

ADVANCING RETENTION IN NUMERACY CONCEPTS WITH ICT-INTEGRATED LEARNING STRATEGIES AMONG LOWER PRIMARY SCHOOL PUPILS IN NIGERIA

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Abstract: The study investigated the effect of ICT-integrated Learner-Self-Controlled, Think-Pair-Share and Concrete-Representational-Abstract learning strategies on the retention of spatial reasoning of lower primary school pupils across ability levels and sex. Non-equivalent experimental research design was employed. A hundred and five (105) pupils in four intact classes were exposed to six weeks intervention and subsequently post-tested. Two retention tests were conducted at two weeks interval. Data collected were analyzed using Analysis of Covariance. The study found significant effect of treatment on the retention of study participants in the ICT-integrated Think-Pair-Share treatment group. No significant interactive effect of ability level was found on pupils' retention and, sex reflected no significant difference.

Introduction: Children's early graft of Mathematics ability is an important predictive factor to later mathematical achievement (Jordan, Kaplan, Ramineni & Locuniak, 2009; Krajewski & Schneider, 2009) and related endeavors in life. So the question of how to promote children's early mathematical know-how and its preservation is of critical importance. Established link exists between spatial ability and Mathematics – both children and adults with better spatial abilities also have higher math scores (Casey, Nuttall & Pezaris, 2001) even in early childhood (Alloway, 2007; Holmes, Adams & Hamilton, 2008). These discoveries incited the National Council of Teachers of Mathematics (NCTM, 2010) in the United State of America to support the development and inclusion of spatial reasoning as part of Mathematics learning in the first grade. Spatial reasoning, a cogent subtopic in numeracy and Mathematics connect on shared underlying processes with potent avenue for mathematical improvement. For instance, neuropsychological and brain imaging studies revealed that corresponding circuitry is being activated when people process both spatial and number tasks (Dehaena, Bossini & Giraux, 1993; Walsh, 2003; and Hubbard, Piazza, Pinel & Dehaene, 2005); there also exists behavioral evidence that numerical magnitudes are mentally represented in a spatial format (SNARC effect). These evidences of shared mental processing raises the possibility that math can be improved with spatial reasoning.

Children aged four to six (4 - 6) years have informal mathematical knowledge about arithmetic, geometry and measurement. This supposedly, should improve the learning of association and rule of number string (Mo, Wang & Chen, 2000); provide platforms for building further interactions and affect children's spatial ability and numerical reasoning. Instead, observation showed that some children could not identify space patterns. This was related to spatial reasoning problem noticed in test characteristics presented to Nigerian learners in local, national and international examinations. Studies revealed that,

spatial reasoning ranked the third of seven Mathematics test items in Senior Secondary School Examination (SSCE) in Nigeria for eight years consecutively (1990 - 1997). Similarly, the University Matriculation Examination (UME) Mathematicstest items (1993-1998) (Jegade, 1998; Jegede, Adelodun & Okoli, 1998). At the primary schools levels, a survey of one State Joint Examinations Mathematics test items conducted by the Osun State Universal Basic Education Board (SUBEB) for primaries three to six pupils within 2011 and 2013 substantiated that, geometry, trigonometry and spatial reasoning ranked significant in testing learners. These were interpreted to mean that children's understanding of space pattern is necessarily demanded by the curricular.

Researches however showed that, performances in spatial reasoning in Mathematics have been unswervingly poor. Most children and adults alike despise, at first site, anything that has to do with numbers, formula, calculations and symbols in Nigeria. The application of ICT in education has been eulogized as potentially powerful and enabling tools for educational change and reform. Used appropriately, ICTs have enhanced educational quality by helping teaching and learning into an engaging, active process connected to real life (Adeleke, 2010; Jo Shan Fu, 2013). In the National Policy on Education (FGN, 2004), the Nigerian government recommends that, preschoolers learn deductively through play while primary school aged pupils learn mainly through practical, exploratory and experimental interactive activities. Hitherto, this study adopts less structured approaches integrating ICT with three different learning strategies – Learners' Self-controlled wherein pupils explore, intrinsically motivate self, seek advice yet, feel autonomous in their learning activities (Bund & Wicemeyer, 2014); Concrete-Representational-Abstract (CRA), a three step learning approach involving engagement of learners in physical manipulation of real objects; representing the real objects by "see-able", semi-concrete images and

finally; utilizing “symbol” in form of numbers and signs to depict the images and concrete objects in solving spatial issues. The latter was the Think-Pair-Share, a cooperative learning strategy that allows time for thinking, time for sharing with a partner and time share among pairs to a larger group thus uniting the cognitive and social aspects of learning as well as promoting the development of thinking and construction of knowledge (Bamiro, 2015).

The following objectives will guide the study:

- a. investigate the comparative effectiveness of the three ICT-integrated learning strategies on the retention of primary school pupils in spatial reasoning;
- b. determine the relative effects of the strategies on retention capability of pupils with varied abilities and;
- c. examine the relative effects of the strategies on retention of boys and girls in the study groups.
- d. determine the difference in retention capability of pupils in two subsequent weeks.

The hypotheses below derive from the stated objectives:

H01. There is no significant interaction effect of the ICT-LSC, ICT-CRA and ICT-TPS treatment groups and ability levels on retention scores.

H02. There is no significant interaction effect of treatment and ability levels on the study retention of participants in spatial reasoning learning.

H03. There is no significant difference in the effectiveness of treatment of the ICT-LSC, ICT-CRA and ICT-TPS and sex on retention scores in spatial reasoning.

H04. There is no significant difference in retention capability of pupils on the basis of time in two subsequent weeks.

Methods: The study adopted the non-equivalent pre-test- post-test, control group experimental design with 3 x 2 x 2 factorial matrix. Ability level of learners was determined by secondary data; the 2011/2012 session’s promotion examination results of the pupils. Those aggregated 65% and above were classified as ‘high’ academic ability, 45-64% as ‘average’ and, pupils scoring 45% and below as ‘low’ academic ability. The average learners participated in the study as intact class members but were disfranchised in the results analysis to maintain two groups of ability levels. Study population consisted of 357,533 pupils’ enrolled in 1, 378 primary schools in Osun State. Sample was eked out using multi-stage and purposive sampling techniques. Primary III class pupils were purposively selected for the study based on the learners’ age (6 – 8 years) consideration for the research scope in early childhood development and

education. Added to age, the entry behavior or experience of learners’, psychomotor dexterity, ability to coordinate, interpret instructions and manipulate computer machine, and previous exposure to computer in teaching-learning situations were considered. An intact classroom from four schools with 105 pupils were sampled in the three major towns of the State where necessary facilities for the research were readily available, the schools’ management wills to accommodate the research and, pupils pass the Spatial Reasoning Entry Test in tandem with homogeneity requirement. One of the instruments for this study included Spatial Reasoning for Children (SpatReC), an interactive, multimedia package designed using C-Sharp (C#) programming language and line with taxonomy based on Benjamin Blooms’ (1956) principles as revised by Anderson and Krathwohl (2001) in Wilson (2013). Another instrument was the Spatial Reasoning Test (SRT) used for pre, post and two retention tests. SRT items were carefully drawn in line with a table of specification. SpatReC package and SRT were scrutinized for content validity. The instruments were also test-run in pilot reliability tests with Cronbach alpha value of 0.876; correlation values at $r = 0.782$ which Berg (1995) asserted high enough to justify the reliability of instruments. The first objective was analyzed using ANCOVA, the second and the third as well.

Results: Tests for significant interaction effect of treatment groups, ability levels and sex on two retention tests were conducted. The result showed that there occurs no significant difference on the basis of experimental group on retention initially - Table 1.

Table 1: Test of Difference in Retention 1 Score of Groups

Retention score		
Tukey HSD		
Treatment	N	Subset for alpha = 0.05
		1
ICT-CRA	26	16.27
ICT-LSC	26	16.62
ICT-TPS	31	16.68
CTRL	22	18.09
Sig.		.186

Further investigations were made to detect if any difference might be as a result of ability grouping and or sex. The study found F-value obtained in the test was 0.336 at the significance level of 0.799 - Table 2.

Table 2: Test of Difference in Retention 1 Scores between Ability groups and Sex

Tests of Between-Subjects Effects						
Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Sex * Ability	Treatment	1.290	3	.430	.336	.799
	retention test1 score	25.540	3	8.513	.798	.498
Corrected Total	Treatment	130.514	104			
	retention test1 score	1102.857	104			

a. R Squared = .010 (Adjusted R Squared = -.020) b. R Squared = .023 (Adjusted R Squared = -.006)

Since the significance is higher than 0.05, the null hypothesis cannot be rejected. It can therefore be concluded that, there is no significant difference in the initial retention scores of participants after controlling for the effect of their previous knowledge on the basis of ability and sex groupings.

The study proceeds to observe the second retention test scores on the same yardsticks. The retention test 2 was conducted six (6) weeks after the posttest and four (4) weeks following the retention test 1. The

result differ in the retention 2 scores of the research participants on the basis of their experimental groupings. It can be seen from Table 3 that, F-value obtained in the test was 3.101 at the significance level of 0.030. Since the significance is less than 0.05, the null hypothesis hereby cannot be accepted. It can therefore be concluded that there is a significant difference in the retention 2 of the participants after controlling for the effect of their previous knowledge.

Table 3: Test of Treatment Group Differences in Retention 2

Tests of Between-Subjects Effects Dependent Variable: retention test 2						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	
Corrected Model	95.835 ^a	3	31.945	3.101	.030	
Intercept	44432.381	1	44432.381	4313.357	.000	
GRP	95.835	3	31.945	3.101	.030	
Error	1040.412	101	10.301			
Total	46730.000	105				
Corrected Total	1136.248	104				

a. R Squared = .084 (Adjusted R Squared = .057)

The source of the identified difference was further explored via a multiple comparison post hoc test; the result seen from the table that only participants in the ICT-TPS group were significantly different from those in control group (Mean difference = 2.688, $p < .05$) in their retention 2. Although participants in

other experimental groups also performed better than those in the control group (LSC - mean difference = 1.399, $p > .05$; CRA - mean difference = 1.168, $p > .05$), the difference produced were not significant as they were greater than 0.05 - Table 4.

Table 4: Multiple Comparisons of Treatment Differences in Retention

Multiple Comparisons - Dependent Variable: retention test score						
Tukey HSD						
(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
TPS	LSC	1.289	.854	.435	-.94	3.52
	CRA	1.520	.854	.289	-.71	3.75
	CTRL	2.688*	.895	.017	.35	5.02
LSC	TPS	-1.289	.854	.435	-3.52	.94
	CRA	.231	.890	.994	-2.09	2.56
	CTRL	1.399	.930	.439	-1.03	3.83
CRA	TPS	-1.520	.854	.289	-3.75	.71
	LSC	-.231	.890	.994	-2.56	2.09
	CTRL	1.168	.930	.593	-1.26	3.60
CTRL	TPS	-2.688*	.895	.017	-5.02	-.35
	LSC	-1.399	.930	.439	-3.83	1.03
	CRA	-1.168	.930	.593	-3.60	1.26

*. The mean difference is significant at the 0.05 level.

It is necessary however to mention that, the discovery of significant differences in retention 2 as against retention 1 is not mere chance. It implies that, test as a learning event, can enhance subsequent recall more than additional study opportunities. However, only at

long retention intervals – six weeks away from initial learning and, four weeks away from revision – and/or when criterion tests stress recall rather than recognition processes that the learner attained retention of taught or learned concepts.

Table 5: Multiple Comparisons of Differences in Retention Scores

Multiple Comparisons							
Tukey HSD							
Dependent Variable	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
retention	TPS	LSC	1.289	.854	.435	-.94	3.52
		CRA	1.520	.854	.289	-.71	3.75
		CTRL	2.688*	.895	.017	.35	5.02
	LSC	TPS	-1.289	.854	.435	-3.52	.94
		CRA	.231	.890	.994	-2.09	2.56
		CTRL	1.399	.930	.439	-1.03	3.83
	CRA	TPS	-1.520	.854	.289	-3.75	.71
		LSC	-.231	.890	.994	-2.56	2.09
		CTRL	1.168	.930	.593	-1.26	3.60
	CTRL	TPS	-2.688*	.895	.017	-5.02	-.35
		LSC	-1.399	.930	.439	-3.83	1.03
		CRA	-1.168	.930	.593	-3.60	1.26

*. The mean difference is significant at the 0.05 level.

Table 5 showed the multiple comparisons of differences in retention scores by group to prove and pinpoints the nuclei wherein the difference resides. While table 5 has given direction toward conclusive statements on the hypothesis under consideration, it is logical to allow statistical decision rule to have the final say. In the retention 1, the F-value obtained was 3.101 at the significance level of 0.030 which is less than 0.05. Since the significance is less than 0.05 in retention test 2, the null hypothesis must be rejected. It can therefore be concluded that, there is a significant difference in the retention scores 2 of the

participants after controlling for the effect of their previous knowledge. Table 6 depicts result of test of difference in the retention scores of the research participants on the basis of the interaction between the experimental groupings and their ability levels. It can be seen from the table that there is no significant interaction effect of experimental groupings and their ability levels on the retention scores even after controlling for the previous learning through the pre-test ($F_{(7,97)} = 1.971, p > .05$). Therefore, the null hypothesis cannot be rejected.

Table 6: Test of Interaction Effect of Treatment and Ability on Retention

Tests of Between-Subjects Effects					
Dependent Variable: retention test score					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	141.472 ^a	7	20.210	1.971	.067
Intercept	36391.467	1	36391.467	3548.513	.000
GRP * Ability	141.472	7	20.210	1.971	.067
Error	994.775	97	10.255		
Total	46730.000	105			
Corrected Total	1136.248	104			

a. R Squared = .125 (Adjusted R Squared = .061)

Highlighting significant difference in the effectiveness of the group and sex on retention scores in spatial reasoning, the retention scores of the research participants were subjected to a test of

difference via ANCOVA using their experimental groupings as the differentiating variable, the pre-test scores as the covariate and sex as the interacting variable. The result presented in Table 7 below:

Table 7: Test of Interaction Effect of Treatment and Sex on Retention

Tests of Between-Subjects Effects					
Dependent Variable: retention 2					
Source	Type III Sum of Squares	df	Mean Square	f	Sig.
Corrected Model	116.974 ^a	7	16.711	1.590	.147
Intercept	41960.376	1	41960.376	3993.193	.000
GRP * sex	116.974	7	16.711	1.590	.147
Error	1019.274	97	10.508		
Total	46730.000	105			
Corrected Total	1136.248	104			

a. R Squared = .103 (Adjusted R Squared = .038)

The table revealed no significant interaction effect of experimental groupings and their sex on the retention scores ($F_{(7,97)} = 1.590$, $p > .05$). The results therefore affirm that, the null hypothesis cannot be rejected.

Discussion: The study applied information and communication technology unto three learning strategies with a view to improve retention of spatial concepts in males and females pupils with low or high ability at the primary school level in Osun State, Nigeria. The notable results include significant effect of treatment on retention scores of study participant. Participants in the ICT-TPS treatment group proved highest retention significantly different from the control group though; participants in other experimental groups also did better but not significantly (> 0.05). This finding contrasted Jordan, Jalali, Clarke, Dyne, Spector & Coates (2013) work which found retention rates to be similar between instructional methods. It is however consistent with Sankey, Birch & Gardiner (2010) whose study participants applauded the various learning resources as assistive in retention. This study confirmed and reinforced that, when audio is used in conjunction with other resources, such as images or text, that the advantage is most prominent regardless of the innate ability of learners.

Furthermore, the study applied new measure probing unto test of difference in retention probability on the basis of sex which reflected no significant difference. The finding is in tandem with Wehrwein, Lujan & Di-Carlo (2007) study for gender difference in learning

quality of physiology undergraduate students. The male and female students have significantly different preference as males tend to be more achievement oriented, whereas females are more socially and performance oriented; males tend to be more externally focused, but females tend to be more introspective and self-critical.

This study also found that there is no significant interaction effect of ability level on retention scores. Selected collaborative testing literature in the work of Zipp (2007) agreed that there might be no significant difference in the amount of improvement experienced by "upper," "middle," or "lower" achieving students as categorized by their first-stage midterm score. Meanwhile, Gilley and Clarkston (2014) saw significant differences in group works compared to individual learners' performances and retention. They concluded that, when students were tested in groups, they showed significantly greater improvement on subsequent individual testing than when tested only as individuals.

Conclusively, if Merriam-Webster definition of retention as ability to retain things in mind; preservation of the after effect of experience and learning that makes recall or recognition possible is relevant; and if the codification by Noel-Levitz (2008) on retention that, the ultimate goal of retention effort is improved experience for students rather than retention per se holds; then short time retention should not be judgmentally applied but that which allows relatively long period of time to prove learning effects.

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