Enhancing Retention and Performance in Numeracy Concepts through Meta-cognitive Training in Computer-mediated Classrooms

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Abstract:
This study determined the effects of meta-cognitive training on pupils' retention of learned numeracy concepts in computer-mediated classrooms. Pretest-posttest control group experimental design was adopted. The population comprised primary school pupils in Osun State while the sample comprised 39 primary three pupils from two schools in two educational zones of the State. Purposive sampling method was used based on availability of computer facilities in the selected schools. This research made use of three instruments which are: Pupils' Achievement Test on Numeracy (PATON,) Computer Numeracy Instructional Package for Primary School Children (CNIP^{2}SC) and One treatment instrument which is Meta-cognitive Training Manual (MCTM). Data obtained were analyzed using Analysis of Covariance (ANCOVA). Results indicated that meta-cognitive training enhances pupils' performance in numeracy in a computer-mediated classroom ($F = 1.20$; $p<0.05$). Furthermore, meta-cognitive training also enhances retention of learned numeracy concepts of the learners ($F = 6.64$; $p<0.05$). In addition, sex, which was used as a moderating variable, did not have a significant effect on the performance of pupils. ($F = 2.16$; $p>0.05$).The study concluded that meta-cognitive training did enhance performance and retention of the pupils in computer-mediated classroom. It, therefore, recommended that teachers should be encouraged to use meta-cognitive training as a strategy in teaching numeracy.

Keywords: Meta-cognitive training, numeracy concepts, retention, computer-mediated classroom

Introduction

Nigeria National Policy of Education (NPE 2004) defines primary education as the education that is given to children from ages six to twelve years, because secondary and higher school levels are built upon primary level education which is the key to education (Federal Republic of Nigeria. (FRN, 2004). Mathematics and computing are part of the core subjects in the Nigerian educational system in which numeracy is integrated.

The National Numeracy Benchmarks Taskforce (1997) defines numeracy as the way by which mathematics is being used to meet various needs in all ramifications. State and Territory curriculum documents also support this definition and expanded it to further mean the ability to think very well and communicate. (Queensland Department of Education, 1994, cited in AAMT/DEETYA, 1997).

The world is going digital by the day and numeracy skill is needed in dealing with daily activities. Even when the computer is used to perform some functions like calculating, the knowledge of numeracy skill is still needed in operating the system. Moreover, part f the components of Mathematics is being detailed in providing an answer to a problem. The answers are normally the same but the step by step by which the answer is arrived at might not be the same. Thus, arriving at the correct answer is the foundation which holds numeracy. Kravitz (2013) stated that Mathematics is a skill that is required of everyone in dealing with daily activities and prevents one from being cheated.

According to Onah, (2003), however, achievement in Mathematics when compared with other science and technological subjects has been a source of concern to some researchers. Meanwhile, in recent times, students' mathematics achievement at all levels in Nigeria has not been encouraging (Onyekuru, 2015).To arrest this situation, the use of computer has been introduced into the classrooms Fengfeng (2008) believes that the use of computers may have positive effect on the

achievement in Mathematic at 4th and 5th grades in the primary schools. (Gbenga-Akanmu & Jegede, 2015) postulated in their study that the introduction of computer in teaching is expected to benefit all groups of learners.

Meanwhile, studies have associated poor performance of pupils to bad foundation and not using the appropriate strategy in teaching certain subjects, particularly Mathematics. Studies have shown that meta-cognitive training had come to the rescue in other subjects. Today's classrooms are becoming computer-driven which makes it therefore necessary to determine whether meta-cognitive training as an intervention will impact better students' numeracy performance and retention of learned numeracy concepts. Ojimba, (2012) opined that the use of appropriate strategy of constructivism should be imbibed in teaching mathematics, which gives room for students to learn and sustain their learning. In addition, the use of computer-aided instruction is a strategy that can be used to improve performance of students in mathematics.

This study is hinged on Flavell's Metacognition Theory (1971). He was encouraged by the work of Jean Piaget. The theory had found its way into the conventional wisdom of metacognition of intentionality. This has to do with thinking that is intentional with a set goal and involves performing an action in step wise manner. The Flavell's meta-cognitive theory is relevant and applicable to this study within the context of meta-cognitive training that was given to the participants in the experimental group because it involves thinking that is intentionally carried out without unhurried activities by the pupils. The pupils were taught how to think properly before solving numeracy questions, plan their work, and look for different strategies for solving numeracy problems. In addition, they were able to monitor and take charge of their learning themselves as stressed in Flavell's theory. The participants were given some practical tasks to carry out which made them to think, identify situations in which intentional and certain information that was needful for solving the problem was being applied, as stressed by Flavel. The participants were able to retrieve information on a particular method that was being used to carry out the tasks that was being given to them, which is also part of what Flavell meta-cognitive theory talks about. Recalling is very important in numeracy and the participants were able to exhibit this very well during the study.

According to De Corte, Verschaffel & Op´tEynde (2000), self-regulation constitutes a feature of effective learning and problem-solving. This skill is aimed at using meta-cognitive knowledge strategically to achieve cognitive goals. The ability to be in charge of one's learning plays a main role in the learning process. Self-regulatory behaviors in Mathematics include identifying how to solve a particular problem with a good knowledge of the particular step to use and apply where necessary to achieve a desired goal. In the past years, this skill has been noticed to be one of the most pertinent predictors of fulfilling difficult learning tasks (Van der Stel & Veenman, 2010). The following objectives guided this study to:

a. Determine the effects of meta-cognitive training on pupils' performance in numeracy in a computer-mediated classroom;
b. Examine the effects of meta-cognitive training on retention of learned numeracy concepts in a computer-mediated classroom;
c. Investigate the moderating effects of sex on the outcome of meta-cognitive training of the learners.

Research Hypotheses:

$H0_1$ There is no significant effect of meta-cognitive training on pupils' performance in numeracy in a computer-mediated classroom;

$H0_2$ There is no significant effect of meta-cognitive training on retention of learned numeracy concepts in a computer-mediated classroom;

$H0_3$ There is no significant effect of sex on the outcome of meta-cognitive training in the performance of the learners in numeracy.

Method

The pretest-posttest control group experimental design was adopted. The population of this study comprised primary school pupils in Osun State while the sample comprised 39 primary three pupils from two schools in two educational zones of a State from six educational zones by using multistage sampling techniques. Purposive sampling method was used based on availability of computer facilities in the selected schools. An intact class of primary three was used for this study which was randomly selected from the arms of primary three in the schools. One of the schools was assigned to experimental group while the second school serves as the control group. This research made use of three instruments which are: Pupils' Achievement Test on Numeracy (PATON,) Computer Numeracy Instructional Package for Primary School Children (CNIP^{2}SC) and one treatment instrument which is Meta-cognitive Training Manual (MCTM), Pupils' Achievement Test on Numeracy (PATON).

The research design is represented schematically as follows:

Y	X	Y	Y	Experimental Group
Y^1	- ^{1}	Y^2	Y^3	Control Group
4		5	6	

Y_1 = pretest administered to experimental group;
X_1 = meta-cognitive training given to experimental group;
Y_2 = post-test administered to experimental group;
Y_3 = retention-test administered to experimental group;
Y_4 = pre-test administered to control group;
Y_5 = post-test administered to control group;
Y_6 = retention-test administered to control group.

The research instruments used for this study were validated by experts in Early Childhood and Educational Technology. Some necessary corrections and adjustments were made to the instruments to establish the content validity which was pilot tested (Rossiter, 2011). To ascertain the reliability of the instruments, a pilot study was carried out on pupils outside the study area for the appropriateness of all the instruments. The study adopted the test-retest method. This method had been used for calculating the reliability of instruments by earlier researchers among which was Bolarinwa (2015). The results correlation ratio using Pearson's Correlation formula was 0.82 for PATON which justifies the positive reliability of the instrument.

The CNIP^{2}SC was given to expert in Educational Technology who checked the package and made some minor corrections before the use of the package. Such as the inclusion drills and practice, then the package to respond in low voice "WRONG" if a wrong answer is given and gives another opportunity to repeat the same question. In addition, the package was field-tested on a group of primary III outside the study area. Some questions had wrong answers and this was corrected before using it on the real group for the experiment.

The Meta-cognitive Training Manual was also subjected to face and contents validity by experts in the field of Early Childhood. Also, addition, the MCTM was field tested on a group of primary III outside the study area by the researcher and the research assistant in attendance. Some necessary corrections which include reducing the specific objectives and giving an explicit explanation on how to achieve the stated objectives were made before using it on the real group for the experiment

PATON was used by the researcher for the pre-test with all the participating pupils (control and experimental). The researcher conducted the meta-cognitive training with the experimental group for a period of 3 weeks by using the (MCTM). The training was based on how the participants could follow a step by step wise method in solving numeracy problems.

The researcher taught numeracy concepts with all the participants both at the experimental and the control group using (CNIP^{2}SC) for six weeks in a computer environment after which the researcher conducted a post-test on all the participants at the end of the sixth week using the PATON.

At exactly two weeks, the researcher conducted a retention test on the two groups. The data obtained were analyzed using descriptive and inferential statistics of Analysis of Covariance (ANCOVA) statistical technique.

Results

1. There is no significant effect of meta-cognitive training on pupils' performance in numeracy in a computer-mediated classroom.

Table 1a: Estimated adjusted means

Group	Mean	Std. Error	Confidence Interval	
Control	7.61	2.39	6.37	10.87
Experimental	11.98	2.01	9.13	14.03

Table 1a shows the means of the two groups with the experimental group having higher mean value. Furthermore, analysis is carried out to determine whether the difference in means is significant or not and the result is presented in Table 1b.

Table 1b: Effect of meta-cognitive training on pupils' performance in numeracy in a computer-mediated classroom

Source	Partial SS	Df	MS	F	p-value	Partial eta2
Model	631.0423	15	62.0695	2.82	0.0124*	
Group	212.9333	1	21.9333	1.20	0.0166*	0.18
Residual	343.3167	23	14.9268			
Total	974.3590	38	25.6410			

Field survey, 2017

Table 1b shows that the difference between the mean scores of the groups' performance is significant with $F = 1.20$; $p<0.05$. Hence, there exist a significant difference between the performance of the control group and the experimental group.

1. There is no significant difference of meta-cognitive training on retention of learned numeracy concepts in a computer-mediated classroom.

Table 2a: Estimated adjusted means

Group	Mean	Std. Error	Confidence Interval	
Control	7.73	2.37	6.31	10.78
Experimental	12.61	2.23	9.17	14.31

Table 2a showed the means of the two groups with the experimental group having higher mean value. Further analysis was carried out to determine whether the difference in means is significant or not and the result is presented in Table 2b.

Table 2b: Effect of intervention (meta-cognitive training) on pupils' retention

Source	Partial SS	Df	MS	F	p-value	Partial eta2
Model	595.3136	29	20.5281	8.98	0.0008*	
Group	15.1885	1	15.1885	6.64	0.0298*	0.24
Residual	20.5839	9	2.2871			
Total	615.8974	38	16.2078			

Table 2b indicates that there is a significant difference in the retention scores of the two groups with $F = 6.64$; $p<0.05$. By implication, there exists a significant difference between the retention of the learned concepts of control and experimental groups.

3. There is no significant effect of sex on the outcome of meta-cognitive training in the performance of the learners in numeracy.

Table 3: Moderating effect of sex on the outcome of meta-cognitive training of learners

Source	Partial SS	Df	MS	F	p-value	Partial eta2
Model	582.6707	30	19.4224	4.68	0.0141*	
Group	12.6838	1	12.6838	2.16	0.0269*	0.15
Sex	0.9320	1	0.9320	0.22	0.6484	
Pre-test score	158.7750	14	11.3411	2.73	0.0783	
Post-test score	211.3063	14	15.0933	3.63	0.0362*	
Residual	33.2267	8	4.1533			
Total	615.8974	38	16.2078			

Field survey, 2017

Table 3 shows that sex did not significantly (F = 2.16; p>0.05) affect how the meta-cognitive training predicted pupils' performance.

Discussion

For hypothesis one, the finding of this study from Table 1 revealed that there was a significant effect of meta-cognitive training on the pupils' performance. This finding goes along with the findings of Dignath and Buttner (2008). The training emphasized meta-cognitive strategies which had a positive outcome on the pupils' performance. Yunusa (2010) who investigated the outcome of this same strategy on instruction on mathematics achievement in low-achieving students found that it enhanced performance in mathematics. The result further showed that it was the group that had the meta-cognitive training that performed better than the control group. Even though Yunusa's study was done in Nigeria, the participants were secondary school students while the current study used primary school pupils. It shows that the intervention works for both secondary and primary school pupils when been exposed to meta-cognitive training. In addition, the result of this study lend support to Krasmarski & Mevarech (2003) study who reported a positive effects of this same strategy on students' mathematical reasoning and in different computerized environments and that meta-cognitive is teachable. This study suggests that meta-cognitive training can counter the negative or stressful perceptions in mathematical performance and that pupils with numeracy problems can benefit from meta-cognitive intervention.

However, the findings of Legg, Angela and Marie, (2009) negated the result of the current study that meta-cognitive necessarily will affect performance in numeracy. This is likely to be because *Legg et. al.* (2009) work with college students and their research was on Math Anxiety which was effective.

Furthermore, the result for hypothesis two revealed that the intervention had a significant effect on retention of the pupils on learned numeracy concepts. This finding lends supports to Bonnie (2013), Metacognition and its Effect on Learning High School Calculus that showed that training of meta-cognitive enhances learning and retention of learners. It is also in agreement with the study of Spellman, Mulder, & Carsten-Conner (2016)who worked on this intervention in the ecology classroom: In addition to this, Zare & Mohammadi, (2011) research on dealing with mathematical problems in students observed that this processing can positively help with dealing with problem and transfer of learning which help in increasing the level of retention of the students. This finding is in contrast to the finding of Donna (2006) who found out that the strategy did not improve the retention of students.

The result for hypothesis three showed that sex did not significantly affect how meta-cognitive training predicted pupils' performance. This result concurs with the findings of Spencer (2004), *Gbenga*-Akanmu & Jegede (2015), Siti &Corebima (2014) whose studies revealed that sex does not have any effect on the retention of

learners.

Based on the findings of this research work, it was concluded that meta-cognitive training as an intervention among primary school pupils in a computer-mediated classroom enhanced their performance and retention in numeracy and that there was no moderating effect of sex on how meta-cognitive training predicted pupils' performance.

The study therefore recommend that teachers should be encouraged to use meta-cognitive training as a strategy in teaching numeracy.

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