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Effect of Metacognitive Instructional Techniques on Students' Achievement and Interest in Basic Science and Technology

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Abstract: The study adopted quasi-experimental design. The study was carried out in Secondary Schools in Niger State. The population of the study consists of seven Secondary Schools in Niger State. The sample of study was two hundred and forty seven (247) JSS 1l, Basic science and technology students in Secondary Schools in Niger State. Basic science and technology Achievement Test (BSTAT) and Basic science and technology Interest Scale (BSTIS) were used as the instrument. The two instruments were validated by three experts from the Department of Industrial and Technology Education, Federal University of Technology, Minna. Pearson Product Moment Correlation Coefficient was used to compute results of the trial testing after test re-test instrument administration and the results indicated positive correlation coefficients of 0.85 and 0.88 for BSTAT and BSTIS respectively. The researcher administered the instrument with the help of two research assistants. Data for the study were collected through pre-test and post test using the Basic science and technology Achievement Test (BSTAT) and the Basic science and technology Interest Scale (BSTIS). Data collected were analyzed using Mean and Standard Deviation to answer the two research questions while Analysis of Co-variance (ANCOVA) was used to test the two null hypotheses at 0.05 level of significance. From the findings, the study revealed that Metacognitive instructional techniques enhances students' achievement in Basic science and technology in junior secondary schools more than the lecture method. The finding also revealed that Metacognitive instructional techniques promotes students' interest in Basic science and technology in junior secondary schools more than the lecture method among others. The study therefore concluded that students' poor achievement and interest in Basic science and technology informed the need for the study on the effect of Metacognitive instructional techniques on students' achievement and interest in Basic science and technology in Niger state.

Keywords: Metacognitive instructional techniques, students, basic science and technology, achievement, interest

I. Introduction

Science is a field of study that involves a dynamic process of seeking for knowledge about nature through observation and experimentation (Anaekwe, *et al.,* 2009). Science education specifically is the training and acquisition of scientific knowledge through observations and analysis of events that helps an individual to integrate effectively into the society (Ifeakor & Okoli, 2011). Ukah (2013) sees science education as a social process and medium for acquisition of relevant knowledge, skills and attitudes for scientific literacy while Ellah (2014) described science education as the knowledge gained through understanding of scientific concepts and processes required for personal decision making, participating in realization that Nigeria and other nations of the world lay emphasis on science education at all levels including secondary education level. According to the National Policy on Education (Federal Republic of Nigeria(FRN), 2014 p.17) the objectives of Post-Basic education among others are to provide trained manpower in the applied sciences, technology and commerce at sub-professional grades and entrepreneurial, technical and vocational job-specific skills for self reliance and for agriculture, commercial and economic development.

The science subjects are very important in providing trained manpower in the applied sciences, technology and commerce at sub-professional grades and entrepreneurial, technical and vocational job-specific skills for self reliance. Their importance in preparing professionals such as chemistry, biology and physics teachers, doctors, pharmacists, agricultural scientists, biologist, engineers and many other professions cannot be overemphasized. Raina (2011) posits that the study of these science subjects also equips its beneficiaries with necessary knowledge; skills and attitudes to enable them interact meaningfully with their environment, solve every day problems and live successfully in this day of advancing science and technology.

Furthermore, Raina observed that the current system of education in Nigeria which focuses on self-reliance and sustainable national development is built around science and technology with its activities centering on the science subjects(Chemistry, Physics and Biology among others).Furthermore, Agbi (2006) opines that the knowledge of science subjects is applied in manufacturing, processing and the development of materials for construction, building, pharmaceutical, water works, foodstuff,

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fertilizers, insecticides and herbicides. The government of Nigeria has demonstrated her concern towards the study of science civic cultural affairs and economic productivity for survival in a changing world. Science education involves various investigative processes and activities with regards to developing, acquiring and controlling knowledge, skills, increasing productive capacity and influencing peoples 'attitude about the natural factors of the environment. This is why one of the goals of science education is to provide knowledge and understanding of the complexity of the physical world, forms and conduct of good life (Federal Republic of Nigeria, 2014). It is well known world-wide that science and technology are central to the changing world because they supply man's basic needs such as food, clean water, shelter, energy, basic healthcare and education among others. It is in this subjects in concrete ways. For instance, the establishment of specialized universities of agriculture and technology, polytechnics and colleges of technology, the 60:40 ratio of university admission policy in favour of science candidates and the establishment of special science schools by some states of the federation are geared towards promoting science education. More importantly, the activities of professional bodies such as Science Teachers Association of Nigeria(STAN), Chemical Society of Nigeria (CSN),Nigerian Institute of Physics (NIP), Nigerian Society of Biochemistry and Molecular Biology (NSBMB) and many others are in line with the stakeholders desire to encourage the effective teaching of these science subjects in the schools.

Basic Science and Technology curriculum adapted a spiral approach of teaching which expressed the fundamental unity of scientific thought. It is expected that by teaching Basic Science and Technology at these level, every Nigerian student would be given the basic knowledge and understanding of what science is all about and exposed to some of the innovations that are taking place around them. This assertion blends with the objectives of science teaching which are to produce individuals who will be able to live effectively in the modern age of science and technology and contribute to the development of the nation (Agogo & Ode, 2011).According to the National Curriculum for Junior Secondary School (FRN, 2012),basic science and technology is aimed at enabling students acquire specific science process skills such as: observing, organizing acquired information, generalizing on the basis of acquired information, predicting as a result of generalization and designing experiment (including controls where necessary) to check predictions. Olusi (2008)earlier shown that concrete steps ought to betaken to get students groomed or trained in science and technology to enable them use scientific facts to interpret natural phenomena such as earthquake, volcanoes and other natural disasters. This may ultimately help them in solving environmental challenges. But the teaching of basic science and technology is faced with myriads of challenges. For instance, the subject is handled by teachers who are single subject specialist either in biology, chemistry, physics, integrated science or agricultural science, taught in an ill-equipped classroom, library and laboratory, without teaching aid. Some of these claims are verifiable because they might not have anything to do with disparity in achievement of students in BECE Basic Science and Technology as it relates to their performance in science at senior secondary education level.

The attainment of the Basic science and technology Education objectives and enhancement of students' achievement in Secondary Schools rely extensively on many factors. These include the failure of the Basic science and technology Education curriculum to satisfy the day-to-day exigencies, the comfort of the people and the technological development of the country (Akinpade, *et al.*, 2020). Other challenges include inadequate qualified teachers, poor methods of instruction, and inadequate teaching facilities and equipment (Amaechi & Thomas, 2016). Regarding the quality and quantity of teachers, relevant literature reveals that there might be shortage of trained teachers to teach Basic science and technology Education in Secondary Schools in Nigeria. Apart from this, some pedagogical skills to impact the knowledge of the students are conspicuously lacking by many of these teachers, they might also be deficient in technical knowledge of the subject matter (Oviawe et al., 2017, & Bashir, 2018). Umar *et al.* (2020), opined that all technical college programmes should be run well to enhance the economic and environmental challenges of the professional tasks involved. These tasks positively influence the technological developments in the industries and have brought about changes and thus rendered analogue method of carrying out work inadequate in the industries or companies while creating the need for new and often sophisticated skills. Obviously, the industries and companies need the services of basic science and technology craftsmen who can adapt to the changes and challenges in technology.

The need for preparing Basic science and technology Education students for these change and challenges becomes paramount and has therefore necessitate a shift from instructional strategies that are based on the behavioral learning theories to those rooted in cognitive psychological learning theories for which Design-thinking learning strategy is one (Pusca & Northwood, 2018; De Gone, 2021). In agreement to the fact, William (2019) posited that the current educational system, regardless of decades of politically, the changing conditions and exponential growth of the world's technology constantly requires countries to transform their learning and teaching strategies so as to adapt to the changing world in this 21st century. Learning strategies employed by teacher is a strong determinant of students' learning outcome (Mohammed & Iredje, 2020). Design thinking is an emerging and instructional learning strategy used to assist students' in obtaining the thinking skills needed for 21st century learning and career development with a strong emphasis on problem solving. Pusca & Northwood (2018) stated that design-thinking was used as a human-centered, open-ended problem-based approach to transform the way teaching and learning is conducted in education, and to solve the different challenges that instructors and students are facing in the context of digital learning and of outcome-based

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curriculum. Design-thinking has been proven to be useful in tackling complex problems that are ill-defined or unknown (Fabiano, *et al.* 2021).

Metacognition refers to a level of thinking that involves active control over the process of thinking that is used in learning situations. Planning the way to approach a learning task, monitoring comprehension, and evaluating the progress towards the completion of a task require metacognitive skills. Russell (2012)advises that to increase their metacognitive abilities, students need to possess and be aware of three kinds of content knowledge: declarative, procedural, and conditional.

Metacognitive teaching method is a learner-centered approach to instruction based on Metacognitive learning theory that says that all knowledge is constructed from a base of prior knowledge. Dougiamans and Papert in Cey (2011) saw constructivism as teaching with an approach that seeks opportunities for students to analyze, investigate, collaborate, share, build and generate ideas based on what they already know rather than facts, skills and processes they can talk freely. Constructivism brings to light the significance of social cognitive, interactions, cooperation and collaboration to teaching and learning context. In other words, students construct their own understanding through the interactions of their existing experiences with whatever they come into contact with. This makes learning a social activity which engages learners to question, challenge and formulate their own ideas and conclusions (Ultanir, 2012). Jackson in Gjergo and Samarxhius (2014) opined that constructivism underpins a number of approaches which includes situation learning, concept mapping, anchored instruction, problem-based learning, cognitive apprenticeship, discovery learning, scaffolding and collaboration.

Student Academic achievement has to do with the successful accomplishment of goals, measured by the extent to which instructional objectives are achieved. According to Eze and Osuyi, (2018), academic achievement is a measure of the degree of success in performing specific tasks in a subject area or area of study by students after a learning experience. Whereas Ahmad and Ombuguhim, (2020) defined achievement as the scholastic standing of a student at a given moment in learning both theoretical and practical skills in Basic science and technology therefore, is essential to students' progress in the changing world of technology. In this regard, effective instructional approach must be developed to improve skills achievement and to maintain acquired skills at a functional level over a period of time. With adoption of design-thinking learning strategies, students' interest might increase. When students' interests are piqued, their performance improves.

Student interest according to Duru*et al.* (2021) is defined as a content-specific, person-object relationship that emerges from an individual's interaction with the environment. According to the authors, interest is an important variable in the school context, as it can influence students' level of participation in learning, Self-efficacy of their learning experience as well as their level of performance. The study therefore poised to find out the effect of Metacognitive instructional techniques on students' achievement and interest in basic science and technology in Niger State.

II. Statement of the Problem

Basic science and technology is one of the trade programme offered at the Secondary Schools which is meant to prepare students with the requisite skills that can make them to be self-reliant after graduation. Such skills include but not limited to demonstration of basic knowledge in theory and practical skill content. It is an essential trade that covers setting out of buildings, form block walls on the concrete foundation, be able to level the building and also possess skills in designing good roofing pattern.

The National Examinations Council (NECO) reports show the persistent records of the students' low performance in Basic science and technology and this has been attributed to teachers' inappropriate pedagogical approaches. Study Mbonyiryivuze, *et al.* (2019) had shown that students' poor academic achievement is as a result of teaching methods employed by teachers. Similarly, Researchers such as Duhu and Ibanga, (2020) and Lawal*et al.*, (2020) also identified several factors responsible for students' poor performance in subjects such as Basic science and technology to be specific, and they classified these factors as students-related factors, teacher related factors, society-related factors and government–related factors. Among other things that form the teacher-related factors is the teaching methods adopted by teacher like conventional teaching method. These learning methods adopted by teacher`s' in the Secondary Schools according Ayonmike, (2020) results to students' abseentism during lesson thereby paving way for students poor learning outcome.

Various methods of improving the poor performance of students have been neglected, hence there is the need to look for more proactive methods that will incorporate individual differences of learners and make them learn in a more profitable way. To search for more efficient methods that will improve students' academic performance call for the trial of another individualized approach such as design-thinking teaching methods. Therefore, the study, seeks to investigate effect of Metacognitive instructional techniques on students' achievement and interest in basic science and technology in Niger State.

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Research Questions

The following research questions guided the study:

1. What are the mean achievement scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method in Niger State?
2. What are the mean interest scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method in Niger State?

Hypotheses

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

Ho_1: There is no significant difference in the mean achievement scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method in Niger State.

Ho_2: There is no significant difference in the mean interest scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method in Niger State.

II. Methodology

The study adopted quasi-experimental design. The study was carried out in Secondary Schools in Niger State. The population of the study consists of seven Secondary Schools in Niger State. The sample of study was two hundred and forty seven (247) JSS II, Basic science and technology students in Secondary Schools in Niger State. Basic science and technology Achievement Test (BSTAT) and Basic science and technology Interest Scale (BSTIS) were used as the instrument. The two instruments were validated by three experts from the Department of Science Education, Federal University of Technology, Minna. Pearson Product Moment Correlation Coefficient was used to compute results of the trial testing after test re-test instrument administration and the results indicated positive correlation coefficients of 0.85 and 0.88 for BSTAT and BSTIS respectively. The researcher administered the instrument with the help of two research assistants. Data for the study were collected through pre-test and post test using the Basic science and technology Achievement Test (BSTAT) and the Basic science and technology Interest Scale (BSTIS). After the pre-test, items of the BSTAT were reshuffled before re-administration for post test. The essence of reshuffling the items was to ensure that students do not memorise all the contents of the BSTAT. Data collected from the two tests (pre-test and post-test) were used for data analysis. Data collected were analyzed using Mean and Standard Deviation to answer the two research questions while Analysis of Co-variance (ANCOVA) was used to test the two null hypotheses at 0.05 level of significance. The ANCOVA was preferred because of its power to take care of the initial lack of equivalence (differences) in the experimental and control groups since intact classes were used for the study. The pretest served as covariate to the post-test and this justifies more the use of ANCOVA for testing the null hypotheses.

III. Results

Research Question 1: What are the mean achievement scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method?

Table 1: Mean Achievement Scores of Students taught Basic science and technology using Metacognitive instructional techniques and those taught using Lecture Method

Teaching Methods	**N**	**Pre-test**		**Post-test**		**Mean Gain**
		Mean	**SD**	**Mean**	**SD**	**Score**
Metacognitive instructional techniques	126	33.28	10.32	79.08	8.80	42.80
Lecture Method	121	33.62	6.20	37.77	7.25	4.15
Total	**247**	**33.45**	**8.26**	**58.43**	**8.03**	**23.48**

Table 1 showed that students taught Basic science and technology in junior secondary schools using Metacognitive instructional techniques had a mean and standard deviation achievement score of 33.28 (10.32) in pre-test while students taught with lecture method had pretest mean and standard deviation achievement score of 33.62 (6.20) respectively. This suggests that at pretest level

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students in both design thinking based and lecture methods almost had the same achievement. The post-test mean and standard deviation achievement of students taught Basic science and technology in junior secondary schools using the design thinking based and lecture methods are 79.08 (8.80) and 37.77 (7.25) respectively. This implies that students taught Basic science and technology in junior secondary schools with design thinking based had better achievement than their counterparts taught using the lecture method. Thus, the Metacognitive instructional techniques enhances students' achievement in Basic science and technology in junior secondary schools more than the lecture method.

Research Question 2: What are the mean interest scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method?

Table 2: Mean Interest Scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method

Teaching Methods	**N**	**Pre-test**		**Post-test**		**Mean Gain**
		Mean	**SD**	**Mean**	**SD**	**Score**
Metacognitive instructional techniques	126	1.69	0.80	3.39	0.68	1.70
Lecture Method	121	1.55	0.62	1.76	0.75	0.21
Total	**247**	**1.62**	**0.71**	**2.58**	**0.72**	**0.95**

Table 2 revealed that students taught Basic science and technology in junior secondary schools using Metacognitive instructional techniques had a mean and standard deviation interest score of 1.69 (0.80) in pre-test while students taught with lecture method had pretest mean and standard deviation interest score of 1.55 (0.62) respectively. This suggests that at pretest level students in both Metacognitive instructional techniques and lecture method almost had the same interest level. The post-test mean and standard deviation interest of students taught Basic science and technology in junior secondary schools using the design thinking based and lecture methods are 3.39 (0.68) and 1.76 (0.75) respectively. This implies that students taught Basic science and technology in junior secondary schools with design thinking based had higher interest in Basic science and technology than their counterparts taught using the lecture method. Thus, the Metacognitive instructional techniques promotes students' interest in Basic science and technology in junior secondary schools more than the lecture method.

H_{O1}: There is no significant difference in the mean achievement scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method.

Table 3: ANCOVA Summary Table of the difference in the mean (x) achievement scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method

Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Corrected Model	109046.255[a]	2	54523.128	1081.545	.000
Intercept	28358.581	1	28358.581	562.534	.000
Pretest	3708.140	1	3708.140	73.556	.000
Method	**106104.674**	**1**	**106104.674**	**2104.740**	**.000**
Error	12300.587	244	50.412		
Total	976558.000	247			
Corrected Total	121346.842	246			

Table 3 shows the F value as 2104.74 and the probability value as .000. The probability value of .000 of this finding is less than the alpha value of 0.05. Therefore, the null hypothesis is rejected and thus, there is significant difference in the mean achievement scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method in favour of the Metacognitive instructional techniques. This implies that students taught Basic science and technology

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with Metacognitive instructional techniques had better achievement compared with their counterparts taught with the lecture strategy.

H_{O2}: There is no significant difference in the mean interest scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method.

Table 4: ANCOVA Summary Table of the difference in the mean (x) interest scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	165.925[a]	2	82.963	163.546	.000
Intercept	313.734	1	313.734	618.469	.000
Pre-Interest	2.219	1	2.219	4.374	.038
Method	**165.854**	**1**	**165.854**	**326.950**	**.000**
Error	123.775	244	.507		
Total	1948.000	247			
Corrected Total	289.700	246			

Table 4 showed the F value as 326.95 and the probability value as .000. Since the probability value of .000 of this finding is less than the alpha value of 0.05. Therefore, the null hypothesis is rejected and thus, there is a significant difference in the mean interest scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method in favour of the Metacognitive instructional techniques. This suggests that students taught Basic science and technology with the Metacognitive instructional techniques had higher interest in the subject compared to their counterparts taught with the lecture method.

IV. Discussion of Results

The data presented in Table 1 and Table 3 revealed that students taught Basic science and technology in junior secondary schools with design thinking based learning had better achievement than their counterparts taught using the lecture method. There is significant difference in the mean achievement scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method. This implies that students taught Basic science and technology with Metacognitive instructional techniques had better achievement compared with their counterparts taught with the lecture method. This finding is expected as students' direct involvement in the teaching and learning processes enhances students' achievement more than teacher-dominated instruction. The finding of this study is coherent with that of Fabiano *et al.* (2021) who found that Metacognitive instructional techniques was very effective in promoting students' academic performance and retention in children.

The data presented in Table 2 answered research question 2 while the data presented in Table 4 answered hypothesis 2. The result of the analysis revealed that students taught Basic science and technology in junior secondary schools with Metacognitive instructional techniques had higher interest in Basic science and technology than their counterparts taught using the lecture method. There is a significant difference in the mean interest scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method in favour of the Metacognitive instructional techniques. This suggests that students taught Basic science and technology with the Metacognitive instructional techniques had higher interest in the subject compared to their counterparts taught with the lecture method. This finding is expected as students' active participation in teaching and learning process rekindles their interests and deactivates boredom and day dreaming. In line with the findings of this study Cerejae*t al.* (2018) found out that students taught using design thinking exhibited higher interest in the subject Technical Drawing, than those taught by their teachers using the lecture method.

V. Conclusions

Students' poor achievement and interest in Basic science and technology informed the need for the study on the effect of Metacognitive instructional techniques on students' achievement and interest in Basic science and technology in Secondary Schools in Niger state. The study indicated that Metacognitive instructional techniques enhances students' achievement and

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interest in Basic science and technology more than the lecture method. Basically, there was significant difference in the mean achievement and interest scores of students taught Basic science and technology using Metacognitive instructional techniques and those taught using lecture method in favour of the Metacognitive instructional techniques. It was concluded that appropriate use of Metacognitive instructional techniques in teaching Basic science and technology would facilitate students' achievement and interest in Basic science and technology.

VI. Recommendations

Based on the findings of the study, the following recommendations were made.

1. Basic science and technology teachers should be encouraged by the government through its relevant ministries to adopt Metacognitive instructional techniques in teaching and learning Basic science and technology for better academic achievement of the students in the subject.
2. The Government through its relevant ministries of education should organize seminars, workshops and symposia for the in-service teachers on the use of Metacognitive instructional techniques for effective teaching and learning of Basic science and technology in junior secondary schools.

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