there is no significant effect of cross-age peer-tutoring strategy on retention of students in co-ordinate geometry; and there is no significant influence of age on students' retention when taught using cross-age peer-tutoring strategy.

Study Contexts

This excerpt of a bigger study captured 34 students in the cross-age peer-tutoring group and 59 in the modified conventional group who were within the same age bracket of 13-19 years. Students in the control group were taught conventionally using a modified lecture method. On the other hand, those in the cross-age classroom were allowed to be paired with an age difference of two to three years with no such restriction. The 14 years old was paired with either 16 or 17 years old, irrespective of their gender. The research assistant in the treatment group was given orientation on how to make best use of the intervention. At the same time, that of the control classroom was only exposed to the concept of coordinate geometry but told to restrict students from discussion and questioning their colleagues. The study laid emphasis on students' age for the fact that the pretest revealed low ability level before the intervention. However, their ability level. The two research assistants were given the lesson package along with the manual and were trained on how to use the instructional manuals. Only the manual corresponding to the instructional strategy was given to each research assistant.

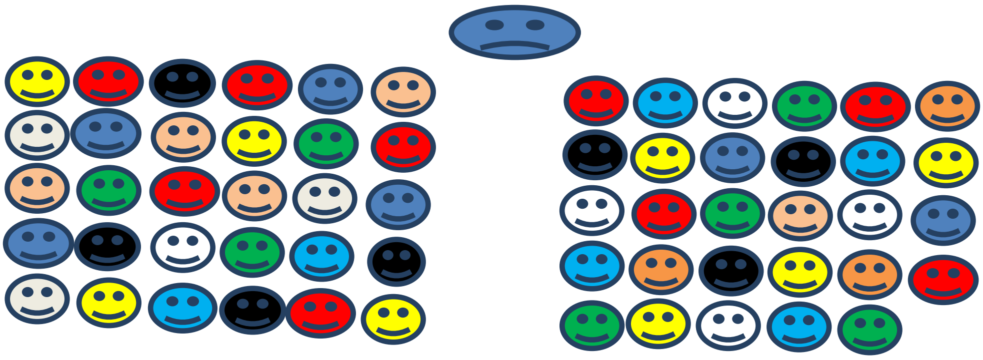

Figure 1. Implementing the Conventional Method

Figure 1 is a one-way instructional approach to teaching. The students of colours or diverse ability levels learn directly from the teacher, who stands as the sole moderator of the activities. Each week, the teacher takes a different topic as presented in the lesson package by the researcher. The concepts Coordinate, Straight Line, Gradient, Nature and Divisions of Straight Lines were treated in the first week. By week two, Distance between two points, distance and angle between two straight Lines were covered. Equation of straight lines given the gradient and a point, Equation of straight lines given two points, area of triangles given three co-ordinates and area of quadrilaterals given four co-ordinates were treated in the third week. In the fourth week the students were exposed to General equation of a circle, centre and radius of circles, Tangent, Length of tangent to a circle and normal to a circle, while equation of Tangent and normal to a circle were handled during the fifth week. As the use of the lesson packages unfold, students paid keen attention to the teacher. Individual learning takes place without interacting with their peers. All communications in form of questions were strictly directed to the moderator, who had no time to respond to all the questions.

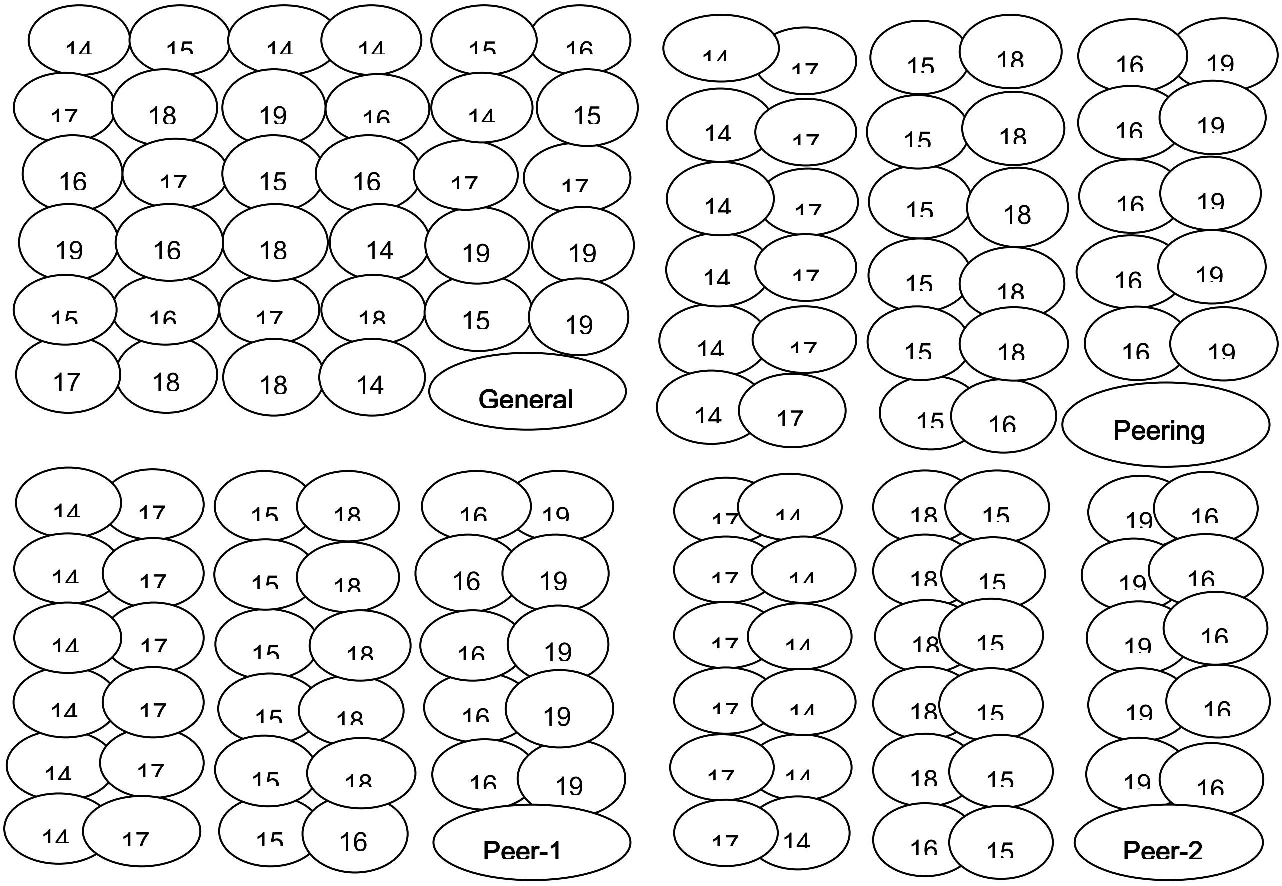

Figure 2. Implementing the Peer-tutoring Instructional Strategies

The information in Figure 2 described the teacher-students, students-students, teacher-materials and students-materials activities taken during the implementation of the peer-tutoring strategy. Meanwhile the researcher planned to adopt the cross ability peer tutoring approach with the aid of students' pre-test scores, but for low pre-test scores, it eventually turned out that the cross age peer-tutoring strategy was adopted. For the fact that the students in totality have not been exposed to the concept of coordinate geometry prior to the pre-test, majority of the students scored below expectation; hence it was difficult to differentiate them in terms of ability levels. So, students were paired by the research assistants based on ages. This constituted the cross-age peer-tutoring. Apart from a pair whose ages differ by one, the rest students are three years younger or older. In stage-1, the teacher identified them by ages and gave specific instructions on how the activities would be carried out. In stage two the teacher paired the 34 students in twos and instructed the older one to play the role of tutor while the younger played tutee in each pair. The tutees were encouraged to ask questions were they did not understand, while the tutors must have prepared to respond to all their challenges before they proceed further. In stage-3, the older student in each pair swung into action as tutor, while the younger ones acted as tutees. In stage-4, the younger ones tutored the older ones, who acted as tutees. Each time new sub-topic was introduced by the research assistant; the students were made to change turns. By this approach the teacher simultaneously kicks the ball from the centre of the field to each pair and the students take over from him to act as teachers (Akudo, 2022).

2. Methodology

Research Design

The study adopted the pre-tests, post-tests non-equivalent quasi-experimental research design, where the experimental and control groups received both pre-test, post-test and post-post-test. While treatment was conducted for participants in experimental group in their intact classes. The factorial matrix (2 X 2 X 3) depicts the independent and moderator variables. The strategies represent the independent variable at two levels, which include Modified Conventional and Peer-Tutoring, while the two moderator variables are gender and age. The gender comprises of male and female, while age consists of 11-13yrs, 14-16yrs and 17-19yrs. The dependent variable is Retention in Coordinate Geometry.

Population, Sample and sampling Technique

The target population consists of all senior secondary school II students in Education District V. Apart from the fact that the students from these zones are within the same age bracket, they are homogenous in terms of curriculum exposure and are taught by teachers under the administration of one Tutor General. So they enjoy the same academic by-laws, freedom and restriction. This set of students are preferable for the study because do not have prior knowledge of co-ordinate geometry, like their predecessors who have already been exposed to the concept. On the other hand, their successors still have other topics to learn before exposure to the concept as stipulated in their scheme of work. Private schools were not captured for the fact that some blend both Nigerian and British curricula and must have exposed the students to the concept. On the other hand, some private schools that operate the Nigerian curriculum only, were not willing to release their students for the exercise for reasons best known to them.

This study employed a total of 93 respondents chosen in their intact classes. The sample consists of 34 in peer-tutoring and 59 in modified conventional groups. In the larger study, the multi-stage sampling technique was adopted in selecting the participants. Three stages were carefully and logically undertaken during the selection exercise. Stage-1 involved stratifying all the senior secondary schools in Lagos State into six clusters based on education districts, out of which the cluster corresponding to education District V was conveniently chosen. Statge-2 picked the selected district which has its central office at Agboju and further stratified it into four education zones, namely: Ajeromi-Ifelodun, Amuwo-Odofin, Badagry and Ojo zones. A school was randomly selected from each zone out of which two zones were used for this study. In stage 3, the science students in their stratified intact classes were purposively chosen for the fact that the concept of coordinate geometry is more relevant to them. Base on the number of students in each class, the schools were purposively and equally assigned to experimental and control groups. In all, there were 34 in peer-tutoring group (16 males and 18 females) and 59 in the modified conventional group (25 males and 34 females). So in all, the multistage sampling technique encompasses: stratified, convenient, stratified, random and purposive sampling techniques.

Research Instruments and scoring criteria

The Students' Achievement Test in Co-ordinate Geometry (SATC) consists of 10 essay questions. This instrument was adapted from the past questions of the West African Certification Examination. It was used to determine the students' pre and post achievement tests in co-ordinate geometry. It was also used to measure students' retention by comparing scores obtained from multiple administrations. The same instrument was used for pre-test before the intervention, for post-test immediately after and re-administered two weeks later as post-post-test. The scoring formula used in the study to determine students' achievement in the tests. Scripts returned blank without any attempt were scored zero, while those with completely wrong or incomplete answers were awarded 2marks. The category that made considerable effort towards correct answers were rated 6marks. Those with nearly correct and correct answers were scored 8marks and 10marks respectively. The following rating scale was adapted from Lagos State University grading system.

Table 1. Rating Scale for SATC

Scores	Grade	Grade point	Grade interval	
70-100	A	5	4.50-5.00	
60-69	B	4	3.50-4.49	Long retention
50-59	C	3	2.40-3.49	
45-49	D	2	1.50-2.39	intermediate retention
40-44	E	1	1.00-1.49	
00-39	F	0	0.00-0.99	Short retention

The rating scale was adapted from LASU Post Graduate Result Sheet (2015). To successfully rate the retention of the respondents, grade points and class intervals are needed. The study could not adopt the WAEC grading system because it is devoid of grade points but contains only grades such as A1 (Excellent), B2 (Very Good), B3 (Good), C4 (Credit), C5 (Credit), C6 (Credit), D7 (Pass), E8 (Pass), F9 (Fail). Whereas the LASU grading system readily and clearly showed the class intervals and the corresponding grade points as displayed in table 1. This table depicts how the scores of the achievement tests were further grouped into three levels of retention: short, intermediate and long. Students with grade points 3.5 to 5 were considered long in retention, those within 1.5 to 3.49 grade points were assigned intermediate in retention, while those within 0.0 to 1.49 were considered short in retention.

Validity and reliability of the Achievement Test

The 10-item theory questions that make up the achievement test was given to three different senior secondary school 2 students outside the sample to ascertain the difficulty index of the instrument. It was also presented to three Ph.D students in mathematics education for further scrutiny and contribution, and thereafter presented to three mathematics experts for perusal, before it was forwarded to the supervisor for final approval. Unlike the results obtained in the pilot test, the test re-test reliability technique was adopted using Pearson R with coefficient of 0.74

for the achievement test. Some precautionary measures were taken to avoid biased results and to ensure internal and external validity of the instruments. 1. It was ensured that only students that participated in the pre-tests were post-tested. Students who were absent on the first day of pre-test participated in subsequent class activities but were not allowed to take part in the post tests. 2. To ensure fair pairing, students were not allowed to choose their own partners independent of the research assistants. The pre-test scores and ages accordingly served as basis for students' pairs. 3. In order to prevent discussion across participants of unlike strategies, the researcher carefully ensured that only one strategy was applied in each school and each local government area. 4. To prevent participants from the usual revision before taking any test, they were not given prior information about the post-post-test. The retention scores were coded using Microsoft Excel package, while means and standard deviations were used to answer the research questions. The null hypotheses were tested using the Analysis of Co-variance (ANCOVA) at 0.05 level of significance. This statistical tool was adopted because students' retention was pre, post and post-post tested three weeks after in their intact classes.

Limitations to the Study

The study excluded students in senior secondary school III who were preparing for external examination during the investigation. At some points, the contacted private schools were not ready to make their students accessible for the study, so the study then sampled only students from public senior secondary schools. However, it was uneasy to gain access to the government owned schools but it was facilitated by the letters of introduction from the HOD, Science and Technology Education Department, Lagos State University. During the treatments, some students in the control group were unwilling to continue with class sections, but later complied when their mathematics teacher and head of department were contacted to rescue the situation. Whenever the treatments and data collection clashed with some unscheduled or emergency school activities, the researchers re-scheduled the section for another favourable time.

3. Results and Discussion

Research question 1: What is the retention of the students in coordinate geometry lessons when taught with conventional and peer-tutoring strategy? This research question was answered with the aid of the results in Table 2 and Figure 3.

Table 2. Retention in coordinate geometry when thought using Conventional and Peer-tutoring strategies

	No	**Pre-retention**	**Retention after 1hr**	**Retention after 1 week**	**Retention after 2 weeks**	**Retention after 3 weeks**
Conventional	59	1	1.82	1.59	1.43	1.00
Peer-tutoring	34	1	2.33	2	1.71	1.55
Average		1	2.08	1.80	1.57	1.28

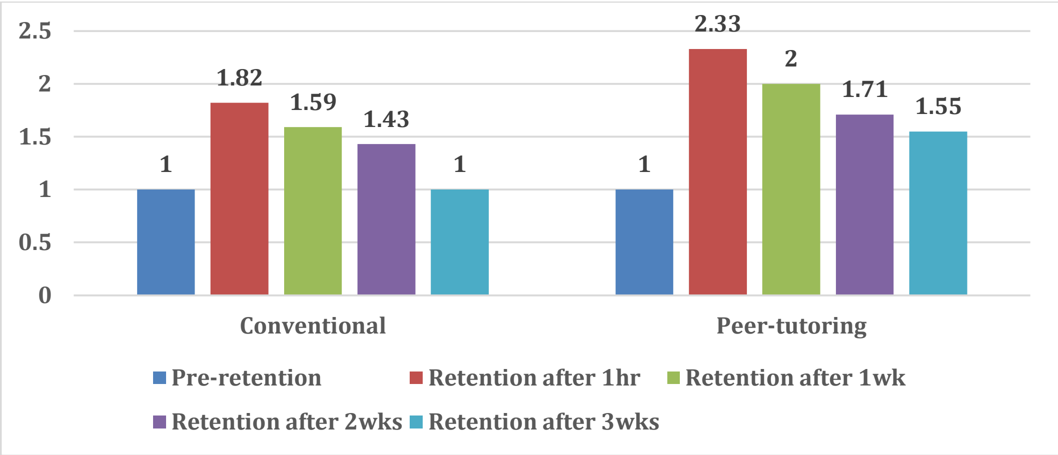

Figure 3. Students' retention in coordinate geometry when thought using Conventional and Peer-tutoring strategies

The outcome in table 2 in conjunction with Figure 3 showed that pre-retention of the students in conventional and peer-tutoring groups were (1 & 1) or low, which rose to (1.82 & 2.33) or intermediate an hour after the treatment. It then slightly nose-dived to (1.59 & 2) as intermediate one week later. Two weeks later, there was a further decline to 1.43 or low for conventional and 1.71 or intermediate for peer-tutoring. But three weeks later those thought conventionally went back to status-quo in retention, while their peer-tutoring counterparts slightly came down to 1.55 and still intermediate. It shows that three weeks later, students in conventional group could not retain knowledge of coordinate geometry acquired but those in peer-tutoring group proved otherwise. Research question 2. What is the retention of the students in coordinate geometry lessons when taught with conventional and peer-tutoring strategy based on gender? The second research question was answered using the outcomes in Table 3 and Figure 4.

Table 3. Retention of the students in coordinate geometry when taught with Conventional and Peer-tutoring strategy based on gender

		No	**Retention after 1hr**	**Retention after 1 week**		**Retention after 2 weeks**	**Retention after 3 weeks**
Conventional	Male	25	1.00	1.78	1.04	1.00	1.00
	Female	34	1.00	1.69	1.09	1.00	1.00
Peer-tutoring	Male	16	1.00	1.81	1.56	1.52	1.50
	Female	18	1.00	1.94	1.83	1.63	1.55
Average			1.00	1.81	1.38	1.29	1.20

Table 3 in conjunction with Figure 4 depicted low retention before intervention irrespective of strategy and gender. This rose to 1.78 & 1.69 or intermediate after an hour for male and female students taught conventionally, 1.81 & 1.94 or intermediate for male and female peer-tutoring respectively, but reduced to 1.04 & 1.09 or low for conventional group and 1.56 & 1.83 or intermediate for peer-tutoring.

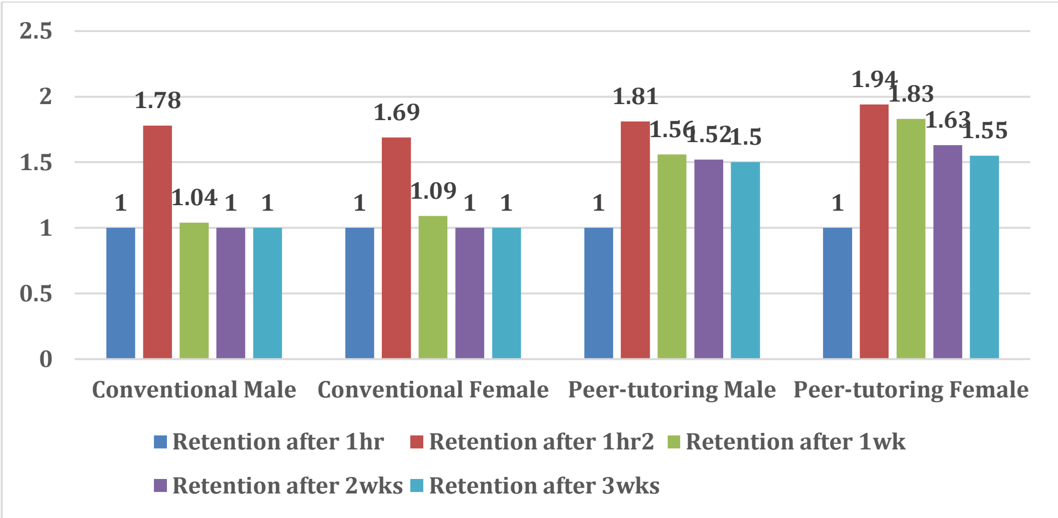

Figure 4. Students' Retention in coordinate geometry when taught with Conventional and Peer-tutoring strategy based on gender

Two and three weeks later, those in conventional was still low at 1 and 1 but intermediate at (1.52 & 1.63) and (1.5 & 1.55) for peer-tutoring. It shows that any noticeable changes in students' retention were not due to gender but strategy.
Research question 3. What is the retention of the students in coordinate geometry lessons when taught with conventional and peer-tutoring strategy based on age? This research question was answered using the results in Table 4 and Figure 5.

Table 4. Retention of students in coordinate geometry lessons when taught with Conventional and Peer-tutoring strategy based on age

		No	Pre-retention	Retention after 1hr	Retention after 1 week	Retention after 2 weeks	Retention after 3 weeks
Conventional	11-		1	1.71		1.00	
	13yrs	59			1.00		1.00
	14-		1	1.73		1.00	
	16yrs				1.08		1.00
	17-		1	1.73		1.00	
	19yrs				1.18		1.00
Peer-tutoring	11-			2.00		1.67	
	13yrs	34	1		2.00		1.08
	14-			1.88		1.56	
	16yrs		1		1.63		1.13
	17-			2.00		1.50	
	19yrs		1		1.54		1.00
Average			1	1.84	1.33	1.29	1.16

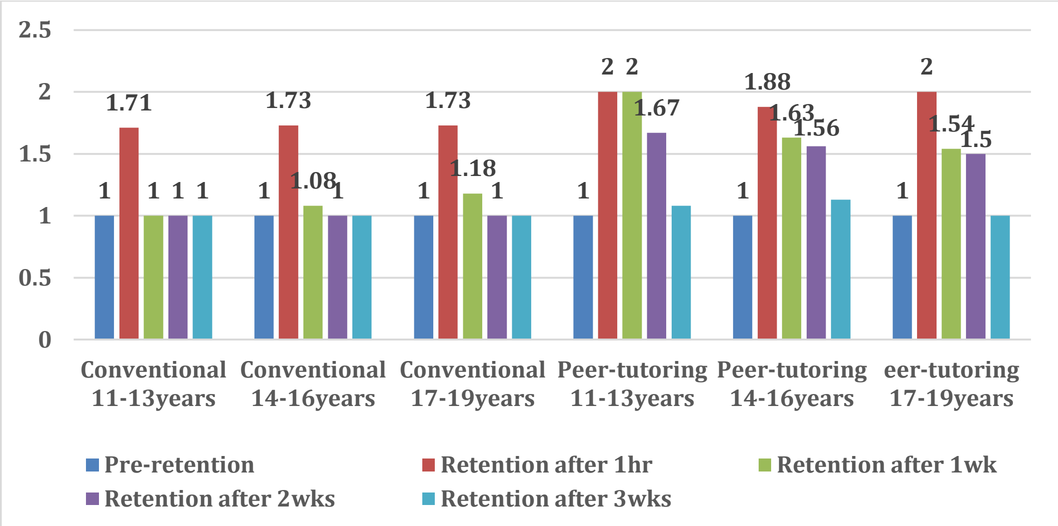

Figure 5. Students' retention in coordinate geometry lessons when taught with Conventional and Peer-tutoring strategy based on age

Table 4 in conjunction with Figure 5 depicted low retention for students across board irrespective of age and strategy. This rose to 1.71, 1.73 & 1.73 or intermediate after an hour for ages 11-13yrs, 14-16yrs & 17-19yrs in conventional group, but 2.00, 1.88 & 2.00 or intermediate for peer-tutoring group respectively. One week later, it conventionally reduced to 1.00, 1.08 &1.18 or low and 2.00, 1.63 & 1.40 for peer-tutoring group respectively. However, two and three weeks later those in conventional group went to status-quo but not so for peer-tutoring group. This also showed that deviations in students' retention are not functions of age but strategy.

Table 5. Statistical significant effect of peer-tutoring strategy on retention of students in co-ordinate geometry.

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	37.192[a]	24	1.550	8.131	.000	.593
Intercept	15.580	1	15.580	81.750	.000	.379
Pre-retention-span	.375	1	.375	1.968	.163	.014
Group	4.660	3	1.553	8.151	.000	.154
Gender	.237	1	.237	1.244	.267	.009
Age	.124	2	.062	.326	.722	.005
Error	25.538	134	.191			
Total	777.000	159				
Corrected Total	62.730	158				

The outcome in table 5 line 4 [$F(3, 134)=8.15$; $p<0.05$] revealed significant effect of peer-tutoring strategy on retention of students in co-ordinate geometry. This statistical effect is largely due to the intervention with peer-tutoring strategy as supported in Figure 2. It implies that peer-tutoring is useful as a strategy for elongating students' retention in coordinate geometry and by extension achievement in general mathematics. With respect to the statistical significant influence of gender on students' retention when taught using Peer-tutoring strategy, it is obvious from the result in table 5 line 5 [F(1, 134)= 1.24; p>0.05] there is no statistical significant influence of gender on students' retention when taught using Peer-tutoring strategy. The data in table 3 equally support the fact that the use of peer-tutoring strategy is not gender biased. About the statistical significant influence of age on students' retention when taught using Peer-tutoring strategy, the output in table 5 line 6 [F(2, 134)= 0.33; p>0.05] depicted no statistical significant influence of age on students' retention when taught using Peer-tutoring strategy. The statistics in table 4 equally maintained that the use of peer-tutoring strategy in coordinate geometry class is not age biased.

Discussions of findings

The study found that peer-tutoring is significantly useful as a strategy for elongating students' retention in coordinate geometry and by extension achievement in mathematics. This agrees with Abdurrahman and Garba (2014); Isah (2015); Moliner and Alegre (2020); Ijeh (2023) who reported that slow learners prolonged their retention of basic mathematics concepts through the use of laboratory activity and peer tutoring strategy longer than those taught conventionally. This is in harmony with the position Benjamin-Frankiln' position earlier reported that learning by teaching goes a long way to improve retention of mathematics knowledge. On the contrary, longer retention was observed by Juweto (2018) with students taught using conventional method than those taught with small group and peer tutoring which was largely attributed to error of random sampling when quasi-experimental design is adopted. This failure to observed the parametric assumption of homogeneity of variance of the participants across groups must have led to some spurious outliers that can internally alter the effect of some interventions. The study also showed that the use of peer-tutoring strategy is neither gender nor age biased. It does not conform with Alex and Mammen (2014); Ijeh (2023) who believed that the existence of significant difference in the retention and achievement of male and female students is closing up globally at a high speed. But on the contrary, Isah (2015); Juweto (2018); Raheem *et al.* (2017) observed that students taught using conventional method, small group and peer tutoring do not significant differ in learning outcome due to gender. However, it does not conform with Timayi *et al.* (2015) who believed that there is an inconclusive global debates on students' performance and retention in coordinate geometry with respect to gender. Furthermore, Stoet and Geary (2013); Ali *et al.* (2014) established that male students outperform their female counterpart in retention. There was no conclusive empirical literature readily accessible with respect to age, hence the decision of the authors was upheld.

This finding has implications for Mathematics instruction in line with the outcome of a quasi-experiment by Aloha and George (2022) which revealed a statistically significant difference likely due to error of randomization of 114 students taught algebra using a peer tutoring strategy and those taught using the teacher deductive teaching method in terms of retention. Furthermore, the work of Dada *et al.* (2023) showed that a combination of cross-age and peer-tutoring are both effective in enhancing the achievement and interest in mathematics of underachieving gifted students, although with a significant differential effect between peer and cross-age tutoring. Ijeh (2023) also observed significant effect of peer-tutoring strategy on students' retention in mathematics but not with respect to gender. Oguegbu and Akanwa (2024) also reported that peer tutoring has a significant impact on students' achievement and retention in mathematics. From this comparative, retention was longer with students taught using conventional method than those taught with small group and peer tutoring but not significant due to gender. This aligned with Raheem *et al.* (2017) who believed that gender played no role in the retention of students taught with peer-tutoring strategy favoring both male and female students as they demonstrated significant improvement in their retention. Thus peer tutoring does not only help in the improving retention of students but also increases the quality of interaction. Moreover, Moliner and Alegre (2020) registered peer tutoring as a beneficial tool for reducing middle school students' mathematics anxiety, regardless of their gender, grade or status.

4. Conclusion

Conclusively, students exposed to peer-tutoring group were significantly longer in ability to recapture previous knowledge of coordinate geometry than those exposed to conventional approach. Granted, learning outcome was good with respect to conventional approach but better with peer-tutoring strategy. Therefore, the strategy is gender friendly and does not discriminate over age. It is pertinent that teachers teach to their level of understanding for long term retention. This is because inability to retain infomation is tantamount to inability to recapture what has been encoded. In turn, inability to recall coded information is not unconnected with hatred, phobia and negative attitude towards the subject. It was finally submitted that underachieve in external mathematics examination is not unconnected with short term retention, which is the inability to recapture acquired experience after a relatively long period, is largely due to students' inability to make frequent and repeated use of acquired mathematical knowledge.

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