National Journal of Advanced Research
ISSN: 2455-216X
Impact Factor: RJIF 5.12
www.allnationaljournal.com
Volume 4; Issue 3; September 2018; Page No. 62-67

Systems analysis strategy and senior secondary student achievement in mathematics in Rivers State, Nigeria

Nduka Wonu[1], Daso Peter Ojimba[2]
[1-2] Department of Mathematics and Statistics, Faculty of Natural and Applied Sciences, Ignatius Ajuru University of Education, Port Harcourt, Nigeria

Abstract
This study is an exploration of the effects of System Analysis Strategy (SAS) on Senior Secondary Class one (SSC1) student achievement in mathematics in Obio/Akpor Local Government Area of Rivers State. The quasi-experimental design was adopted. A total of 127 SSC1 students took part in the study. This included 68 students in the treatment group and 59 students in the control group. Mathematics Achievement Test (MAT) with 25 items was used to measure the student mathematical achievement. The items of MAT were composed of topics from the 3rd term scheme of work in the 2013-2014 academic session. The reliability index of MAT was 0.75 obtained using KR-20. An arm of the SSC1 was used as a treatment group with another arm as the control group in the selected school. The treatment group received instruction using the SAS. Three research questions and three hypotheses guided the investigation. Mean and standard deviation were used to answer the research questions whereas Analysis of Covariance (ANCOVA) was used to test the hypotheses. The students were taught under Constructionist/Learning While Doing(C/LWD) study environment for an entire school term. The result indicated that student mathematical achievement of both groups of students improved over time due to treatment with greater learning progress among the treatment group. The male students in the treatment group gained more from the experiment than their female counterparts in the same group. The result further showed a significant main effect of SAS on student mathematical achievement. There was no significant main effect of sex on student mathematical achievement. The interaction effect between sex and treatment was not also significant on student achievement in mathematics. The study recommended among others that mathematics teachers should start using the SAS in mathematics instructions.

Keywords: achievement, mathematics student, system analysis strategy

Introduction

The indispensability of mathematics for scientific and technological development of any nation can never be overemphasized. Due to the importance of mathematics for national development, Nigeria made mathematics a core subject in her primary and secondary levels of education. However, for some years now, student performance in the subject appears to dwindle. This penitent state of student mathematical performance is also reflected in the annual national examinations such as the Senior Secondary Certificate Examination conducted by West African Examination Council (WAEC) and National Examination Commission (NECO). It is believed that irrespective of how the learners receive instructions if the foundation is deficient, every effort made could sum to a useless job. Student poor performance in mathematics seems to worsen as they go to higher classes. Multifarious factors have been drawn in for this sad situation. This includes among others, lack of student motivation or interest in learning mathematics, high anxiety, low self-efficacy, inappropriate earlier teaching and so on [1].

To improve upon the student performance in mathematics, the tryout of a teaching strategy that could ignite the passion of students in problem-solving and lead them to creativity and critical thinking among senior secondary schools in the Rivers State of Nigeria is worthwhile and timely. The Higher Order Mathematics Skills (HOMS) of problem formulation, problem analysis and problem-solving could be developed by the students when Systems Analysis Strategy (SAS) is adopted by the mathematics teachers. Systems analysis is the application of systems theory with a tool known as systems thinking. To understand the SAS, concepts such as the system, systems theory, and systems thinking must be divulged.

A system could be considered as two or more interacting components. The arrangement of the components of the system determines the relationship between them. The removal or addition of a component of the system can alter the behavior of the system. For example, a car is a system of several components such as the wheels, engine, the body, and the propeller among others arranged in a special way. A pile of the bicycle parts is not a system because they are not arranged [2]. The feedback in the system can be *reinforced*. Suppose a man driving a car with a certain speed decides to push more on the pedal, more gas will be required by the engine, and this will lead to faster speed and then more excitement. Secondly, if he pushes the pedal much more, more gas will be required by the engine, faster speed will be attained and then over speed limit may occur. This leads to balancing feedback.

However, systems theory originated from the study of ecology, through which scientists have discovered that complex webs of life exist throughout nature. It was found that what seems to be minor changes or additions to a natural system can result in striking and unforeseen effects. The field of system theory has undoubtedly aided in making coherent the complex globe of organizations. The field of system theory views the system from the perspective of the entire system, its different subsystems and the recurring patterns in the relationships between the subsystems. The understanding and changes in organizations have greatly been influenced by this theory. A scholarly strand of system theory is the field of systems thinking. Systems thinking is an approach to managing and understanding complex feedback systems. It originated from the field of simulation modeling of system dynamics [3].

Systems thinking is a way of assisting an individual to view systems from an expansive perspective. That includes seeing the entire structure, cycles, and patterns in systems, instead of seeing only specific events in the system. This broad view aids in the identification of the actual causes of problems in organizations and identify where to work to address the issues. Diverse tools and principles for the analysis of changing systems have been produced by systems thinking. Systems thinking could be briefly summarized in the following terms:

- Understanding how things that are part of a whole can influence one another
- A change in one thing can affect other things
- It increases system awareness
- An effective approach to solving complex problems [2].

In practice, what is to be thought in a system involves working with parts, understanding how parts can influence a whole, foreseeing possible consequences or different possibilities, understanding the context where the phenomenon is inserted, seeing and understanding the existence of connections that may be hidden and working with colleagues (e.g fellow students) to see how parts of a system can work together to reach big result.

For instance, in mathematical problem solving, a student could be confronted with the simple exponential equation problem given below:

Solve the equation $5^{2(x-1)} \times 5^{x+1} = 0.04$ for x.

The knowledge of basic operations, change of subject of formula and laws of indices are the subsystems that should interact effectively for the successful solution of the problem (suprasystem) since it involves the exponential equation. System analysis is applied to complex problem-solving. In application, it involves describing the system or problem, identifying the components, identifying the relationships between the components, making the system visible with a model (e.g formula/relations or flowchart) and showing how the system responds to changes [2]. It is similar to Polya 4-phase of problem-solving steps [4]. Given a problem question, we understand the problem, plan, carry out the plan (prototype), and evaluate. These entire processes could be repeated until the desired result is achieved.

Students' reflection on their successes in problem-solving task performance, what led them to the specific solution, what resources were used, who were involved in the situation, what were the difficulties faced, what can be repeated to solve more similar problems, and what has to be changed to successfully solve harder problems entail systems thinking in the mathematics context. A systems approach aids the student to comprehend interconnected/interrelated elements, loops, feedbacks, the structure of a system and effective way to solve problem. [5]. To the researchers, Systems Analysis Strategy (SAS) can be defined as an instructional approach that applies the tenets of system thinking tools of analyzing, organizing and the ability to remember and sequence series of subsystems of a macro system to proffer solution. System Analysis Strategy (SAS) is predicted among other strategies that are scientifically based and good instruction in programmes to strengthen mathematical skills. Burns and Bozeman [6] had earlier propounded that the students should build models of the system themselves and that this would lead them to deeper learning, a deeper understanding of the processes involved and their relationship with each other.

Furthermore, Joubert and Goede [7] investigated the efficacy of critical systems thinking (CST) in the improvement of student performance in networking. The use of critical systems thinking in an action research for enhancing student performance was demonstrated. Thornton, Gary, and George [8], found that systems thinking is a vital component in an attempt to improve teaching and learning. For successful learning the study established that it is the duty of educators to concentrate on ensuring that vicissitudes are regularly made to the system, determine high-leverage improvement and adapting response with learning goals. The advancement of student learning outcome will be huge when systems thinking is made a focal point of the development of instructions.

Systems thinking hold the expectation of transforming the school into an organizational kind of school, where teachers become responsible for their students' performance and principals possess the authority to effectively manage the school; an institution where the syllabus stresses the acquisition of critical thinking skills over dry facts and the conventional lecture method is replaced with the learner-centered learning. Systems thinking is implemented in the school either as a problem-solving structure that improves student understanding of a given subject or as a reformation apparatus for producing a more effective educational system [9].

There is a dearth of literature on the efficacy of SAS on student achievement in mathematics. Systems analysis strategy has a close tie with concept mapping in mathematics. Ige [10] established that learner-centered instructional strategy improves student reflective and critical thinking skills more than the traditional teaching method which is teacher-centered, dominated with teaching activities. Cheema, & Mirza [11] explored the efficacy of concept mapping in advancing student general science achievement. The study found that concept mapping was more effective than the conventional teaching approach. The experiment was, however, more beneficial to the male participants than their female counterparts in general science.

The Problem

Student achievement in mathematics in both internal and external examinations seems to be waning. The summary of student performance as expressed by May/June WASSCE showed that for the period of three years (2012-2014), the percentages of credit passes in mathematics were 49.0%, 36.0%, and 31.30% respectively. These figures were below fifty percent. Stakeholders in education are concerned about the underachievement of students which has become a recurring decimal. Many factors, such as student attitude, lack of instructional materials, and teaching methods have been adduced for this ugly trend in student achievement in mathematics. Specifically, the conventional teaching strategy adopted by the teachers does not lead students to creativity and critical thinking while solving mathematical problems. It is noteworthy that the use of SAS has not been applied in senior secondary schools in Nigeria, particularly in mathematics, to find out whether it could reverse this underachievement. Therefore, the present study intends to investigate the efficacy or otherwise of SAS instruction in the improvement of senior secondary class 1 (SSC1) student achievement in mathematics.

Purpose of the study

The main purpose of the study is to investigate the effect of SAS on student achievement in mathematics at the senior secondary class 1 in Rivers State. Specifically, the study intends to:

1. determine the main effect of SAS on senior secondary student achievement scores in mathematics
2. explore the differences existing between the male and female student achievement in mathematics at the senior secondary class I taught using SAS and those taught using the problem-solving strategy
3. determine the interaction effect of treatment and sex on senior secondary student achievement in mathematics

Research questions

These research questions guided the study

1. What is the main effect of SAS on senior secondary student learning achievement scores in mathematics?
2. How can we describe the difference existing between the mathematical achievement of the male and the female senior secondary students taught using SAS and those taught using the problem-solving strategy?
3. What is the interaction effect of treatment and sex on senior secondary student achievement in mathematics?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance.

H_{01}: There is no significant effect of SAS on senior secondary student learning achievement scores in mathematics.

H_{02}: There is no significant effect of sex on senior secondary student achievement in mathematics

H_{03}: There is no significant interaction effect of treatment and sex on student achievement in mathematics

Materials and Methods

- **Design:** The study adopted the pretest-posttest, control group, quasi-experimental design as it focuses on finding out the efficacy of SAS on SSC1 student mathematical achievement.
- **Participants**: A sample size of 127 SSC1 students from a selected senior secondary school in Obio/Akpor LGA of Rivers State took part in the study. This includes 68 students in the treatment group and 59 students in the control group. There were 38 male and 30 female students in the treatment group whereas there were 32 male and 27 female students in the control group.
- **Instrumentation**: A 25-item researcher-designed instrument, Mathematics Achievement Test (MAT) was used to measure senior secondary student mathematical achievement. The items were multiple choice type with four options but only one correct option inclusive. The items of MAT included topics from the 3rd term scheme of work in the 2013-2014 academic session. The total number of items for each topic, process objectives based on the relative importance and the time spent in teaching the topics guided the decision on the design of the MAT. The instrument was validated by mathematics educators. The reliability coefficient of MAT was 0.75, obtained using Kuder-Richardson K-20.
- **Data collection procedure:** One arm of the SSC1 was used as the treatment group with another arm as the control group in the selected school. The teaching in both treatment and control groups were done by their regular classroom teachers. To obtain the prospective and retrospective achievement of the students before and after the instruction, pre-test and posttest were administered respectively.
- **Treatment group:** The regular class teacher of the treatment group participated in one-week training conducted by the researchers on the application of SAS under constructionist / Learning While Doing (C/LWD) study environment. The strategic components of the SAS were explained to the teachers viz: LIPOF= links, Inputs, Process, Output and Feedback. The instruction in the treatment group was facilitated using a well-designed lesson plan. The phase objectives of the plan included 5 key segments viz: Capture of the student attention using real-life examples, Review of the previous lesson, Development of the lesson based on specific objectives, Application of the learned concepts, Summary of the present lesson and Preview of the next lesson (CRIDASAP). After the Pre-MAT was administered and retrieved, the students were grouped. The students were permitted to brainstorm for their group names and slogans/cheers. Smart Wired cards were used to assist group members to identify the attributes that best describe each of them. Lessons were taught in large and small groups of students. The first lesson was dedicated to understanding the strategy and study kits/worksheets. The instructions on the remaining lesson periods were centered on the use of the SAS in solving mathematical problems. The regular teacher scheduled the instructions and activities based on the availability of time and space in the school. However, the processes were summarized in Table 1 below:

Table 1: The summary of the key activities in the experimental group

Team task	Activities
Introductory class	▪ Capture student attention ▪ Grouping of the students ▪ Students choose their group leaders ▪ Brainstormed for group name and slogan ▪ The System, System thinking, System analysis ▪ Use of worksheet
System Analysis in C/LWD setting	▪ Learned more about System Analysis Strategy ▪ Constructionist/Learning While Doing (C/LWD), for problem-solving/project development demonstrated by the teacher. ▪ The LWD team task of stage 0-3: Stage (0) problem selection, stage (1) brainstorming for solution ideas, stage (2) development of a solution to the selected problem and stage (3) Work together to revise, finalize, and share solved problems with other groups.
The review of the steps illustrated in the SAS worksheet	▪ Review of the steps in SAS worksheet. ▪ Study the self-directed system analysis questions ▪ C/LWD detailed steps for solution rehearsed.
More study/use of worksheet questions	▪ Use of the SAS strategic questions ▪ Development of student self-directed questions
Reviewing all of the SAS questions/LWD steps	▪ Use of SAS worksheet ▪ Practice the C/LWD problem-solving stages 0-3 introduced earlier
Teacher supervision of instruction using the SAS in LWD setting	▪ Solving problems using worksheets ▪ Teacher monitoring students and asks questions when necessary in order to trigger the critical thinking abilities of the students ▪ Share solved problems by groups

For the successful implementation of SAS, the teacher played the role of instruction facilitator. The teacher guided the students to understand the problem (system) and its interrelationship. To do this, the strategy self/teacher directed questions in the worksheet were asked by the teacher in each stage of the problem solving to trigger student critical thinking abilities. The summary of the questions asked during the development of the instructions are summarized in Table 2:

Table 2: Summary of the expected self/teacher questions found in the SAS worksheet.

SAS Strategic component	Self/Teacher directed questions
Links	▪ What math concepts are involved in the system? ▪ What are the relations, function facts…related to the problem?
Inputs	▪ What are the input parameters etc required to solve the problem? ▪ Can you relate it to any other problems?
Process	▪ What process is required to successfully solve the problem?
Output	▪ Did you get the answer?
Feedback	▪ Can you review the result or answer? ▪ Can you obtain the answer differently?

Control group

The students in this group were also instructed by their regular mathematics teacher who did not take part in the training. The teacher posed questions on the chalkboard, demonstrated the procedures involved in the solutions to the specific mathematical problem. The students copied down the steps and were sometimes allowed to solve some of the problems as class work. The teacher guided the students through Polya phases of problem-solving [4], viz: understand the problem, devise a plan, carry out the plan and look back or evaluate the solution. The Polya's problem-solving strategy is assumed to be the conventional problem-solving strategy useful in mathematics and used in the present study. The instruction in both groups lasted for one term of the 2013-2014 academic year. Then a Post-MAT was administered and retrieved at the end of the instructions in the term.

Data analysis

Mean and standard deviation were used to answer the research questions whereas Analysis of Covariance (ANCOVA) was used to test the hypotheses at. 05 alpha level. Analysis of Covariance is appropriate when the mean score on pre-test in each group indicates a significant difference between the groups due to non-random assignment. The Analysis of Covariance is a transformation of the raw scores to a new set of scores adjusted for the effects of the covariate. This shows that ANCOVA is the analysis of adjusted means. The ANCOVA is often used in an attempt to compensate for not having made a random assignment of subjects to groups [12]. That is when consideration is on intact classes.

Results

Table 3: Mathematical achievement mean scores of students in treatment and control groups

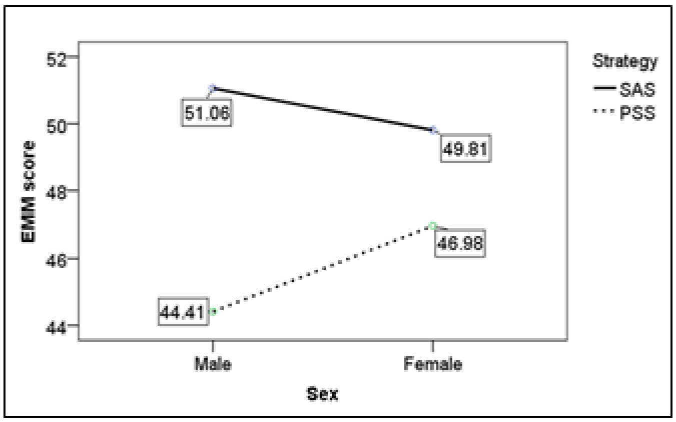
Dependent variable	Learning strategy	Adjusted Mean	SD	N
Achievement	SAS	52.47	10.87	68
	PSS	43.32	6.85	59

Table 3 showed that the adjusted mean mathematical achievement score of students instructed with the SAS was 52.47 ± 10.87. The adjusted mean mathematical achievement score of students instructed using the PSS was 43.32 ± 6.85.

Table 4: Sex associated adjusted mean scores of students instructed using SAS

Sex	Learning strategy	Adjusted Mean	SD	N
Male	SAS	52.42	12.50	38
	PSS	41.88	6.34	32
Female	SAS	52.53	8.58	30
	PSS	45.04	7.15	27

Table 4 shows that the male students who received instructions using SAS had an adjusted mean score of 52.42 ± 12.50 and their counterparts who adopted the PSS had an adjusted mean score of 41.88 ± 6.34. The female students who were instructed with the SAS had an adjusted mean score of 52.53 ± 8.58 and their counterparts who adopted the PSS had an adjusted mean score of 45.04 ± 7.15.



Covariates appearing in the model are evaluated at the following values: premat= 39.72

Fig 1: A plot of intersction effect of strategy and sex on estimated marginal mean (EMM) scores of Post-MAT

Fig. 1 shows the graph of interaction of the instructional models and sex on student mathematical achievement. It shows that the Estimated Marginal Mean (EMM) score of the male students instructed with the SAS was 51.06 whereas that of their female counterparts who were instructed with the same strategy was 49.81. The EMM score of the male students who were instructed with the PSS was 44.41 whereas that of their female counterparts taught using the same strategy was 46.98.

Table 5: Summary of ANCOVA result on the main effect of SAS on student mathematical achievement

Source	Sum of squares	df	Mean square	F	Sig.	η^2
Pre-MAT	1981.998	1	1981.998	28.390	0.000	0.189
Treatment	545.202	1	545.202	7.809	0.006	0.060
Sex	13.263	1	13.263	0.190	0.664	0.002
Treatment * Sex	113.693	1	113.693	1.629	0.204	0.013
Error	8517.194	122	69.813			

a. R Squared =. 359 (Adjusted R Squared =. 338)

Table 5 shows that SAS had significant effect on the student mathematical achievement ($F1, 122=7.809$, $p=0.006$, $\eta^2=0.060$). The H_{01} was rejected at 0.05 alpha level. There was no significant main effect of sex on student mathematical achievement ($F1, 122=0.190$, $p=0.664$, $\eta^2=0.002$). The H_{02} was not rejected at 0.05 alpha level. The interaction effect of sex and instructional models was not statistically significant over student mathematical achievement ($F1, 122= 1.629$, $p= 0.204$, $\eta^2=0.013$). The H_{03} was not rejected at 0.05 alpha level.

Table 6: Simple-main effect analysis of student achievement in mathematics

Independent variables	Sum of squares	df	Mean square	F	Sig.	η^2
Learning strategy						
Male	628.723	1	628.723	7.475	0.008	0.100
Female	86.823	1	86.823	1.628	0.208	0.029
Sex						
SAS	46.080	1	46.080	0.470	0.496	0.007
PSS	107.800	1	107.800	3.053	0.086	0.052

Table 6 shows that male students instructed with SAS and those taught using PSS differed significantly over mathematical achievement ($F=7.475$, $p=0.008$, $\eta^2=0.100$). The female students taught using different strategies did not differ significantly in mathematics achievement ($F=1.628$, $p=0.208$, $\eta^2=0.029$). Table 6 further shows that the students of both sexes instructed using the SAS did not significantly differ over mathematical achievement ($F=0.470$, $p= 0.496$, $\eta^2=0.007$). The students of both sexes instructed using the PSS did not significantly differ over mathematical achievement ($F=3.053$, $p=0.086$, $\eta^2=0.052$).

Discussion

The result in Table 3 shows that students taught mathematics using SAS performed better than their counterparts taught using the problem-solving strategy, with an adjusted mean difference of 9.15. The statistical test result in Table 5 established that SAS had significant effect on student mathematical achievement in Obio/Akpor LGA. The H_{01} was rejected at 0.05 alpha level. The finding of this study is in agreement a previous finding [8] which established that systems thinking should be a very important constituent in efforts to advance learning.

The result in Table 4 shows that the male students taught using different strategies performed differently. The male students that adopted SAS significantly outperformed their male counterparts who adopted the problem-solving strategy (Table 6). The female students instructed with SAS outperformed their female counterparts instructed with PSS, the established difference was not statistically significant at. 05 alpha level. Estimated Marginal Mean (EMM) scores as shown in Figure 1 indicated that SAS favoured the male students whereas PSS favoured the female students. The statistical test on Table 5 indicated that students of both sexes did not differ significantly over mathematical achievement. The H_{02} was retained at 0.05 alpha level. This finding was in disagreement with a previous study [11] which established that concept mapping significantly favoured male students over the female students in terms of achievement in general science.

Table 5 further showed that the interaction of instructional models and sex was not also significant at 0.05 alpha level. The mathematical achievement of both sexes did not differ significantly in each group. That means, students of both sexes efficiently utilized the components of each strategy to obtain the results.

Conclusions

Based on the findings of the present study, the following conclusions were drawn

1. There is now an empirical evidence on the efficacy of the SAS in the advancing student mathematical achievement. It established that a constructivist instructional model, such as SAS could be implemented in a constructionist learning environment.
2. This method of education is not sex bias and would greatly improve student mathematical learning achievement as both male and female students were found to advance in learning achievement as a result of the instructions using SAS.
3. The mathematical achievement of both sexes was slightly different in each group; the interaction of instructional models and sex was not statistically significant.

The implication of the findings is that the students in the treatment group were able to identify the mathematical concepts involved in the problems, the relations, functions, and facts related to the problems. They found it easier to identify the input parameters required to solve the problem and they were also able to relate it to other problems. They successfully determined the process required to solve the problems, judge the accuracy of the answers obtained, review the answer and try different ways of solving the same problem. Efficient use of these skills resulted in improved achievement among students who implemented the SAS in a constructionist learning environment.

Based on the findings of the present study, the following recommendations were made:

1. The mathematics teachers should endeavour to apply SAS in the teaching of mathematics in the senior secondary schools.
2. Stakeholders should encourage the mathematics teachers and ask principals to enforce the application of SAS in a constructionist environment in the senior secondary schools in Rivers state.
3. The students of both sexes should be engaged equally in mathematical problem-solving task performance to lessen the existing gender inequality in mathematics education.

References

1. Munro J. Dyscalculia: A unifying concept in understanding mathematics learning disabilities. Australian Journal of Learning Disabilities. 2003; 8:4.
2. Lough T. Systems thinking. A paper presented at the collaborative workshop of Schlumberger Excellence in Education Development, (SEED) held in Port Harcourt, Nigeria. 2014, 24-28, www.planetseed.com
3. Sterman J. Business dynamics: Systems thinking and modeling for a complex world. New York: Irwin/McGraw-Hill, 2000.
4. Polya G. How to solve it. Princeton N. J.: Princeton University Press, 1957.
5. Center for Ecoliteracy. Explore systems thinking, 2012, www. ecoliteracy. org/ natureour- teacher/ systems-thinking.
6. Burns PC, Bozeman WC. Computer-assisted instruction and mathematics achievement. Is there a relationship? Educational technology. 1981; 21(10):32-39.
7. Joubert AG, Goede R. Using Critical Systems thinking to Improve Student Performance in Networking. World Academy of Science, Engineering and Technology. 2012; 64:683-686.
8. Thornton B, Gary P, George P. Systems thinking a skill to improve student achievement. The Clearing House. 2004; 77(5):222-227.
9. Lannon-Kim C. Revitalizing the Schools: A Systems Thinking Approach. The Systems Thinker. 1991; 2(5):1-5.
10. Ige TA. Concept of Mapping and Problem-Solving Teaching Strategies as Determinants of Achievement in Secondary School Ecology. Ibadan Journal of Educational Studies. 2001; 1(1):290-301.
11. Cheema AB, Mirza MS. Effect of concept mapping on students' academic Achievement. Journal of Research and Reflections in Education. 2013; 7(2):125-132. http://www.ue.edu.pk/jrre,
12. Adetula LO. Statistical tools for mathematical science education research. Paper presented at the workshop for lecturers of mathematical sciences in tertiary institutions held at national mathematical centre Kwali, Abuja, 2010.