IMPROVING PUPILS' ACHIEVEMENT IN MATHEMATICS: A COMPARATIVE STUDY OF MNEMONICS AND JIGSAW INSTRUCTIONAL TECHNIQUES

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Abstract
There is a need to determine the most suitable teaching strategy to enhance learners' academic achievement. This ensures that a sound educational foundation is laid to foster learners' interest in education activities. On this note, this study investigated and compared the effectiveness of Mnemonics and Jigsaw instructional strategies to determine the most effective among them. A pretest-posttest non-randomized quasi-experimental research design was utilised for the study. A total of 118 pupils in four intact primary five classes formed the sample size of the study. The study was guided by one research question and one hypothesis. Pupils' Mathematics Achievement Test (PMAT) was employed for data collection. An internal consistency reliability index of 0.85 was obtained for the PMAT using the Kuder-Richardson formula 20 (KR20), while a temporal stability estimate of 0.93 was obtained using the Pearson correlation coefficient. While employing the Analyses of covariance (ANCOVA), the hypothesis was tested at a 0.05% probability level. The findings of the study indicated that the jigsaw instructional technique proved more effective in improving the pupils' academic achievement in mathematics than the mnemonic instructional strategy. The researchers, therefore, recommended that primary school teachers be trained in the use of the jigsaw instructional technique and that the technique should be massively deployed in primary schools, especially in teaching mathematics.

Keywords: Pupils, Achievement, Mathematics, Mnemonics, Jigsaw Instructional Technique.

Introduction

Primary education (PE) is the first and the foundation stage of formal education characteristically succeeding preschool and preceding high school education. PE curriculum is designed for children between the ages of 6 and 11 years (FRN, 2014). The United Nations International Children's Emergency Fund (UNICEF) conceptualized PE as the bedrock of education, teaching children the basic skills for a future and meaningful life in society (UNICEF, 2022). Every level of education has set goals and objectives. The PE has specified age-appropriate objectives for the learners within the scope of its set objectives. The objectives of PE in Nigeria are inculcating permanent literacy, numeracy and the ability to communicate efficiently, and lay a sound basis for scientific, critical and reflective thinking among others (FRN, 2014; Uba, 2017). Numeracy is strongly tied to mathematics since numeracy has to do with numbers and the whole idea of mathematics is the manipulation of numbers (Okenyi, 2023). Numeracy is the art of recognizing numbers and the ability to solve mathematical problems, as mathematics is a game of numbers (Apriyani, 2022). Mathematics, on the other hand, sharpens the brain for scientific, critical and reflective thinking.

Mathematics is a vital and core school subject at all levels of education in Nigeria. Credit passes in English and mathematics are required for eligibility and entry into any Nigerian University to study any discipline (Buba & Umar, 2015). Mathematics as the language of science inculcates the skills of inquiry, logic, critical and flexible thinking in the learner (Luitel, 2018). Mathematics, therefore, is a "conditio sine qua non" for the study of high-profile disciplines such as Engineering, Architecture, and Medicine among others,

which are reserved for high academic achievers (Mabena & Rampela, 2021). Buba and Umar argued that since a solid background in English Language and Mathematics improves cognition, they can as well predict learners' success in academics. Mathematics enhances the development of intellectual resilience for academic excellence, logical reasoning, as well as critical and flexible thinking, needed for inventions and innovations (Okenyi, 2023). A well-orchestrated mathematics education is the bedrock for progress in developing nations: enhance the education system, shape the future of the children, improve the economy of the nation, refine the culture and the morality of the people as well as improve their standard of living (Ibrokhimovich et al., 2022). For these and more, mathematics education is most needed in Nigeria's primary level of education.

However, the obvious learners' underachievement in mathematics has become a cankerworm preventing many African countries (Nigeria inclusive) from attaining their Millennium Development Goals (DMGs) (Okenyi, 2023). The International Mathematics Union (2020) in its annual report pointed out that there exists a weak mathematics education in elementary and high school levels in many African countries leading to a decrease of the potential population of learners, that opt for mathematics-related courses in the universities. Numerous factors such as learner-related, teacher-related and school-related variables account for this worrisome situation. Authors like Mabena et al. (2021) cited negative self-esteem, poor language development, ill disposition and unhealthy attitudes as learner-related factors while citing poor teaching skills, inadequate training, as well as poor pedagogical content knowledge as teacher-related variables that contribute to learners' poor achievement in Mathematics. Ugwuanyi and Okeke (2020) argued that the major factor that militates against pupils' achievement in mathematics and sciences is the inadequate teaching strategy known as the talk and chalk (TC) method utilized in Nigerian schools. The authors, therefore, advocated for a paradigm shift in the teaching methods in the primary schools. TC method is teacher-centered and non-interactive thereby making mathematics learning less inspiring and dull for the pupils. TC method is the situation where the teacher delivers the instruction by explaining (talking) and demonstrating on the chalkboard. It is primarily a lecture method of classroom instruction (Sharma & Kumar, 2018). This method of instruction is not engaging to the learner and does not present to the learners the opportunity for active participation in the teaching/learning process (Okenyi, 2023). Learners need interactive, engaging and cooperative means of the teaching-learning process for a successful academic activity. Such methods like Mnemonics and Jigsaw instructional strategies are engaging interactive and cooperative and could be good alternatives to the TC method (Senthamarai, 2018). The researchers, therefore, proposed to determine which is the better option in improving pupils' learning achievements between Mnemonics and Jigsaw teaching-learning strategies.

A Mnemonic is a memory device or technique that enables the mind to easily store and retrieve information. Kakharov and Azizov (2022) viewed mnemonic as a mental technique utilized by the brain to link new data to prior information by the use of visual or acoustic cues. This implies that mnemonics is the use of pictures, audio, rhythms, music and poems among others to improve memory. Mnemonic is a memory formula that is designed by compressing a large volume of information into a memorable short format that enables the learner to recall the larger form of the information as soon as he/she evokes the short format thereby using it as a tip to remember the larger information (Odeyemi & Akinsola, 2015). Mnemonics learning techniques are learning strategies that arm the typical and the atypical learners with unique procedures to improve their accommodation as well as retrieval of information based on strategic or significant words, acronyms and or rhythms (Lubin & Polloway, 2016). Mnemonic is, therefore, a learning process whereby the learner's cognitive

capacity is enhanced through a unique formulation of notes and figures to facilitate encoding, assimilation and recall of information for use.

The jigsaw model of teaching and learning is a cooperative instructional strategy that has depicted a latent influence on students' learning. It is a teaching model that makes the student responsible in such a way as to learn the subject and teach it to his/her peers (Jainal & Shahrill, 2021). The jigsaw teaching model is a learning technique that enables a learner to mingle and interact with other learners in the same category without hindrances. Hence, it is an interactive teaching strategy where learners engage in a reciprocal association that is profound and spontaneous (Okenyi, 2023). Its scaffolding fashion evokes profound communication and collaboration among learners. The model is designed after the Jigsaw model. The jigsaw model of teaching is shaped to involve two kinds of groups namely home groups (Hg) and expert groups (Eg) (Suendarti & Virgana, 2022). The jigsaw teaching approach is built around the idea that each student can achieve his/her goal while cooperating with other students, on the ground that he/she also contributes to others achieving their own goals (Odeyemi & Akinsola, 2015).

In the jigsaw teaching model, the class is divided into 4-5 groups (depending on the class size) with each group numbering between 3-4 members. These groups a labeled the Hg, and the teacher, thereafter, introduces the topic for study and since he has like 4 groups of 4 students each, splits the topic into 4 themes. The teacher ensures that every student in the Hg is assigned a theme different from the others (Achor et al., 2022; Suendarti & Virgana, 2022;). The next step is that the members of the Hgs like the jigsaw puzzle dissolve into new groups referred to as Expert Groups (Egs). The members of the Egs are learners who have similar themes. Here in the Eg they study the theme in detail and gain mastery of the theme (Azeez, et al., 2020). At the expiration of the time the Egs dissolved and the members went back to the Hgs where each student took turns to listen and teach his/her peers the aspects they have mastered in the Egs.

In this manner, each student teaches and learns from his/her peers as well. The teacher then administers a test at the end of the session. The process results in the students depending on one another for success as well as ensuring mutual trust while drawing inspiration from each other leading to reduced racial discrimination and improved academic success (Azeez, et al., 2020; Suendarti & Virgana, 2022). The jigsaw model is, therefore, a teaching-learning model that is engaging, interactive and learner-centered.

Mnemonics and Jigsaw teaching models are both utilized by instructors and learners as alternatives to lecture methods to improve academic achievement. In summary, the mnemonics teaching method was developed to improve the learner's effectiveness in encoding and retrieval of data by utilizing some visual or auditory hints. Such hints improve the learners' skills to establish a link between his/her prior knowledge and the current information. Mnemonics teaching strategy aids learners with learning or developmental infirmities to recall new materials with less stress by creating a link between new content information with prior knowledge by visualizing some clues in the form of pictures or letters/words or their combinations. The three main forms of Mnemonics strategy are; keywords, peg words, and letter-methods or acronyms. This strategy utilizes loci, chunking, and rhymes thereby making learning fun and easier. In the Mnemonics learning strategy, Roy G Biv as a name can be used to recall the 7 colours of the rainbow: red, orange, yellow, green, blue, indigo, and violet.

Jigsaw-teaching-learning strategy on the other hand involves organizing groups of learners to become "experts" on specific aspects of a body of knowledge and, afterwards, share the materials with other groups of learners "home group". The approach facilitates easy understanding and retention of information while assisting the learners in developing team spirit and collaboration skills. The Jigsaw learning strategy emphasizes cooperation and

shared responsibility among the group members. The success of each group is dependent on the collaboration and active participation of every member of the group. This implies that the Jigsaw teaching-learning approach is interactive, learner-centered and cooperative.

In the mnemonics technique, the learners' success depends on the individual learner's efforts, commitment and hard work. It is individualistic and developed to assist learners with learning difficulties or impairments. The rhymes aspect of mnemonics makes it a play-way method and most suitable for young learners. In a jigsaw strategy, the individual learner's success depends on the cooperation of other learners. It involves group or teamwork and teaches cooperation and respect among learners. It is interactive and seems to suit adult learners better than very young learners.

Over the years, the Mnemonic teaching-learning strategy has been successfully utilized by educators in different areas of knowledge for students who experience learning difficulties (Jurowski et al., 2015; Lubin & Polloway, 2016; Odeyemi & Akinsola, 2015). The teaching method has proved successful in improving the vocabulary acquisition skills of the students and learning of Bangladesh Anatomy (Amiryousefi & Ketabi, 2011, Akhter, 2022). Mnemonic is a significant factor in enhancing the academic achievement of tertiary students in sciences, statistics and social studies. (Odeyemi & Akinsola, 2015; Ntibi et al., 2018; Jurowski et al., 2015; Mahaffey, 2020). At the secondary school level, a mnemonic technique has proved successful in improving the learners' academic achievement in biology and mathematics irrespective of gender (Olu-Ajayi,2022; Nwuba & Osuafor, 2022; Nwuba et al., 2022; Odeyemi & Akinsola, 2015; Maghy, 2015; Boon et al., 2019). Mnemonics has also proved successful in aiding high school students' understanding of chemical concepts (Das, 2018; Mahaffey, 2020). In Poland, mnemonics strategies have been utilized in the past three decades in some specific ways and have recorded huge success in aiding Polish students in the knowledge and application of science concepts (Jurowski et al., 2015). Visual mnemonics have proved efficient and convenient in developing and inculcating the skills of creativity and critical thinking in learners (Nur, 2018; Cioca & Nerișanu, 2020). Mnemonics is efficient in enhancing learning, encoding and retrieval of information in all areas of life and learning and benefits learners of all ages and levels (Coraiola et al., 2018; Radović & Manzey, 2019). Mnemonics could play a significant role in improving primary school pupils' academic achievement in different areas of school learning (Ghoneim & Elghotmy, 2016; Ajayi & Olawole, 2022; Ramli et al., 2022)

On the other hand, the jigsaw learning strategy effectively and efficiently encouraged the development of listening skills, interaction, and responsiveness by ensuring that each person in the group is assigned to play an essential part in the learning process. Furthermore, this strategy decreases the incidences of victimization and bullying as well as mitigate the effects of abuse among learners at all levels of education (Odeyemi & Akinsola, 2015; Nurbianta & Dahlia, 2018; Van Ryzin & Roseth, 2018; Sawyer & Obeid, 2017). On the question of intrinsic motivation for the learning process and enhancing senior students' interest in learning, the jigsaw strategy has proved to be an effective tool (Haftador et al., 2021; Alfaruqy, 2021; Ojekwu & Ogunleye, 2020; Shakerian & Abadi, 2020; Tofi et al., 2022). The Jigsaw strategy has been used to improve the academic achievement of secondary school students in numerous school subjects such as algebra, mathematics, chemistry, and physics among others (Fasasi & Hussaina, 2022; Haftador et al., 2021; Shakerian & Abadi, 2020; Tofi & Asibi, 2022; Alfaruqy, 2021; Ojekwu & Ogunleye, 2020; Alfaruqy, 2021; Sawyer & Obeid, 2017; Van-Ryzin & Roseth, 2018; Obafemi et al., 2023; Nurbianta & Dahlia, 2018). The strategy has been proven to enhance pupils' achievement in specific school subjects such as English Language and Mathematics (Obafemi et al., 2023). However, literature is scarce on the relative efficacy of mnemonics and jigsaw instructional strategies on pupils' achievement in mathematics. Thus, the researchers hypothesized that there is no

significant difference in the mean achievement scores of pupils taught using mnemonics and those taught using the jigsaw instructional strategy.

Methods

The design utilized in the study was non-randomized pretest/posttest quasi-experimental research design. A pretest/posttest quasi-experimental research design is a study in which the participants are assessed with the same measures before and after treatment to ascertain if any observable changes could be attributed to the intervention (Budert-Waltz et al., 2022). Recently, researchers have successfully utilized the design in some related studies (Bagheri & Mohamadi, 2021; Masek & Yamin, 2012; Alwhaibi et al., 2020). The study was carried out in the Enugu-North Senatorial Zone, Enugu State, Nigeria. Enugu-North Senatorial zone is made up of six Local Government Education Authorities (LGEAs); Uzo-Uwani, Igbo-Etiti, Nsukka, Udenu, Igbo-Eze North, and Igbo-Eze South LGEAs. Numerous educational institutions are located in the zone, yet learners in the environment seem to perform dismally in mathematics. The population of the study comprised all the 15,703 pupils in primary 5 classes in the entire 5,903 public primary schools in the study area.

A purposive sampling technique was used to sample two public primary schools in the study area (This was necessary to sample schools that have up to two streams of primary 5 classes. School A had 61 pupils; 30 and 31 pupils for mnemonics and jigsaw groups respectively and was made up of 40 girls and 21 boys. While school B had 57 pupils; 27 and 30 pupils for mnemonics and jigsaw groups respectively and made up of 38 girls and 19 boys. Thereby having two (2) groups each for mnemonics and jigsaw respectively. The tool for data collection was the Pupils' Mathematics Achievement Test (PMAT) which was adapted from the Comprehensive Mathematics Inventory (CMI) (Reys & Rea, 1970). The PMAT is a 20-item multi-choice instrument with answers ranging from A, B, C to D. Any correct answer attracts one mark, making it a total of 20 marks. The maximum score of 20 points and minimum score of 0 were utilized in the scoring of the PMAT. The data collection tool was validated by three experts, one each from the Childhood Education, Educational Psychology, and Measurement and Evaluation units, Faculty of Education, University of Nigeria, Nsukka.

Treatment Process

Before the takeoff of the program, the two groups: the mnemonics and jigsaw groups were pretested and the result of the test was recorded, analyzed and saved as the benchmark or the evidence of the cognitive development of the pupils before the treatment. Thereafter, the mnemonics group were taught Geometry and Multiplication by their regular teacher utilizing the Mnemonics teaching strategy while the jigsaw group was instructed on the same topic utilizing the Jigsaw instructional method. The aspects of geometry taught as it is contained in the curriculum were properties of shapes. This involved identifying shapes, being able to remember their properties, and comparing and classifying them. The multiplication was that of tens and hundreds. The two groups were taught by their regular teachers who were adequately instructed on the mnemonics and jigsaw techniques respectively. In the mnemonics group, the teacher used rhythms, Loci, peg words and acronyms, while allowing the learners to construct their individual rhythms, loci, peg words and acronyms as they wished. While the jigsaw group's teacher utilized the normal home and expert groups. The classes were interactive, engaging, stimulating and lively. The treatment lasted for four weeks. Two weeks after the treatment, there was a follow-up program to determine the extent of retention. At the end of the four weeks, the pretest was rearranged and administered to the learners as a posttest. The efficacy of the mnemonics and jigsaw teaching

strategies on pupils' academic achievement in mathematics was determined by employing the analysis of covariance (ANCOVA), while Partial Eta Squared was utilized in reporting the effect size of the intervention.

Result

Table 1: Mean analysis of the achievement scores of the pupils

Treatment	no	Pre-test Mean	SD	Post-test Mean	SD	Mean Gain
Mnemonics	30	5.76	1.22	15.26	1.11	9.50
Jigsaw	31	5.93	1.18	16.87	1.83	10.94

Table 1 indicates that pupils taught mathematics utilizing mnemonics teaching approach had a mean achievement score of (M = 5.76, SD = 1.22) at the pretest while, at the posttest they had (M =15.26, SD = 1.11), whereas, those instructed utilizing jigsaw instructional approach had mean achievement scores of (M = 5.93, SD = 1.18) at the pretest and (M = 16.87, SD = 1.83) at the posttest. In addition, the mean gain achievement scores of 9.50 and 10.94 for the two groups respectively, indicate that the pupils taught mathematics utilizing jigsaw approach had higher mean achievement scores than those taught using the mnemonics strategy. However, the posttest standard deviations of 1.11 and 1.83 for the two groups imply that the pupils taught mathematics utilizing the jigsaw teaching method had higher variation in their individual achievement scores than those of the jigsaw group.

Table 2: Analysis of covariance of the effect of the treatment on the achievement of pupils

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	39.241[a]	2	19.621	8.285	.001	.222
Intercept	619.727	1	619.727	261.700	.000	.819
Pretest	.002	1	.002	.001	.978	.000
Treatment	39.078	1	39.078	16.502	.000	.221
Error	137.349	58	2.368			
Total	15953.000	61				
Corrected Total	176.590	60				

a. R Squared = .222 (Adjusted R Squared = .195)

Table 2 exposed the fact that there is a significance in the mean scores of pupils taught mathematics utilizing mnemonics and jigsaw instructional strategies in favour of the jigsaw group, F (1, 58) = 16.502, p = .000. Therefore, the null hypothesis is rejected (p < .05). In addition, the effect size of .221 shows that 22.1% change in the achievement scores of pupils in mathematics is attributed to the effect of jigsaw teaching-learning methods.

Discussion

The outcomes of the result of the study showed that both mnemonics and jigsaw instruction strategies had a significant positive effect on the academic achievement of pupils in mathematics. It was further found that there was a significant difference between the scores of the pupils taught mathematics utilizing mnemonics and jigsaw instructional techniques in favour of those taught utilizing jigsaw instructional strategy. This implies that the participants in the jigsaw group retained their improved achievement at the follow-up assessment more than those in the mnemonics group. These results reveal the effectiveness of the jigsaw teaching method over the mnemonics instruction approach in enhancing pupils'

academic success in mathematics. The conclusions of the investigation are this way because the pupils' exposure to the jigsaw instruction package activated active involvement and interest in the teaching-learning process in the classroom. For the 4-week duration of the intervention, the pupils participated in the classroom activities with interest and enthusiasm. These findings are in line with earlier findings, which showed that the jigsaw teaching method stimulates learners' interest by capturing their interest and resulting in improved academic achievement in all school subjects (Haftador et al., 2021; Alfaruqy, 2021; Ojekwu & Ogunleye, 2020; Shakerian & Abadi, 2020; Michael et al., 2022; Tofi et al., 2022). Furthermore, the study validated the earlier conclusions of Fasasi and Hussaina, (2022), Shakerian and Abadi (2020), Alfaruqy (2021), and Obafemi et al. (2023) that the jigsaw teaching-learning approach is the most effective technique in improving the academic achievement of secondary school students in numerous school subjects such as algebra, mathematics, chemistry, and physics among others.

Conclusion

The study, therefore, concluded that the jigsaw instructional technique is more effective in improving pupils' academic achievement in mathematics than the mnemonics instructional technique. This is evident since the pupils who were taught mathematics using the jigsaw instructional technique achieved significantly better than their counterparts who were taught using the mnemonics instructional strategy.

Recommendations

In line with the findings of the investigation, the researchers suggested that:

1. workshops organized to educate the primary school teachers on jigsaw teaching-learning techniques.
2.
3. the jigsaw instructional technique should be massively employed in primary schools, especially for the teaching of mathematics.

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