



## Effect of Sequential Multiple Representations (SMR) on the Academic Achievement of Senior Secondary School Students in Electric Circuit

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### ABSTRACT

*This study investigated the effect of Sequential Multiple Representations in Enhancing Senior Secondary School Physics Students' Achievement in Electric circuits. The intervention involved a sequence of four lessons conducted over a period of 6 weeks, with the first and last week used for pre and post-test. The intervention was set deliberately to push students to use multiple representations in a particular sequence (starting from word to symbols, diagram, and then generating equations) to solve electric circuit problems. Two research questions and two hypotheses were set up to guide the study. A quasi-experimental research design of a pre-test post-test non-equivalent control group was used for the study. The population of the study comprised all 3600 students offering physics in the fifteen public co-educational senior secondary schools in the Bauchi metropolis. The sample size of the study was 86 using multi-stage sampling. The instrument used for data collection was a Physics Problem-Solving Task on Electric Circuit (PPSTEC) with a reliability coefficient of 0.76. The research questions were answered using mean and standard deviation while the hypotheses were tested using ANCOVA at 0.05 significance level. The findings of the study indicate that SMR can be effective in enhancing students' achievement in physics and there was no gender difference when students were taught using SMR. Based on the finding it was concluded that the use of sequential multiple representations as a teaching strategy is an effective tool for enhancing students' achievement. The research, therefore, recommends further research with different sets of students, and in different contexts across Nigeria to provide more empirical evidence on the role of sequential multiple representations as a means of developing students' problem-solving skills in electric circuit problems.*

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### INTRODUCTION

Physics is one of the foundational science subjects that students offer in senior secondary schools and a course in first year in College or University taken by science and engineering students. It plays a dominant role in the attainment of the goal and objectives of any nation. Problem-solving constitutes greater part of Physics curriculum in secondary schools

across different topics. Research has shown that many students have difficulties in understanding physics concepts (Haratua & Judyanto, 2016) and in particular students often lack problem-solving skills (Adadan, Irving & Trundle, 2009). The lack of students' problem-solving skills has resulted in a situation where many students have developed negative attitude towards Physics (Mekonnen, 2014). This has also made the achievement of students in Senior Secondary



Schools Certificate examination to be low resulting to poor enrolment of students in Physics related courses in the university.

Several problem-solving strategies have been used in order to improve both the conceptual and procedural knowledge of physics concepts but this has not improved the performance of students in anyway. This may be due to the fact emphasis is only placed on the procedural aspect of problem-solving where students have to just follow a specific step in solving a particular problem by going straight in trying to get a mathematical equation that best fits the problem while conceptual aspect of problem-solving is often presented to students in abstract symbolic form (Rosengrant, Heuvelen & Etkina 2009). According to Rosengrant, Heuvelen and Etkina (2009), there have also been studies on physics learning indicating that students taught with emphasis primarily on using mathematics to develop and apply concepts fail test with seemingly simple conceptual questions that measure understanding.

Research has also shown that problem-solving is not enough to make students to make students successful problem solvers (Haratua & Judyanto, 2016). While students deal with abstract concepts, they need a tool such as a representation to be able to visualize the problem in order to solve it better. Representation serves as an intermediary that bridge the gap between abstract concepts to practical understanding (Haratua & Judyanto, 2016).

The use of representations in supporting and developing students' problem-solving skills has been identified in the literature (Prain, & Waldrup, 2006). The work of Kohl and Finkelstein (2008), provides additional evidence regarding the positive effect of exposing students to the application of multiple representations for problem solving. In Physics, representation is classified broadly into four. These are word representations (studying the problem in a narrative form); diagrammatic representation (such as motion diagram, force diagram, graphs, bar charts, field diagram, circuit diagram etc.); symbolic representations and mathematical equations (Jonassen, 2011). The combination of the two or more of these representations is

referred to as multiple representations. The use of multiple representation has been found to support student's understanding of abstract concepts like electric circuit (Prain & Waldrup, 2006). Problem-solving involving the application of multiple representations may take the form of specific strategies consisting of sequential steps where information provided in a task is first translated in different forms before finally being manipulated mathematically.

The content focus of the intervention is on Electric circuit. This choice was driven by a number of key factors: Firstly, Electric circuit is an important and fundamental aspect of secondary school Physics curricula in Nigeria. Secondly, there is extensive research in the field of physics Education related to Electric circuit with particular emphasis on the use of multiple representations (Metioui, 2012). Thirdly, a significant body of evidence in Nigeria points to difficulties across the teaching and learning of concepts related to this area (Erinosho, 2013).

The Nigerian Educational Research and Development Council (NERDC, 2004) report confirms that many teachers who teach Electricity in secondary school believe that their students find this sub-discipline of Physics difficult to learn. The aim of this study therefore, is to offer a teaching intervention with particular focus on sequential multiple representations in the teaching of Electric circuit with the aim of enhancing physics students' problem-solving skills thereby improving their academic achievement in Electric circuit.

### **Research Objectives**

The study had the following objective:

- i. To determine the effect of Sequential Multiple Representation SMR on the mean academic achievement of Students taught the concept of Electric circuit.
- ii. To determine the influence of Gender on mean academic achievement scores of students taught the concept of Electric Circuit using Sequential Multiple Representation.



### Research Hypothesis

The following null hypotheses were formulated and tested at 0.05 level of significance

- i. There is no significant difference in the mean academic achievement scores of students taught the concept of Electric circuit using SMR and those taught using conventional methods.
- ii. There is no significant difference in the mean academic achievement scores of male and female students taught the concept of electric circuit using SMR.

### METHODOLOGY

The research employed a quasi-experimental design, specifically non-equivalent control group design. The population of the study comprised of all the 3600 SSI Physics students in all the 15 co-Educational public senior secondary schools offering Physics in Bauchi Metropolis (Bauchi State Ministry of Education, 2019). Multi-stage sampling was used in the study. First, 15 co-educational schools were purposively selected out of the 43 schools in Bauchi metropolis. Simple random sampling technique was used to select 2 schools out of the 15 public schools in Bauchi metropolis. The assignment of schools to either experimental and control was also done using a tossed coin. A pre-test on problem-solving task in Electric circuit was administered to the two schools to determine the equality of the two groups. The intervention group (Experimental) had 45 students while the non-intervention group (Control) had a total of 41 students making the sample size to be eighty-six (86).

Four (4) sequences of lessons on Electric Circuit were developed, and used in the teaching intervention. Both the pretest, the teaching intervention and the posttest were carried out for 6 weeks. In each week, 2 periods (40) minutes each was used for the intervention.

The instrument that was used for data collection is a Physics Problem-solving Task on Electric Circuit (PPSTEC). The PPSTEC comprised of two sections, the first section sought to elicit students' demographic information while the second section has 30 objective type questions and the questions were divided across the topic under consideration. The questions were used to measure students' conceptual understanding in terms of achievement of the concept of Electric circuit before and after teaching intervention. The questions for the PPSTEC were adapted from the past Senior Secondary School Certificate Examinations (SSCE). The questions are also aligned to Blooms taxonomy of classifying questions into lower and higher order cognitive objective.

### RESULTS AND DISCUSSION

The data presented in the tables are used to answer research questions and were used to test the hypothesis at 0.05 level of significance.

**Research Question 1:** What is the effect of Sequential Multiple Representation SMR on the mean academic achievement of Students taught the concept of Electric circuit?

**Table 1:** Mean Achievement and Standard Deviation of Students taught with SMR and Conventional Method

Group	Pre-test			Post-test			Mean Gain
	N	$\bar{x}$	SD	N	$\bar{x}$	SD	
Intervention	45	9.20	2.64	45	22.35	3.98	13.15
Non-Intervention	41	10.59	2.52	41	18.08	4.21	7.59

The data in table 1 shows the pretest and posttest mean scores and of students taught Electric Circuit using SMR to be 9.20 and 22.35 with mean gain score (within) of 13.15. On the

other hand, those taught using conventional method had a pretest, posttest and mean gain score (within) of 10.59, 18.08 and 7.59 respectively. The data shows that both the

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posttest score and mean gain score of students taught Electric Circuit using SMR is higher than those taught using conventional method indicating that SMR was found to be effective in improving students' achievement in Electric Circuit.

**Research Question 2:** What is the influence of Gender on mean academic achievement scores of students taught the concept of Electric Circuit using Sequential Multiple Representation?

**Table 2:** Mean Achievement and Standard Deviation of Male and Female Students taught with SMR and Conventional Method

Gender	Pre-test			Post-test			Mean Gain
	N	$\bar{x}$	SD	N	$\bar{x}$	SD	
Male	26	10.21	2.55	26	22.07	3.86	11.86
Female	19	9.65	2.43	19	21.15	3.42	11.50

The data in table 2 shows the pretest and posttest mean scores of male students taught Electric Circuit using SMR to be 10.21 and 22.07 with mean gain score (within) of 11.86 while female students had a pretest, posttest and mean gain score (within) of 9.65, 21.15 and 11.50 respectively. This shows that male and

female students' taught using SMR had a mean gain in the pretest of 0.56 and a posttest mean gain of 0.36 indicating that not much difference exist in the achievement score of male and female students taught the concept of Electric circuit.

### Hypothesis Testing

**Table 3:** Summary of Analysis of Covariance of Students' Achievement Scores in Electric Circuit by SMR and Gender

Sources	Type III Sum of Squares	df	Mean Square	F	Sig
Corrected Model	756.260	4	189.065	13.371	.000
Intercept	1506.417	1	1506.417	125.190	.000
Achievement Pretest	620.532	1	620.532	57.387	.000
Approach	71.254	1	71.254	5.922	.041
Gender	1.693	1	1.693	0.141	.613
Error	974.712	81	12.033		
Total	18505.000	86			
Corrected Total	1965.214	85			

**HO<sub>1</sub>:** There is no significant difference in the mean academic achievement scores of students taught the concept of Electric circuit using SMR and those taught using conventional methods.

Table 3 shows that  $F(1, 81) = 5.922$ ,  $P(0.041) < 0.05$ . This indicates that the difference between the mean academic achievement score of students taught Electric Circuit using SMR and those taught using conventional method is statistically significant. Hence, the hypothesis



was rejected in favour of students taught Electric Circuit using SMR.

**HO<sub>1</sub>:** There is significant difference in the mean academic achievement scores of male and female students taught the concept of electric circuit using SMR.

Table 3 also shows that  $F(1, 81) = 0.141$ ,  $P(0.613) > 0.05$ . This indicates that the difference between the mean academic achievement score of male and female students taught Electric Circuit using SMR is not statistically significant. Hence, the hypothesis was accepted.

### DISCUSSION OF FINDINGS

The findings of the study as shown in table 1 and 3 indicates that a significant difference existed between students taught the achievement in physics. The finding is agreement with the finding of Kohl, Rosengrant and Finkelstein (2007) who stated that when multiple representation is used in solving problems, it affects students' performance in physics problem solving and can also be used to solve abstract problems. This result is also in agreement with the work of Kohl and Finkelstein (2008), which provides evidence regarding the positive effect of exposing students to the application of multiple representations for problem solving.

Findings from the studies also indicates that there was no gender difference between male and female students taught the concept meaning that the teaching method was effective to both genders.

### CONCLUSIONS

Based on the findings and discussions, it can be concluded that Sequential multiple representation in physics problem solving is a very effective method of enhancing senior secondary school academic achievement in Physics.

### RECOMMENDATIONS

Based on the findings of this study, the researchers recommended that, Physics teachers should be encouraged to use sequential multiple representations as a tool for enhancing students' conceptual understanding of physics concepts and problem-solving skills.

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