CONTRIBUTION OF COGNITIVE LEARNING STRATEGY COMPONENTS TO STUDENTS' ACADEMIC ACHIEVEMENT IN MATHEMATICS

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Abstract
This study aimed to investigate the usage of cognitive learning strategy components (in-depth study, pre-expository effort, wide-range of study, rehearsal and organization) by secondary school students as well as their contribution to academic achievement of students in Mathematics. To carry out the study, two (02) research questions were raised and hypothesized. A correlation research design was adopted and all senior secondary school (SS 2) students in Benin City made up the population and a sample size of 140 students was used. Simple random sampling technique was employed. A questionnaire titled Mathematics Cognitive Learning Strategies Scale (MCLSS) with reliability co-efficients of .78, .82, .80, .52 and .59 for in-depth study, pre-expository effort, wide-range of study, rehearsal and organization respectively and .89 for the entire scale was used for data collection. Mathematics scores of students for the 2018/2019 third term results were standardized using Z and T scores to allow for comparison. The data obtained from the questionnaire and the Mathematics standardized scores were analyzed. Hypothesis 1 was tested using one sample t-Test while hypothesis 2 was tested using linear regression. Findings show that students significantly make use of the five (05) Cognitive strategy components to enhance their Mathematics learning and that cognitive learning strategy components together contributed significantly to enhance academic achievement of students in Mathematics. However, rehearsal learning strategy contributed most to achievement in Mathematics. Based on the findings, it was recommended among others that Students should be encouraged to engage the use of rehearsal learning strategy to enhance their Mathematics learning as rehearsal strategy reduces Mathematics anxiety.

Key Words; Mathematics Learning, Performance of Students in Mathematics, Cognitive Learning Strategy Components and Rehearsals

Introduction

Mathematics being an important subject that plays significant role in the technological advancement of any nation has to be effectively learnt by students to bring about effective acquisition of Mathematical knowledge and skills. This is for better understanding of Mathematics concepts and improvement in Mathematics achievement. The improvement in learning and achievement are the basic agendum of every education system. Therefore, effective Mathematics learning should be considered a continuous process until there is evidence of improvement in interest and performance of the learners in the subject, particularly at the secondary school level. Academic performance of students at all levels of schooling is influenced by effective learning of students. It is a known fact that students vary considerably in how they learn. Learning depends on many personal factors. More so, every student has a distinct learning style. Learning styles of students at every level of educational attainment are apparently based on how students receive and process information differently. The essence of education is to shape students' attitudes and orientation towards learning. Most importantly, education helps to shape students by instilling positive attitudes toward learning, developing a desire for knowledge and developing effective learning skills in them (Kopsovich, 2001).

To Magno (2009), the main strategies of learning should not depend only on the information, understanding and memorization of concepts in Mathematics to have better achievement, rather, acquiring knowledge of or skill in by studying effectively to gain (a habit, mannerism) by experience and exposure to examples. Therefore, it is of paramount importance for learners to regulate themselves in order to critically determine the process to reflect on and strategies that should be engaged in a cognitive task. The cognitive task according to Magno (2009), are learning strategies that involve memorization, problem solving approach, directing one's attention to the stimulus, and answering of tests. Magno (2009) stated that *learners who are academically self-regulated are independent in their studies, diligent in listening inside the classroom, get high scores in tests, able to recall teacher's instruction and facts lectured in class, and submit quality work* (p. 56).

Clark and Chopeta (2004) posit that there is wide range of subjects taught and learned all over the world. However, the knowledge that people acquire from learning could be facts, concepts, processes, procedures, and principles. Learning of Mathematics among the categories identified involves the categories of concepts understanding, adequately following the procedures, and ensuring that the principles are abided by (Liu & Lin, 2010). Mathematics is an important subject which needs to be effectively studied. In order to acquire good knowledge and get good grades in the subject, students are to ensure they find more ways to improve on their acquisition of Mathematics skills. Therefore, to be acquainted

with appropriate Mathematics learning skills, students are to effectively improve on their learning strategies used in studying the subject. Schunk; O'Neil and Drillings; Pajares and Kranzler in Liu and Lin (2010) stated that *there are numerous factors which may affect students' learning performance such as teachers' instructional methods, learning environment, students' learning strategies, and motivation* (p. 221). Again, they stressed that "*among all, the level of students' motivation and learning strategies employed by them play crucial roles in their effective learning"* (p. 221).

Thompson and Mascazine (1997) *stated that students' learning is influenced by their learning styles defined as: the preference, tendencies, and strategies that an individual exhibits while learning.* They further stressed that students who accept responsibility for their own learning, discover, understand and also apply strategies to complement their dominant learning styles. They also create, think and reflect about Mathematics concepts as well as engage in multiple instructional and learning strategies to maximize their learning. Such students are more likely to become more efficient in learning Mathematics and making sense of new information. Thus, for effective study to take place, students have their role to play by strategizing different plans of action in order to bring about change in the rate of understanding. Markham (2004) therefore defined *learning strategies as adopting a plan of action in the acquisition of knowledge, skills or attitude* (p. 5).

Learning strategies have been mainly viewed under cognitive learning strategies and meta-cognitive learning strategies (Osarumwense, 2015). Cognitive learning strategies are learning strategies that play vital roles in students' effective learning. Shodhganga (2007) studied the impact of cognitive learning styles of students on intelligence and found no significant difference between them. Stoffa, Kush and Heo (2010) found that there is a high relationship between cognitive learning strategies used by students and their academic performance. Specifically, they stated that cognitive learning strategies play major role in higher academic performance of students than meta-cognitive learning strategies. Osarumwense (2015) also found that cognitive strategies contribute more to achievement followed by meta-cognitive and finally learning resources management strategies. Thus, cognitive learning strategies are needed by students for processing information.

Sharma (nd) described learning for problem solving as a higher order learning process that requires the use of cognitive abilities such as thinking, reasoning, observation, imagination, generalization among others. According to him, this tool is very useful to overcome difficult problems encountered by people. Markham (2004) noted that *cognitive strategy is adopting a plan of action in the process of organizing and processing information* (p. 5). The three key components of cognitive strategies according to Pintrich, in Artino (2006) are

rehearsal, elaboration and organization. However, Schmeck and Ribich (1978) classified it into four components: Imagery, organization, depth of processing and rehearsal. Osarumwense (2015) classified it into 5 factors: Rehearsal, in-depth coverage of content of instruction, wide-range of coverage of instruction, pre- expository effort of learners and organization.

Rehearsal strategy is a key factor of learning that aids retention. It involves reciting, naming or practicing the learning material over and over. Jill (2013) noted that skill acquisition during learning activities is enhanced by Incremental rehearsal. Fredrick, Miroslav and Gaelle (2013) noted that Mathematics anxiety has negative impact on students' performance in simple Arithmetic tasks and however noted that anxiety is a key factor for reducing Mathematics achievement. According to them, when students study Mathematics over and over, they tend to cope with internal and external resources in order to create cognitive system that is capable of augmenting and transforming working memory capacity of the individual to eliminate the resource drain that may be caused by Mathematics anxiety. Ashcraft and Krause, (2007) noted that Mathematics anxiety consumes working memory resources by using it to maintain and retrieve negative performance-related thoughts and memories which on the long run impair the performance of the students. Students that are Mathematics anxious use limited cognitive resources when working on a Mathematics problem because part of the cognitive resources has been used up by tension which eventually leads to poor academic achievement of the students in numeracy (Frederic, Miroslav & Gaelle, 2013). Therefore, the engagement of students in rehearsal strategy of learning can greatly be used to fight Mathematics anxiety.

Rehearsal according to Schmeck and Ribich (1978) is of two forms: Type I and Type II rehearsals. The Type I rehearsal is also known as simple repetitive strategy. This type improves retention in a limited manner which could be regarded as surface approach of learning. Type II rehearsal on the other hand, is an in-depth approach of learning and therefore could be classified as a more elaborative strategy of learning in which learning is less repetitive and produces a considerable increase in retention. Kesici and Endogan (2009) however found in their study that rehearsal strategy in general is not the most effective strategy for learning more complex cognitive processes. Pintrich (2004) as well as Kesici and Erdogan (2009) indicated that individual should not use a surface approach (Type I rehearsal strategies) to learn and gain Mathematics abilities. An in-depth approach of studying is likely to give a better result than a surface approach. Thus, Brabeck and Jeffrey (2014) noted that, it does not matter what subject you teach, but the differences in students' performance are affected by how much they practice. To Brabeck and Jeffrey (2014), for students to effectively practice, they need to pay serious attention to their studies. To do that, they need to engage in Type II rehearsal in order to acquire new knowledge or skills that can later be

developed into more complex knowledge and skills. They went further to assert that deliberate practice makes expert of people while surface practice (Type I rehearsal) such as work, play and rote repetition that is simply repeating a task will not automatically improve performance but on the long run makes novice of people.

Pre-expository Effort: Steedly, Dragoo, Arafeh, and Luke (2008) believe that learning *is a very personal experience* (p. 6). Therefore, an individual can strategize different ways in which he/she can effectively study. Pre-expository effort talks about curiosity of getting familiar with the learning task before an individual is presented with the learning task by the teacher. Herrick (2014) noted that children should read and do some problems in their textbooks ahead of the class and that they will find the learning material easy as at the time the class will catch up with the student. Herrick (2014) further emphasized that if the learner does not have a textbook, the learner should be curious enough to go on-line for lessons he/she thinks will be coming up and study ahead of the class, summarize the knowledge gained and lay more emphasis on the most important aspects. When a student studies ahead, he/she will have a better knowledge on that topic and have access to additional information**.** More so, the teacher will be impressed if the learner can positively contribute to the learning exercise and come up with additional information.

Herrick (2014) argues that learners who want to get ahead in learning should try as much as possible to do much assignment at school in order to have enough time to get ahead at home. Herrick (2014) also encouraged learners to take extra classes and attend summer school in order to be exposed to the content of learning before being taught at school. Kumon (2012) emphasized that summer break should be a means of supporting and extending children' learning and that parents should find out about those topics which children are to be taught in the coming school term and engage them with assignment and fun research project which will expose them to the basic knowledge to succeed at school. Kumon (2012) also supported that students should study during the holiday by attending remedial classes. He also encouraged that learning activities through experimentation be used to teach students so that they will be exposed to the teachings that will take place when they resume.

Higbee (2001) noted that studying ahead of time gives room for learner to be at an advantage over his/her classmates. Steedly et al (2008) noted that good learners manage and take charge of the learning process and they identified focusing attention and planning ahead as one of the seven qualities of self- instruction. Freeman, Edd and Wenderoth (2013) also noted that active learning improves students' performance. When students study ahead, they tend to be familiar with the content of instruction which in turn will reduce anxiety of the students as most students are affected by Mathematics anxiety. Ashcraft (2002)

noted that anxiety of students in Mathematics could be caused by placing heavy demands on working memory and the system for conscious, effortful mental processing. Ashcraft (2002) further stressed that cognitive performance is disrupted to the degree that the Mathematics task depends on working memory. Mathematics anxiety can be reduced by early exposure and mastery of the learning task. Exposure and mastery is possible if extra time is created and learners study continuously. Frederic, et al (2013) noted that rehearsal is a key to reducing Mathematics anxiety.

Elaborate strategy consists of paraphrasing, summarizing and selecting main idea from texts (Patrick, Ryan & Pintrich in Kesici & Erdogan 2009). Elaborate strategy gives room for learners to study a wide range of information and from the wide range of information studied, important ideas are then located or identified for encoding which are basic knowledge that are needed for the topic of interest. Anderson in Jill (2013) noted that when a student "knows" a large quantity of information, the student has many records in his/her memory. Elaborate strategy is a more complex and more extensive way of processing information (Schmeck & Ribich, 1978 and Liu & Lin, 2010). However, elaborate strategy according to Patrick, et al in Kesici and Erdogan (2009), shows a low possibility of being sufficient for learning subject such as Mathematics which consists of computational skills and problem solving skills.

Organization strategy includes selecting, clustering, or outlining learning materials such as making simple charts, diagrams, or tables to help put learning materials into forms they can be easily understood (Schmeck & Ribich, 1978 and Lin & Liu, 2010). The Dartmouth (2014) encouraged the use of organization strategy as it serves as a means of reducing stress and increasing success. Thus, The Dartmouth (2014) noted that when presented with a problem, one should identify which procedure to adopt for solving the problem, after getting the procedure for tackling the problem, specify the type of problems that should be solved with that procedure, identify basic features that should be in those problems, that is the main characteristics that should be in such problems in order for students to be able to choose at a glance the right procedure or formula to use. It is advisable for students to do that before sitting for any test for each chapter (area of interest). To enhance learning, students can make a chart of the different types of problems, and indicate a way of identifying the procedure to use to solve the different types of problems. When all these are done, the student will succeed in organizing the learning material in the manner that he or she can easily understand.

Statement of the Problem

Mathematics is usually seen as the language of science and technology. It is a requirement for effective study of other school subjects in areas like numbers and numeration, variation, graphs, fractions, equations and also in volume.

Fafunwa (1980) revealed in his research study that everyone lives in a world where science and technology have become an integral part of the world culture. Therefore, for any nation to be relevant, the role Mathematics plays in educational system must not be underrated. However, In spite of its importance, the performance of students in the subject has been a great concern to the society. Reports made on yearly basis on academic achievement of students in Mathematics reflect students' low performance at both internal and external examinations (Ashiaka, 2010). Zalmon and Wonu (2017) gave a breakdown of percentage performance of students who made A_1-C_6 from year 1991 to year 2016 in Mathematics as follows; in 1997 and 1999 students' percentage performance was below 10%. In 1991, 1993, 1994, 1995, 1996, 1998, 2002 and 2007 students'
percentage performance was between 10.00% and 20.00%. In 1992 and 2008 students' percentage performance was between 20.01% and 30.00%. In 2000, 2005, 2006,2009, 2010, 2011, 2013, 2014, 2015 and 2016 students' percentage
performance was between 30.01% and 40.00%. In 2001, 2003 and 2012 students' percentage performance was between 40.01% and 50.00%. Finally, in 2004 students' percentage performance was above 50.00%.

Clearly from the statistics above, students have been performing poorly in Mathematics over the years. Only in one (1) year (2004) out of 26 years was Mathematics percentage performance recorded above 50 since 1991 till 2016 for grade levels A_1-C_6. Without doubt, poor performance of students in Mathematics is alarming. Thus, the researchers began to wonder if students make use of cognitive learning strategies in studying the subject as it has been proven to have high influence on students' excellent performance in Mathematics (Osarumwense, 2015). Hence, the researchers deemed it necessary to investigate if students make use of cognitive learning strategy components as well as the contribution of the components to academic achievement of students in the subject.

Research Questions

The following research questions were raised for the study;

1. Do secondary school students make use of cognitive learning strategy components to enhance their Mathematics learning?
2. Do cognitive learning components contribute to students' achievement in Mathematics?

Hypotheses

The two research questions were hypothesized for the study;

1. Secondary school students do not significantly make use of cognitive learning strategy components to enhance their Mathematics learning.
2. Cognitive learning strategy components do not significantly contribute to students' achievement in Mathematics.

Purpose of the Study

This study aimed to investigate if secondary school students make use of cognitive learning strategy components to enhance their Mathematics learning as well as to find out the contribution of the components to Mathematics learning.

Methodology

The study employed correlation research design and all senior secondary school (SS 2) students in Benin City were used as the population. In the study, a sample size of 140 students was used. Simple randomly sampling technique was employed to select seven (7) schools from the City and 20 students (10 males and 10 females) from each randomly selected schools which gave a total of 140 students. A questionnaire titled Mathematics Cognitive Learning Strategies Scale (MCLSS) served as the instrument for data collection. The reliability co-efficients of of .78, .82, .80, .52 and .59 for in-depth study, pre-expository effort, wide- range of study, rehearsal and organization respectively and .89 for the entire scale were obtained. The questionnaire consisted of two sections: A and Section B. Section A sought for demographic data such as name of school, identification code to enable the researchers identify the Mathematics scores of students. Section B was based on (10 items for in-depth study, 6 items for pre-expository effort, 11 items for wide-range of study, 6 items for rehearsal and 7 items for organization) 40 items for the entire scale which addressed the interest of the study. Also, the Mathematics scores for the 2018/2019 third term examination were collected from Mathematics teachers of the schools used and the scores were standardized using Z and T scores to allow for comparison from one school to the other. The data obtained from the questionnaire and the Mathematics standardized scores were analyzed. Hypothesis 1 was tested using one sample t-test while hypothesis 2 was tested using Linear Regression.

Findings

Test of Hypotheses

Hypothesis 1: Secondary school students do not significantly make use of cognitive learning strategy components to enhance their Mathematics learning.

Table 1: One-Sample Statistics of the Usage of Cognitive Learning Strategy Components

Cognitive Strategy	Number	Mean	Std	t	Sig.(2tailed)
Rehearsal	1390	3.2295	.73569	36.969	.000
In-depth Study	1341	2.7703	.89412	11.071	.000
Wide-Range of Study	1390	3.2180	.76221	35.120	.000
Pre-Expository	836	2.9677	.79830	16.940	.000
Organization	943	3.3001	.72128	34.064	.000

From Table 1, the approximate mean scores of 3.23, 2.77, 3.22, 2.97 and 3.30 and p-values of .000, .000, .000, .000 and .000 were obtained for rehearsal, in-depth study, wide-range of study, pre-expository effort and organization respectively. It therefore means that secondary school students significantly make use of the five (05) cognitive learning strategy components to enhance their Mathematics learning. Thus, the null hypothesis is not retained

Hypothesis 2: Cognitive learning components do not significantly contribute to students' achievement in Mathematics.

Table 2a: Model Summary of Regression Analysis of the Prediction of Cognitive Learning Strategy components on the Students' Mathematics Achievement

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2887.900	5	577.580	2.985	.014[b]
	Residual	25932.071	134	193.523		
	Total	28819.971	139			

a. **Dependent variable; Students' Mathematics Achievement.**
b. **Predictors; (constant), Cognitive Learning Strategy components.**

In Table 2a, p-value of .014 which is less than .05 α level of significance was obtained. It therefore means that the cognitive learning strategy components

significantly contributed to academic performance of students in Mathematics. Thus, the null hypothesis is not retained.

Table 2b: Parameter Estimates of Regression Analysis of the Prediction of Cognitive Learning Strategy components on the Students' Mathematics Performance

Adj r^2 Model	Unstandardized Coeffs		Standardized Coeffs	Sig.	r	r-Square
	B	Std Error	Beta			
Constant	8.799	11.176		.432	1	
Rehearsal	1.269	.512	.220	.014		
In-depth Study	-.011	.245	-.004	.965	.317[a]	.100
Wide-Range of Study	.414	.249	.170	.099		
Pre-Expository	.220	.390	.060	.573		
Organization	-.213	.347	-.062	.541		

a. **Dependent variable; Students' Mathematics Achievement**

Table 2b revealed that the R Square is .100. This means that 10.0% of the dependent variable (students' Mathematics performance) was explained by the predictor (Cognitive learning strategy components). The constant term was approximately 8.80 and the predictor (Cognitive learning strategy components) were approximately 1.27, -.01, .41, .22, and -.21 for rehearsal, in-depth study, wide-range of study, pre-expository effort and organization respectively and r which is approximately .32 represents the correlation between the predictor variables and the dependent variable. It shows that there is a positive moderate correlation between Mathematics achievement and cognitive learning strategies. In Table 2b, p-values of .432, .014, .965, .099, .573 and .541 were obtained for constant term, rehearsal, in-depth study, wide-range of study, pre-expository effort and organization respectively. Only rehearsal whose p-value is .014 is less than .05 α level of significance. It therefore means that only rehearsal cognitive learning strategy component significantly contributed to academic achievement of students in Mathematics. Therefore, the null hypotheses is not retained.

The regression equation is $\mathbf{Y_1 = X_i + C_1}$

Therefore, $\mathbf{Y = 1.27X_1 - .01\ X_2 - .41X_3 + .22X_4 - .21X_5 + 8.8,}$ where Y is the students' Mathematics achievement and the X is the cognitive learning strategy components**.** All the cognitive learning strategy components together contributed significantly to Mathematics achievement but Rehearsal contributed most to Mathematics performance.

Discussion of Findings

The findings of the study show that secondary school students significantly make use of the five (05) cognitive components (rehearsal, in-depth study, wide-range of study, pre-expository effort and organization) to enhance their Mathematics learning. It was also found that cognitive learning strategy components together significantly contributed to academic achieveeement of students in Mathematics. The findings of this study are in line with that of Shodhganga (2007) who studied learning styles of high school students and found that there is no significant difference between the cognitive styles and intelligence of government and private school students. Also in line with the findings of this study, Osarumwense (2015) found that cognitive strategies contribute more to achievement followed by meta-cognitive and finally learning resources management strategies. Stoffa, Kush and Heo (2010) also noted that researches have shown that there is a very significant relationship between cognitive learning strategies used by students and their academic performance. Specifically, Stoffa, et al (2010) stated that *"within the work frame of meta-cognition, cognitive learning strategies play a major role by providing methods for students to gain higher academic achievement*".

It was found from this study that among the five cognitive learning strategy components, only rehearsal learning strategy component significantly contributed to academic achievement of students in Mathematics. Rehearsal strategy has been proven to reduce Mathematics anxiety of students. Anxiety has been found to be a major cause of poor academic achievement of students in Mathematics. For example, Fredrick, Miroslav and Gaelle (2013) noted that Mathematics anxiety has negative impact on students' performance in simple Arithmetic tasks but stressed that rehearsal is a key factor for reducing Mathematics anxiety. They were also of the opinion that when students study Mathematics over and over, they tend to cope with internal and external resources which in turn will create cognitive system that is capable of augmenting and transforming working memory capacity of the individual to eliminate the resource drain that may be caused by Mathematics anxiety. Ashcraft and Krause, (2007) noted that Mathematics anxiety drains working memory resources by using it to maintain and retrieve negative performance-related thoughts and memories which will after wards impair the performance of the students. Students that are Mathematics anxious use limited cognitive resources when working on a Mathematics problem because part of the cognitive resources has been used up by tension which eventually leads to poor academic achievement of the students in numeracy (Frederic, Miroslav & Gaelle, 2013). Since students significantly make use of rehearsal, in-depth study, wide-range of study, pre-expository effort and organization strategies and it was found that rehearsal contributed significantly to academic achievement of students in Mathematics, it could be that their use of

rehearsal strategy helped in the reduction of their Mathematics anxiety level which probably influenced their enhanced Mathematics results.

Conclusion

It can be concluded that secondary school students significantly make use of rehearsal, in-depth study, wide-range of study, pre-expository effort and organization (Cognitive strategy components) to enhance their Mathematics learning and that cognitive learning strategy components significantly contributed to academic performance of students in Mathematics.

Recommendations

Based on the findings of this study, it was recommended that

1. Students should be encouraged to engage the use of rehearsal learning strategy to enhance their Mathematics learning as rehearsal strategy reduces Mathematics anxiety.
2. Students should be encouraged to study wide and deep to enable them cover the entire content of instruction which in turn will expose them to every area expected to be covered for effective Mathematics learning.
3. Students should be encouraged to organize Mathematics ideas, concepts, formulae for effective learning of the subject.
4. Students should be encouraged to study preparatory Mathematics topics before they are presented with the topics at school to enable them gain foreknowledge of those topics.

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