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Interaction patterns: An approach for enhancing students' retention in geometric construction

Ifeoma Julie Osakwe [1], Felix Oromena Egara [1*], Onyemauche Christopher Inweregbuh [1], Augustina Chinyere Nzeadibe [1], Chinyere N. Emefo [2]

[1] Department of Science Education, University of Nigeria, Nsukka, NIGERIA
[2] Department of Mathematics, School of Secondary Education, Federal College of Education, Bichi, NIGERIA
*Corresponding Author: felix.egara@unn.edu.ng

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ABSTRACT

The effect of interaction patterns on JS3 learners' retention in geometric construction was investigated in Anambra State, Nigeria. The researchers used a quasi-experimental approach with a non-equivalent control group for the pre- and post-test. The population consisted of 1,813 JS3 leaners. The study's subjects were a group of 155 JS3 learners drawn from two schools. Two JS3 classes in the schools were assigned to the experimental and control groups at random. The geometric construction retention test (GCRT) was used to collect data, and it was validated by three experts. The reliability coefficient of the GCRT was 0.80. The mean and standard deviation of the data were used to report the study's questions, whereas the hypotheses were tested via analysis of covariance at a 0.05 level of significance. According to the findings, students taught geometric construction utilizing interaction patterns remembered more material than those taught using the expository approach. It also found a statistically significant difference in retention between urban and rural learners, favoring urban learners. The interaction effect of group and location on student retention was not significant. One recommendation of this study is that teachers should use interaction patterns as an instructional method when teaching geometric construction.

Keywords: geometric construction, interaction pattern, location, mathematics, students' retention

INTRODUCTION

Mathematics is the key to science, and it is unmistakably the cogwheel that drives scientific and technology activities in today's globalized world (Cobb, 2018). The goal of establishing national capacity in science and technology relies heavily on mathematics. Nations that embrace mathematics, science and technology are likely to enjoy a better standard of living and are less dependent on others (Inweregbuh et al., 2020; Okeke et al., 2022a, 2022b). This advantage is not unconnected with the fact that this is an age where possession and application of scientific and technological knowledge have endowed nations of the world with economic and political advantages over others. As a result, any shortcoming in this area is a hindrance to the achievement of science and technology goals.

Despite the importance accorded mathematics in the educational system in Nigeria, most students are still not interested in the subject (Egara et al., 2018, 2021; Evans et al., 2019; Kumah et al., 2016). This in turn leads to poor achievement and retention in ordinary level (O/level) mathematics examinations. This situation calls for some investigations to address the problems of mathematics education in Nigeria and Anambra State in particular. One of the factors that contribute to learners' poor mathematics achievement is their inability to retain what they have learned (Nzeadibe et al., 2019). In collaboration with achievement, retention is measured (Nzeadibe et al., 2020). This means that achievement and retention are inextricably linked. The amount of academic content a student learns in a given length of time is measured by students' achievement while students' retention is the preservation and recall of the learned concept (Etukudo, 2011). Therefore, improving learners' achievement necessitates improving their retention of concepts learned.

Poor teaching methods and the non-use of appropriate instructional resources, among other variables, have been highlighted in studies as contributing to persistently low achievement and retention of school students in mathematics (Nzeadibe et al., 2019; Okeke et al., 2022b; Tuliao, 2020). Mathematics teaching in Nigeria primary and secondary schools is centred on the expository method (Okpala, 2011). The authors also observed that what predominates in the primary and secondary school classrooms is the teacher-centered approach. The teaching dynamics have a significant impact on how much pupils learn. Though student

achievement and retention in mathematics are not only a result of the teacher's teaching activities, but it does also have a significant impact on classroom learning. During class, teachers build a broad pattern of conduct, and students establish specific forms of behavior to match this pattern. The combination of the teaching pattern and the engagement of the students results in a unique classroom environment with a unique interaction pattern. The classroom interaction pattern is the most common or regular way for students to engage in the classroom. The way messages are successfully conveyed in the classroom between the instructor and the students to fulfil instructional objectives is referred to as the classroom interaction pattern (Nnorom & Erhabor, 2019). Interaction pattern in the mathematics classroom is an important factor in the examination of students' mathematics retention (Osakwe, 2017).

The four basic classifications of the classroom interaction patterns are teacher-student interaction pattern, student-student interaction pattern, teacher-material interaction pattern, and student-material interaction patterns (Osakwe et al., 2019). A teacher-student interaction pattern is one in which the teacher interacts with a single student or a group of students. In the student-student interaction pattern, during class, the students react to each other's actions, attitudes, and ideas in a pattern known as student-to-student interaction. Ogbu (2011) further classified student-student interaction patterns into a cooperative, competitive, and individualistic interaction patterns. Altun (2015) described a cooperative interaction pattern as one in which students work together in small groups (usually four to six members) and are rewarded for their achievement as a group. Osakwe (2017) described a competitive interaction pattern as one in which students' goal achievement is negatively correlated. In an individualistic interaction pattern, there is no correlation among the goal attainment of the participants. The pattern of student-student interaction enriches education, especially when collaboration and cooperation between students occur. Long-term dialogue among students allows students to critically evaluate the viewpoints of others (Osakwe, 2017). The teacher-material interaction pattern is when a teacher manipulates instructional materials, machines, or equipment for the goal of skill learning or to emphasize a point or explain some concerns for the students, this is referred to as a teacher-material interaction pattern. The student-material interaction pattern is when students engage in instructional materials, machines, and equipment to solve practical issues or experiment with specimens or models, they are engaging in a student-material interaction pattern.

Miyazoe and Anderson (2010) expanded up the initial four categorizations of interaction patterns with the additions of teacher-teacher and content-content interaction patterns. Teacher-teacher interaction pattern extends the foundation of a learning community and the advantages of a common reservoir of teaching expertise and experience (Markewitz, 2007). Teachers may now interact with one another in ways that they have never been able to before. As regards to content-content interaction patterns, search engines on the internet are one example of modern technologies that enable content to interact with other content (Osakwe, 2017). The use of an effective interaction pattern helps in the diagnosis of students' weaknesses and the implementation of corrective measures. Studies have shown the effectiveness of interaction patterns in mathematics (Ifamuyiwa & Lawani, 2008; Ingram et al., 2018; Katiambo et al., 2019) and other areas of discipline (Modupe, 2021; Olugbenga & Ojo, 2017; Setianingsih, 2018) but no research, to the best of the researchers' knowledge, has been conducted on using classroom interaction pattern on junior secondary school students' retention in geometric construction in the south-east region of Nigeria. Therefore, there is a need to find out the effect of interaction patterns on students' retention in geometric construction in Idemili North Local Government of Anambra State. Another important variable to consider in this study is school location.

One educational variable that appears to be influencing the learning of mathematics is school location (rural and urban) (Osakwe et al., 2019). Several studies have been conducted considering school location as a factor influencing students' achievement and retention in mathematics. Some claim differences exist in favour of rural students (Ajai et al., 2013; Oyeromi et al., 2018) while others claim urban students' superiority over their rural counterparts in mathematics (Awodun & Oyeniyi, 2018; Ayub et al., 2017; Sovia et al., 2019). Also, some claimed that school location is not a factor to influence students' mathematics achievement and retention (Ntibi & Edoho, 2017). Again, studies have found a strong interaction effect between teaching approach and school location on students' mathematics achievement (Ajai et al., 2013; Ebhomien & Oriahi, 2018) and a non-significant interaction effect of instructional approach and school location on students' achievement in chemistry (Konyefa & Okigbo, 2021). Consequently, the debate on school location in the research community is still on and inconclusive. Hence, there is a need to find out in this study if school location influences students' retention in geometric construction when taught using classroom interaction patterns. The major objective of this research was to investigate the effectiveness of classroom interaction patterns on students' retention in geometric construction in Idemili North Local Government of Anambra State. Specifically, the research sought to find out

(i) the effect of interaction patterns on the retention of students in geometric construction and

(ii) the effect of interaction patterns on the retention of students in urban and rural areas in geometric construction.

Research Questions

The study was guided by the following research questions:

1. What are the mean retention scores of JS3 students taught geometric construction utilizing the interaction patterns and those taught with the expository method?
2. What are the mean retention scores of JS3 students in urban and rural schools in the experimental group?

Hypotheses

For this study, the following null hypotheses were developed and put to the test at a 0.05 level of significance:

1. There is no significant difference between the mean retention scores of JS3 students taught geometric construction utilizing the interaction patterns approach and those taught utilizing the expository method.

2. There is no significant difference between the mean retention scores of urban and rural JS3 students taught geometric construction utilizing the interaction patterns.
3. There is no significant interaction effect of group and location on JS3 students' retention in geometric construction.

METHOD

This study was conducted using a quasi-experimental research design. A non-equivalent control group was utilized for the pre- and post-test. This research was carried out at Anambra State's Idemili North Local Government Area. The study included all JS3 students in the area, with a total population of 1,813 JS3 students in the 16 government-owned secondary schools during the 2020/2021 academic session (Post Primary School Services Commission, 2020). The study's contents come inside the JS3 mathematics curriculum, which is why JS3 was chosen. By employing simple random sampling, two schools were stratified by location. Two JS3 intact classrooms were randomly selected and assigned to experimental and control groups in each of the schools. The sample included 155 JS3 learners from the two schools studied. The geometric construction retention test (GCRT) was utilized to collect data. The researchers created this instrument. There were 30 multiple choice questions in all. The items were developed using a table of specifications to ensure proper coverage of the study's content area as well as a consistent spread throughout the cognitive domain's levels. Three research professionals, one of whom specialized in measurement and evaluation and the other two in mathematics education, validated the GCRT. The reliability coefficient of 0.80 was calculated using the Kuder-Richardson formula20 (K-R20) after the GCRT was trial-tested.

Experimental Procedure and Data analysis

The researchers trained two regular mathematics teachers each with BSc. (Maths/Ed) in the two schools selected for the research for three days on the use of interaction patterns. First and foremost, the GCRT was given to all study participants as a pre-test. After that, the treatment was given for a total of six weeks. In each school, the experimental group was taught geometric construction through an interaction pattern approach, whereas the control group was taught the same themes through an expository way. Post-GCRT was given to the students at the end of the six-week treatment period. The researchers took another two-week break to see if the knowledge learned was retained. The instrument (GCRT) was reshuffled and administered as a retention test by the same research assistants to assess student retention in each group. The GCRT was gathered, marked, and analyzed. The study questions were described utilizing mean and standard deviation, while the hypotheses were tested utilizing analysis of covariance (ANCOVA) at a 0.05 level of significance.

RESULTS

Research Question 1: What Are the Mean Retention Scores of JS3 Students Taught Geometric Construction Utilizing the Interaction Patterns and Those Taught with the Expository Method?

According to the results in **Table 1**, the experimental group's post-test mean score and standard deviation were 23.43 and 4.07, respectively, while the control group's post-test was 16.95 and 3.38. The mean and standard deviation of retention in the experimental group, on the other hand, were 23.39 and 3.76, respectively. The experimental group retained learnt ideas with a mean difference of -0.04. In the case of the control group, the mean and standard deviation scores of retentions indicated 15.01 and 3.38 respectively. The mean retention score of 15.01 was a decline from 16.95 in the post-test. The control group retained learnt ideas with a mean difference of -1.94. The experimental group retained more of the geometric construction concept taught.

Table 1. Mean retention scores and standard deviations of groups

Groups	n	Post-test		Retention		Mean difference
		Mean	Standard deviation	Mean	Standard deviation	
Experimental	85	23.43	4.07	23.39	3.76	-0.04
Control	70	16.95	3.38	15.01	3.38	-1.94

Research Question 2: What Are the Mean Retention Scores of JS3 Students in Urban and Rural Schools in the Experimental Group?

Table 2 shows that the experimental group's mean retention scores varied across urban and rural learners. For the experimental group of urban students, the mean retention score was 24.15 and the standard deviation was 3.81. The experimental group in rural students also had a mean retention score of 22.79 and a standard deviation of 3.63, respectively. The urban had a mean retention gain of 0.27 while that of rural was a decline of -0.3.

Table 2. Mean retention scores and standard deviations of location

School location	n	Post-test		Retention		Mean difference
		Mean	Standard deviation	Mean	Standard deviation	
Urban (experimental)	43	23.88	4.10	24.15	3.81	0.27
Rural (experimental)	34	23.09	4.03	22.79	3.63	-0.3

Hypothesis 1: There Is No Significant Difference Between the Mean Retention Scores of JS3 Students Taught Geometric Construction Using the Interaction Patterns and Those Taught Using the Expository Method

Table 3 shows that an F-ratio of 1,964.006 was produced, with a probability value of 0.00 as a result. This 0.00 probability value was compared to 0.05 and found to be significant because 0.00<0.05. As a result, the null hypothesis of no significant difference in mean retention scores between the experimental and control groups was rejected, and it was concluded that the experimental group retained geometric construction content considerably better than the control group.

Table 3. ANCOVA of students' retention scores

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared	Decision
Corrected model	8,657.828[a]	8	1,082.229	513.115	.000	.934	
Intercept	256.277	1	256.277	121.508	.000	.295	
Post-test	2,894.977	1	2,894.977	1,372.589	.000	.825	
Group	4,142.355	1	4,142.355	1,964.006	.000	.871	Sig.
Location	6.171	1	6.171	2.926	.088	.010	NS
Group*location	7.241	1	7.241	7.426	.065	.012	NS
Error	613.759	291	2.109				
Total	120,710.000	300					
Corrected total	9,271.587	299					

Hypothesis 2: There Is No Significant Difference Between the Mean Retention Scores of Urban and Rural JS3 Students Taught Geometric Construction Utilizing the Interaction Patterns

Table 3 shows that the probability value of 0.088 was found for F=2.926 on mean retention scores of the experimental group's urban and rural learners. This associated probability value of 0.088 was compared to an alpha level of 0.05 that had already been determined. The value 0.088 was higher than the previously established level of significance of 0.05, (0.088>0.05). As a result, the null hypothesis of no significant difference between urban and rural students' mean retention scores was not rejected. This suggests that the difference between urban and rural students' mean retention scores in the GCRT was not statistically significant.

Hypothesis 3: There Is No Significant Interaction Effect of Group and Location on JS3 Students' Retention in Geometric Construction

Table 3 further reveals that there exist no interaction effect of group and location on JS3 students' retention in geometric construction (F=3.433; p>0.065). This associated probability value of 0.065 was compared to an alpha level of 0.05 that had already been determined. The value 0.065 was higher than the established level of significance of 0.05, (0.065>0.05). As a result, null hypothesis 3 was not rejected. Thus, the researchers conclude that group and school location have no significant interaction effect on JS3 learners' geometric construction retention.

DISCUSSION

Table 1 showed that learners who were taught geometric construction utilizing interaction patterns retained considerably more information than those who were taught using the explanatory method. The findings implicated instructional methods as a determinant in students' recall of mathematics in general and geometric construction in particular. The ANCOVA results in **Table 3** supported this, showing a significant difference in mean retention scores between the experimental and control groups, favoring the experimental group. This research backs up Omwirhiren's (2015) finding, that students who were taught using a student-centered technique recalled more information than those who were taught using a traditional lecture method. Azuka (2009) argued for the use of instructional strategies that encourage students' participation and activity in secondary school mathematics instruction to improve students' retention. This indicates that when the teaching and learning process is meaningful, such as using appropriate Interaction Patterns, students are more likely to remember what they have learned.

Results in **Table 2** indicated that students in the urban area retained the geometrical construction better than learners in the rural area with a slight difference. However, further analysis as shown in **Table 3**, revealed that there was no significant difference between urban and rural students' retention scores in the geometric construction taught. The reason for the no significant difference could be that students in the rural and urban areas enjoyed the concept taught using the classroom interaction pattern. This classroom interaction pattern could have motivated them to engage actively in the geometric construction taught which could have led to recall what was learnt. This finding supports the findings of Ajai et al. (2013) and Ntibi and Edoho (2017) who in their respective studies claimed that location is not a factor to influence students' mathematics achievement and retention. Consequently, the finding of this study contradicted the findings of Oyeromi et al. (2018) that revealed a significant difference in favor of rural students' achievement in mathematics. The finding also opposed the findings of Awodun and Oyeniyi (2018) and Sovia et al. (2019) who reported urban students' superiority over their rural counterparts in mathematics. These significant differences that existed could be that the learners were indifferent to the methodology applied during the conduct of the research.

Again, analysis of results in **Table 3** showed no significant interaction effect between group and location on students' JS3 retention in geometric construction. This implies that school location does not influence JS3 students' retention in geometric construction when exposed to the classroom interaction pattern applied in this study. The reason for the no significant difference could be that the classroom interaction pattern approach is not meant for a particular school location but user friendly and also taking cognizance of the fact that the mathematics teachers that applied the method shared the same attributes which may have

led to both urban and rural area students' retention in the mathematics concept taught. The finding of this study corroborates the finding of Konyefa and Okigbo (2021) who reported no significant interaction effect of instructional approach and school location on students' achievement in Chemistry. However, the study's finding disagrees with the findings of Ajai et al. (2013) and Ebhomien and Oriahi (2018) who found a significant interaction effect of instructional method and school location on students' achievement in mathematics. This disagreement could be that the instructional method applied in their research favored students at a particular school location more.

CONCLUSION

The researchers concluded because of the findings that the utilization of classroom interaction patterns significantly improved students' retention in geometric constructions as compared with the expository instructional approach and it was also concluded in the study that school location as a factor does not play a significant role on students' retention in geometric construction when exposed to classroom interaction approach.

Contribution to the Literature

1. This study makes a significant contribution to bettering mathematics education, since it is the first study to consider how interaction patterns affect secondary school students' retention in geometric construction in Anambra State.
2. This study clarifies for educational scholars how interaction patterns can help students remember geometric construction better, irrespective of their location in the mathematics classroom.
3. The study's findings revealed that utilizing interaction patterns in the mathematics classroom provide positive students' engagement with their pairs, mathematics teacher and the content.

Recommendations

The following recommendations are provided based on the findings of this study:

1. In secondary schools, classroom interaction patterns should be employed to teach geometric construction.
2. Teachers at secondary school mathematics should be trained in the use of interaction patterns in teaching and learning mathematics through extensive seminars, workshops, and in-service training.

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Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

Ajai, J. T., Imoko, B. I., & Okwu, E. I. (2013). Comparison of the learning effectiveness of problem based learning (PBL) and conventional method of teaching algebra. *Journal of Education and Practice, 4*(1), 132-138.

Altun, S. (2015). The effect of co-operative learning on students' achievement and views on the science and technology courses. *International Electronic Journal of Elementary Education, 7*(3), 451-468.

Awodun, A. O., & Oyeniyi, A. D. (2018). Influence of school location on students' academic achievement in junior secondary school basic science in Ekiti State, Nigeria. *Journal of Emerging Technologies and Innovative Research, 5*(6), 125-129.

Ayub, A. F. M., Yunus, A. S. M., Mahmud, R., Salim, N. R., & Sulaiman, T. (2017). Differences in students' mathematics engagement between gender and between rural and urban schools. *AIP Conference Proceedings, 1795*(January), 020025. https://doi.org/10.1063/1.4972169

Azuka, B. F. (2009). *Active learning in the mathematics classroom. Training manual for capacity building workshop for secondary and primary schools' mathematical science teachers*. National Mathematical Center.

Cobb, P. (2018). The relevance of improvement research to mathematics education. *Éducation et Didactique* [*Education and Didactics*], *12*(1), 129-132. https://doi.org/10.4000/educationdidactique.3123

Ebhomien, P. A., & Oriahi, C. I. (2018). Interaction effects of computer assisted instruction on secondary school students' academic achievement in mathematics. *FUO Quarterly Journal of Contemporary Research, 6*(3), 250-257.

Egara, F. O., Eseadi, C., & Nzeadibe, A. C. (2021). Effect of computer simulation on secondary school students' interest in algebra. *Education and Information Technologies, 27*, 5457-5469. https://doi.org/10.1007/s10639-021-10821-8

Egara, F. O., Nzeadibe, A. C., & Okeke, A. M. (2018). Effect of computer simulation on junior secondary school students' achievement in algebra. *African Journal of Science, Technology and Mathematics Education, 4*(1), 84-94.

Etukudo, U. E. (2011). Influence of teachers' gender on pupils' academic achievement in mathematics in primary schools. *ABACUS: Journal of the Mathematical Association of Nigeria, 36*(1), 165-173.

Evans, G. U. F., Ekpofia, C. A., & Thompson, M. E. (2019). The influence of primary school background on students' achievement in junior secondary school mathematics in Akwa. *Journal of Research & Method in Education, 9*(1), 1-7.

Ifamuyiwa, A., & Lawani, A. (2008). Interaction patterns in mathematics classrooms in Ogun State secondary schools. *Academic Leadership: The Online Journal, 6*(3), 11.

Ingram, J., Andrews, N., & Pitt, A. (2018). Revisiting the roles of interactional patterns in mathematics classroom interaction. In *Proceedings of CERME10* (pp. 1300-1307).

Inweregbuh, Onyemauche C. Ugwuanyi, C. C., Nzeadibe, C. C., Egara, F. O., & Emeji, I. E. (2020). Teachers' practices of creativity in mathematics classroom in basic education. *International Journal of Research Publications, 55*(1), 1-6. https://doi.org/10.47119/IJRP100551620201254

Katiambo, D., Mutsotso, S. N., & Wasike, D. W. (2019). Classroom interaction patterns and students' learning outcomes in secondary school mathematics in Kenya. *International Journal of Science and Research, 8*(9), 1405-1409.

Konyefa, B. I., & Okigbo, E. C. (2021). Effect of ethnochemistry instructional approach on secondary school students' achievement in chemistry in Bayelsa State. *International Journal of Education and Evaluation, 7*(5), 1-11.

Kumah, M. S., Region, V., Akpandja, T. K., Region, V., Djondo, B. I., & Region, V. (2016). Factors contributing to the poor performance in mathematics: A case study among students in colleges of education-Ghana. *Researchjournali's Journal of Mathematics, 3*(2), 1-12.

Markewitz, L. (2007). *Student-student interaction in an online continuing professional development course: Testing Anderson's equivalency theorem* [Master's dissertation, Athabasca University].

Miyazoe, T., & Anderson, T. (2010). Empirical research on learners' perceptions: Interaction equivalency theorem in blended learning. *European Journal of Open, Distance and E-learning, 1*, 1-9.

Modupe, O. C. (2021). Effects of interaction pattern on students' interest in keyboarding in colleges of education in South-West, Nigeria. *European Journal of Education and Pedagogy, 2*(1), 40-45. https://doi.org/10.24018/ejedu.2021.2.1.26

Nnorom, N. R., & Erhabor, P. O. (2019). Effect of classroom interaction patterns on secondary school students' cognitive achievement in biology. *International Journal for Cross-Disciplinary Subjects in Education, 10*(1), 3981-3985. https://doi.org/10.20533/ijcdse.2042.6364.2019.0484

Ntibi, J. E.-E., & Edoho, E. A. (2017). Influence of school location on students attitude towards mathematics and basic science. *British Journal of Education, 5*(10), 76-85.

Nzeadibe, A. C., Egara, F. O., Inweregbuh, C. O., & Osakwe, I. J. (2020). Effect of problem-solving and collaborative strategy on secondary school students' retention in geometry. *African Journal of Science, Technology and Mathematics Education, 5*(1), 9-20.

Nzeadibe, A. C., Egara, F. O., Inweregbuh, O. C., & Osakwe, I. J. (2019). Effect of two meta-cognitive strategies on students' achievement in mathematics. *Journal of CUDIMAC, 7*(1),43-57.

Ogbu, J. E. (2011). Effects of integrative application of interaction patterns on students' cognitive achievement in basic electricity. *Journal of Science Teachers Association of Nigeria, 46*(1),71-81.

Okeke, M. A., Aneshie-Otakpa, V. O., Orga, C., Egara, F. O., Ubebe, S. A., & Inweregbuh, O. C. (2022a). Effect of google classroom on secondary school students' engagement and achievement in mathematics. *African Journal of Science, Technology and Mathematics Education, 8*(1), 411-417.

Okeke, M. A., Obun, A. V., Oguguo, B. C. E., Emeji, I. E., Egara, F. O., Orga, C. A., Osakwe, J. I., Odo, I. O., Nzeadibe, A. C., Kwalat, S. K., Inweregbuh, C. O., Sunday, O. Agugoesi, O. J., Emmanuel, N., Olaniyi, O. N., Albert L. P., Abugu, G. N., Dangbong, C. B., Matawal, D., … Obenyem, B. I. (2022b). Effect of spaced learning on primary school pupils' interest and retention in mathematics. *Multicultural Education, 8*(3), 141-151. https://doi.org/10.5281/zenodo.6350547

Okpala, J. U. (2011). Improving the teaching and learning of primary mathematics through appropriate teaching styles. In *Proceedings of 2011 National Annual Conference* (pp. 160-167). Mathematical Association of Nigeria.

Olugbenga, O., & Ojo, O. E. (2017). Effects of cooperative, competitive, and individualistic classroom interaction patterns on students' academic performance in physics in Ogun State, Nigeria. *European Journal of Education Studies, 3*(10), 595-608. https://doi.org/10.5281/zenodo.1039349

Omwirhiren, E. M. (2015). Enhancing academic achievement and retention in senior secondary school chemistry through discussion and lecture methods: A case study pf some selected secondary schools in Gboko, Benue State, Nigeria. *Journal of Education and Practice, 6*(21), 155-161.

Osakwe, I. J. (2017). *Effects of interaction patterns on students' achievement and retention in geometric construction* [Unpublished master's thesis]. Enugu State University of Science and Technology.

Osakwe, I. J., Obodo, G. C., & Inweregbuh, O. C. (2019). Improving secondary school students' achievement in geometric construction using interaction pattern approach. *Journal of the Mathematical Association of Nigeria (Mathematics Education Series), 44*(1), 151-157.

Oyeromi, S. O., Omiyale, G. T., Lato, E. T., & Oyebamiji, W. T. (2018). Analysis of rural/urban students' academic performance in Oyo State, Nigeria: Implication for educational planners. *International Journal of Research and Innovation in Social Science, II*(VII), 73-81.

Post Primary School Services Commission. (2020). School enrolment statistics in Awka, education zone. *Awka Zonal Office*.

Setianingsih, R. (2018). Patterns of interactions at grade 5 classroom in learning the topic of statistics viewed from cognitive load theory patterns of interactions at grade 5 classroom in learning the topic of statistics viewed from cognitive load theory. *Journal of Physics: Conference Series, 953*, 012212. https://doi.org/10.1088/1742-6596/953/1/012212

Sovia, A., Herman, T., & Afgani, J. (2019). Differences in mathematical understanding concepts of urban, suburban, and rural students. *International Journal of Scientific and Technology Research, 8*(10), 3623-3628.

Tuliao, J. D. (2020). Instructional materials used in teaching mathematics: Basis for enhancing mathematics program. *International Journal of Psychosocial Rehabilitation, 24*, 7.