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Analysis of Magnitudes and Variation of Effect Size on ICT Teaching Strategies on Secondary School Students' Achievement in Sciences in Nigeria

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Abstract

The study analyzed magnitudes and variation of effect size on ICT teaching strategies on secondary school students' achievement in Sciences in Nigeria. Three research questions guided the study. The design of the study was meta-analytic review. The sample of the study was 47 studies. The sampling techniques were purposive and snowballing. Pro-forma was used for data collection. The instrument was validated by experts and the internal consistency reliability value of 0.96 was obtained using inter-rater agreement. Data collected were analyzed with percentage, effect size, average weighted mean Z and Fisher statistical transformation table. Cohen's d-value guidelines for effect sizes were used for results interpretation. The findings of the study revealed positive statistically significant effect on ICT based teaching strategies for junior secondary school students' academic achievement in Science in Nigeria. The study also revealed negative statistically significant effect size for senior secondary school students' academic achievement in Science in Nigeria. However, there was small variation of effect size between the Junior and Senior Secondary School Students on ICT teaching strategies on Secondary School Students' academic achievement in Science in Nigeria. It was concluded from the study that utilization of ICT-based teaching strategies in Secondary School Science subjects facilitate and enhance the students' academic achievement in Nigeria. It was recommended from the study that ICT teaching strategies in Science subjects for Junior and Senior Secondary Schools should be utilized.

Keywords: Effect size, ICT, teaching strategies, academic achievement, meta-analysis and science

Analysis of Magnitudes and Variation of Effect Size on ICT Teaching Strategies on Secondary School Students' Achievement in Sciences in Nigeria

At any given task or assignment, it is expected that at the end of the course, the recipient(s) would attain certain levels of achievement based on the stipulated objectives. In education, academic achievement is seen as successfully and typically doing an educational task by efforts, comportment and skills. Due to the importance attached to academic achievement of students, educational programmes have become a hot topic, especially with increased accountability for classroom teachers. Academic achievement is said to have been attained when a student improves in his ability level in a given educational task. No wonder that Makata, (2018) noted that students' academic achievement measures the quality of academic content a student learns in a determined period of time. Academic achievement connotes final accomplishment of educational noteworthy goals, after much efforts, often in spite of certain obstacles.

Academic achievement is an indicator of the success in the whole of the learning process. Sukarta, (2010) reported that academic achievement is an information about knowledge, attitude, behavior and skill achieved by students after taking part in teaching and learning process within a certain period. Academic achievement can be influenced by some related factors like environment and teaching methods (Pandney, 2018). This environment and teaching methods are inter-related situations in teaching strategies that are influenced by facilities such as ICT especially in the areas of Science for effectiveness and efficiency of academic achievement. Academic achievement is measured by students' performance once or multiple times to assess how well the students performed based on set standard. For students to perform very well in Science, they require high standard of academic achievement in Science. ICT as a tool for academic achievement in Science is the product of Science. ICT therefore, makes teaching strategies in Science to be real and concrete in order to help students achieve academically.

In general, Science is a way of investigating into the “known” and “unknown” facts. This means that, Science is “searching” and “researching fact” the searching means to “discover” new

facts while the researching means to re-look into already discovered facts. Ochei, (2014) sees Science as an investigation process which gives priority to the activity of formulating, reformulating and testing hypotheses to produce the end results. Science is discovery and rediscovery of the truth in accordance with principles and rules which alone guarantee scientific validity. Science is a body of knowledge that has been exemplified with mathematical, chemical and biological equations; observed and reported with analytical and experimental critical function characterizing proof of concept(s). Furthermore, going by the importance of Science in development, all over the world, Science has been regarded as most pertinent global concerns in education and countries that are under-developed, especially Nigeria, aspire to grow in it.

In the Nigerian context, there are alarming attempts to advance in Science. Consequently, Science in Secondary Schools was divided into Upper Basic (Junior Secondary School) and Senior Secondary School levels. At the Upper Basic level, Science is presented to the learners as two separate subjects as 'Basic Science" and "Basic Technology" comprising the subjects: Basic Science, Basic Technology, Information Technology and Physical and Health Education at Junior Secondary while at the Senior Secondary school, the core Science subjects comprise of Physics, Chemistry and Biology for the attainment of the teaching objectives of Science. According to Adeniyi, (2010) this separation is to enable the learners to develop interest in Basic Science and achieve the following objectives of Science content; acquiring basic knowledge and skills in Science; applying their scientific and technology knowledge and skills to meet societal needs and taking advantage of the numerous career opportunities offered by Science and become prepared for further studies in Science-related courses in the bid for a sound foundation technologically.

These objectives are highly pertinent to any country's educational system. To achieve these objectives of Science many researchers have investigated teaching strategies via ICT as programme learning to revolutionize classroom settings of Science (Nwagbo & Ugwuanyi, 2012). Information and Communication Technology (ICT) is fundamental to life. The term ICT was introduced in the early 1990s to replace that of Information Technology (IT) in recognition of the

communication abilities and facilities offered by the computer (Lillian-Rita, 2012). ICTs are electronic devices or gadgets that can aid and ease the flow of communication and information. Lallana and Margaret, (2013) opined clearly that ICT refers to "a broad field encompassing computers, communications equipment and the services associated with them" (p268). Services associated with ICTs include, communication, receiving and sending information which could be an idea, phenomenon, body of knowledge, theories, models among others.

By using modern ICTs, parents, teachers and students can send information and retrieve required responses or information within a short time. ICT is a teaching strategy of learning by doing; popularly referred to as "practice makes perfect.

Nigeria Federal Ministry of Education (as cited in Mary, Esther & Arubhu, 2011) defined ICT as:

> Traditional technologies of radio, video, and television to the newer technologies of computers, hardware, software, etc) as well as the method, practices, progresses, procedures, concepts and principles that come into play in the conduct of the information and communication activities" (p15).

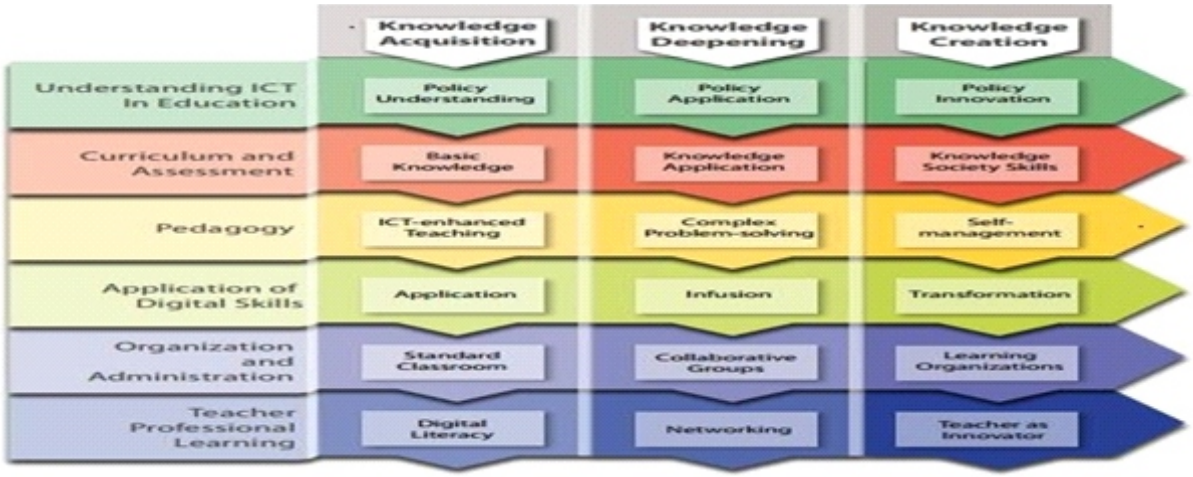
Thus, ICT is not just the applications of computer systems and mini-computers such as phones but also a skill for life. It is a fundamental skill required by every individual to enable them to live self-reliant and autonomous in the global village. Consequently, in Nigeria, ICT was introduced in the National Policy on Education (NPE) document and aims at enhancing and improving the competencies of teachers in the development and promotion of effective teaching and learning FME, 2019). This is because, in educational institutions in developing countries such as Nigeria, today's classroom teachers must be prepared to provide ICT-supported learning opportunities for students (Aduwa-Ogiegbean, 2017). ICT in teaching and learning enhances teacher-parent, teacher-teacher, teacher-student and student-student learning. ICT stands as a pinnacle and pivotal motivational factor for teachers, society and students learning in terms of activeness. Gusen and Olarinoye, (2017) submitted that ICT in teaching strategies, possesses the

potential of reforming the pedagogical methods of the teacher, expanding access to quality education for teachers and students and improving the management of education systems for teachers and students.

Therefore, education in Nigeria today cannot be relevant without effective preparation of new ICT in professional practices (Ikelegbe cited by Valentine & Augustine, 2017). It is obvious that the future of any country is at risk when the students, including the schools, are not equipped with the present trends of societal values with the dynamism of ICT. UNESCO, (2018) conducted an extensive consultation to identify the competencies that teachers should develop and possess to use ICT facilities effectively in the classroom teaching strategies. This consultation resulted in the UNESCO ICT Competencies Framework for Teachers (ICT-CFT) which was first published in 2008 and was modernized in 2011and 2018 as shown below:

Figure 1

UNESCO ICT Competencies Framework for Teachers in Nigeria



(Source: UNESCO, 2018)

The 2015 Qingdao Declaration, at the International Conference on ICT and Post-2015 Education, further reiterated the importance of the professional development of teachers to effectively integrate ICT into their work, stating:

> *"Successful integration of ICT into teaching strategies requires rethinking the role of teachers and reforming their preparation and professional development. It calls for promoting a culture of quality in all its aspects: staff support, student support, curricula design, course design, course delivery, strategic planning and development. We will therefore ensure that teacher training institutions are equipped and prepared to use ICT adequately to expand the benefits of training and professional development programmes to all teachers, and to act as the vanguard for technology-supported innovations in education. We also commit to providing teachers with system-wide support for the pedagogical use of ICT, to incentivize teacher innovation, and to develop networks and platforms that allow teachers to share experiences and approaches that may be of use to peers and other stakeholders" (UNESCO, 2018; p13).*

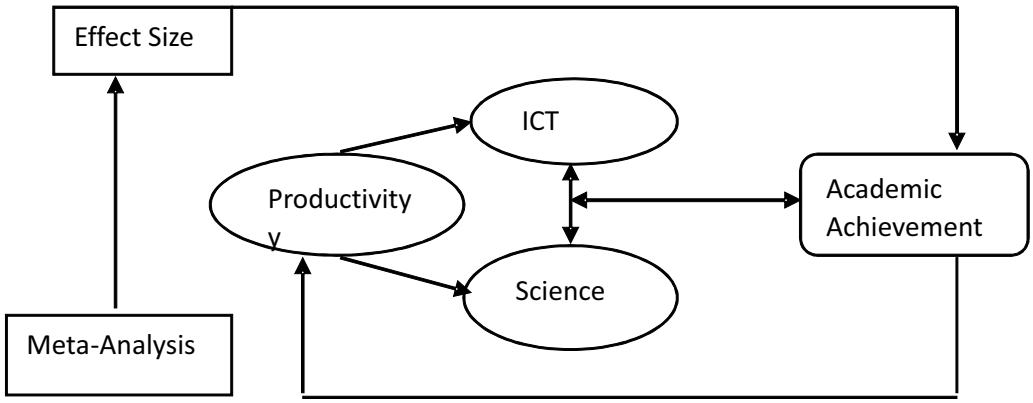
Thus, the *six aspects of teachers work which are* Understanding ICT in Education; Curriculum and Assessment; Pedagogy; Application of Digital Skills; Organization and Administration and Teachers' professional learning has led many researchers and scholars into venturing tirelessly and are still working through several studies to determine the effectiveness of ICT teaching strategies on secondary school students' academic achievement in Science. Many of these studies have come up with many findings that are divergent with agreement and disagreement on the effects of ICT teaching strategies on Secondary School students' academic achievement in Science. Some of these studies are full of different forms of errors that emanate from systematic, random, hawthorn effect and perhaps class levels among others. These have made the various studies have inconclusive inferences and generalization in findings. In order to unify these divergent findings and to arrive at conclusive inference and generalization in findings, meta-analysis was adopted to synthesize the findings

Meta-analysis is a statistical tool that combines the results of multiple studies. **It** is performed when there are multiple studies addressing same question, with each researcher

reporting measurements that have some degree of error(s) that surmised different results/findings. Meta-analysis is a study where the researcher compiles numerous previously published studies on a particular research question and re-analyzes the results to find the general trend for results across the studies (Salters, 2010). It is a statistical technique for combining the results of different studies to see if the overall effect is significant (John, 2009). It is a way of combining the results of all the relevant studies effect sizes, where the effect may be in one direction in each of the original studies, but then switch direction when the data are combined (Borenstein, Hedges, Higgins & Rothstein, 2009). Meta-analysis is used to quantify results from individual studies. It is a statistical technique that is used to amalgamate, summarize and review previous quantitative research (Busham & Wells, 2011). It is used to remedy the inconsistencies that exist among similar research reports already carried out. Okwundu, (2014) noted that some of the difficulties in the synthesis of the results of a number of research findings is dependent on statistical tools for data analysis. In spite of these cumbersome situations, there is need to gather the studies that have been done already to arrive at a conclusion of what holds in the various research findings using statistical tool(s) such as meta-analysis. This approach of meta-analysis is usually computed with effect sizes. That is, effect size of ICT teaching strategies is a determinant of secondary school students' academic achievement in science in Nigeria as illustrated in Fig. 2.

Figure 2

Schematic Diagram of Conceptual Variables



(Source: Ochei, 2024)

In statistics, an effect size is a measure of the strength of a phenomenon (for example, the change in an outcome after experimental intervention) (Brand, Bradley, Best & Stoica, 2011). Hence effect size is a measure that describes the magnitude of the difference between two groups as may be revealed. Effect sizes represent a standard measure by which all outcomes can be assessed. An effect size is typically calculated by taking the difference in means between two groups and dividing that number by their combined (pooled) standard deviation. Okwundu, (2014) surmises that one can tell the number of standard deviations' difference between the means of the treatment and comparison conditions. For example, an effect size of .25 indicates that the treatment group outperformed the comparison group by a quarter of a standard deviation.

It is the amount of impact or change that can be attributed to two or more groups called the treatment and control in experimental studies' designs. According to Robert (2002), 'effect size is simply a way of quantifying the size of the difference between two or more groups. An effect size is a standardized difference denoted by the symbol `*d*. It is the mean difference between groups in standard score form. It is the ratio of the difference between the means to the standard deviation (Yu, 2001). The logic of calculating ES is that researchers should be concerned with not only whether a null hypothesis is false or not, but also how false it is. The larger the effect size, the greater the power of a test is. According to Yu (2001), an effect size is exactly equivalent to a Z-score of the standard normal distribution. The Cohen's value denoted by 'h' is easy to calculate, readily understood and can be applied to any measured outcome in Education or Social Science. It is particularly valuable for quantifying the effectiveness of a particular treatment, relative to some comparison. It allows us to move beyond the simplistic “does it work or not?” to the far more sophisticated, “how well does it work in a range of context?” Effect size is an important tool in reporting and interpreting effectiveness. One of the main advantages of using effect size is that when a particular experiment has been replicated, the different effect size estimates from each study can easily be combined to give an overall best estimate of the size of the effect.

This process of synthesizing experimental results into a single effect size estimate is

known as 'meta-analysis'. It was developed in its current form by an educational statistician, Gene Glass (Glass, McGraw & Smith, 1981) though the roots of meta-analysis can be traced a good deal further back, and is now widely used, not only in education, but in medicine and throughout the social sciences. The routine uses of effect sizes, however, has generally been limited to meta-analysis for combining and comparing estimates from different studies and is too rare in original reports of educational research (Mustapha*, 2010*). This is despite the fact that measures of effect size have been available for at least 60 years (Huberty, 2002). The American Psychological Association has been officially encouraging authors to report effect sizes since 1994 but with limited success (Wilkinson *et al.,* 1999). This shows the dearth of the magnitude of effect sizes in multiple studies and the variation between class levels. Hence, the study meta-analytically determined the magnitude and variation of the effect size on ICT teaching strategies on Secondary School (Junior and Senior) students' academic achievement in Science in Nigeria.

Theoretically, this study is anchored on the theories of Edward Chaos (1961), Suarez Needs Assessment (1990) and Random Effect Model by Gene (1976). The Chaos theory describes system or research findings that are confusing as shown below:

Figure 3

Random and Diverse Findings in Chaos Theory

Fig 3: Random and Diverse Findings in Chaos Theory (Edward, 1961)

Chaos was concerned about random data or different results from the data to generally unify the outcomes of the studies to a general conclusion as in the case of this study. To arrive at the general conclusion of this study, it requires analysis from Suarez theory. According to Suarez, the main aim of any need analysis is to identify deficits that exist as it is observed in multiple variations of

findings in ICT teaching strategies in Science. The results of the analysis are used for further action like remediation to improve on the existing situation. Such remediation in this study is the adoption of meta-analysis to integrate several research findings in ICT teaching strategies in Science. The random effect model of meta-analysis is based on the assumption that all the effect sizes are not identical but varies as in the case of this study.

The study investigated the significant magnitudes and variation of effect size on ICT teaching strategies on secondary school students' academic achievement in sciences in Nigeria. Specifically, the study determined:

1. The summary of the results of the positive and negative statistically significant and non-significant cases of all the studies investigated on ICT teaching strategies on Junior and Senior Secondary School Students' academic achievement in Science in Nigeria
2. The quality of mean effect size (large, medium and small) for the studies investigated on ICT teaching strategies on Junior and Senior Secondary School students' academic achievement in Science in Nigeria
3. The variation of effect size on all the studies investigated on ICT teaching strategies on Junior and Senior Secondary school students' academic achievement in Science in Nigeria.

Research Questions

The study answered the following research questions:

1. What is the summary of the results of the positive and negative statistically significant and non-significant cases of all the studies investigated on ICT teaching strategies on Junior and Senior Secondary School Students' academic achievement in Science in Nigeria?
2. What is the quality of mean effect size (large, medium and small) for the studies investigated on ICT teaching strategies on Junior and Senior Secondary School students' academic achievement in Science in Nigeria?
3. What is the variation of effect size on all the studies investigated on ICT teaching strategies on Junior and Senior Secondary school students' academic achievement in Science in Nigeria?

Effect Size Computation

Most investigators do not provide effect size estimates along with their tests of' significance. Consequently, there arises the need to compute the effect size where needed, from the tests of significance provided by the researcher. Rosenthal (1984) pointed out that investigators sometimes report only their ts (t-statistic often used to calculate effect size measure such as d and correlation coefficient) and dfs (degree of freedom plays a critical role in interpreting the statistical significance and effect size, as they influence the distribution and thresholds for significance) without reporting their sample sizes. Some may report just their correlation coefficient values, r, and others their F and X^2 (chi-square) values or other statistic. Usually, the statistic reported determines the steps to be taken in the computation of effect size.

To compute effect size using Correlation Coefficient 'r' as effect size estimate, where the statistic reported in a study is r, the effect size for that particular study remains the value of 'r'. Where other statistic besides 'r' is reported, the appropriate conversion guideline is employed to convert the statistic reported to effect size estimate `f (i.e. Cohen's fused in the context of ANOVA to quantify the magnitude of group differences relative to the variability within the groups). To obtain the mean effect size of all the studies involved, the average correlation coefficient is computed. This is done by converting each `t.' to its correlation Fisher's Z value using a table of Z values for 'r'. Each transformed Z is then weighted by its corresponding N-3. All the weighted are summed and divided by the sum of the weights. After that the resultant average Z value is reconverted to `r' (Downie & Heath, 1974:232). Thalheimer and Cook (2002) stated with reasons, that Cohen's d has two advantages over other effect-size measurements. "First, its burgeoning popularity is making it the standard. Thus, its calculation enables immediate comparison to increasingly larger numbers of published studies. Second, Cohen (1992) suggestion that effect sizes of .20 are small, .50 is medium, and .80 is large, and enables us to compare an experiment's effect-size results to known benchmarks."

Cohen's d - $d=\frac{xt-\ xc}{Spooled}$ - - - - - 1

X_t = mean of the treatment or experimental group

x_c = mean of the control group

S_{pooled} = pooled standard deviation

To get the S_{pooled} according to Cohen (1992), the formula is as follows;

$$S_{pooled} = \sqrt{\frac{\{(nt-1)St2+(nc-1)Sc2}{nt+nc}} \text{ - - - -- - 2}$$

Where n = number of subjects

S = pooled standard deviation

St^2= standard deviation of group 1

Sc^2= standard deviation of group 2

nt= sample size of group 1

nc= sample size of group 2

If standard errors are given instead of standard deviation, then the standard deviations are calculated as; S = $SeN\sqrt{n}$. The resulting value for each group is substituted in 3 and the n applied in 1 and 2 above.

Where S= standard deviation

Se= standard error

N= population

n= sample size

according to Cohen (1992), if there are no standard deviations or standard errors, then

$$d = \sqrt{\left(\frac{nt+nc}{nt\ nc}\right)\left(\frac{nt+nc}{nt+nc-2}\right)}$$

The formula for calculating Cohen's d from F-test is thus:

$$d = \sqrt{F\left(\frac{nt+nc}{nt\ nc}\right)\left(\frac{nt+nc}{nt+nc-2}\right)} \text{ - - - - - - 3}$$

Where n_t, n_c and d have their usual definitions, while F is the F-statistic (ie. the F-value).

If the Mean Squared Error (MSE) is known, then the formula below is used:

$$d = \frac{Xt - Xc}{\sqrt{MSE\left(\frac{nt + nc - 2}{nt + nc}\right)}}$$

Using t-statistic and sample size, $d = \frac{t(n1 + n2)}{\sqrt{(n1+n2-2)(n1n2)}}$ - - - 4

Where n1 and n2 = sample sizes of the experimental and control groups

t = the t-test statistic or the value of t in the experiment

If sample sizes are equal (i.e. n1= n2), the equation reduces to: $d = \frac{2t}{\sqrt{df}}$ - - 5

Where df = N-2

For F-test, $d = \frac{2\sqrt{F}}{\sqrt{df\ (error)}}$ - - - - - - 6

Using correlation coefficient, $d = \frac{2r}{\sqrt{1-r^2}}$ - - - - 7

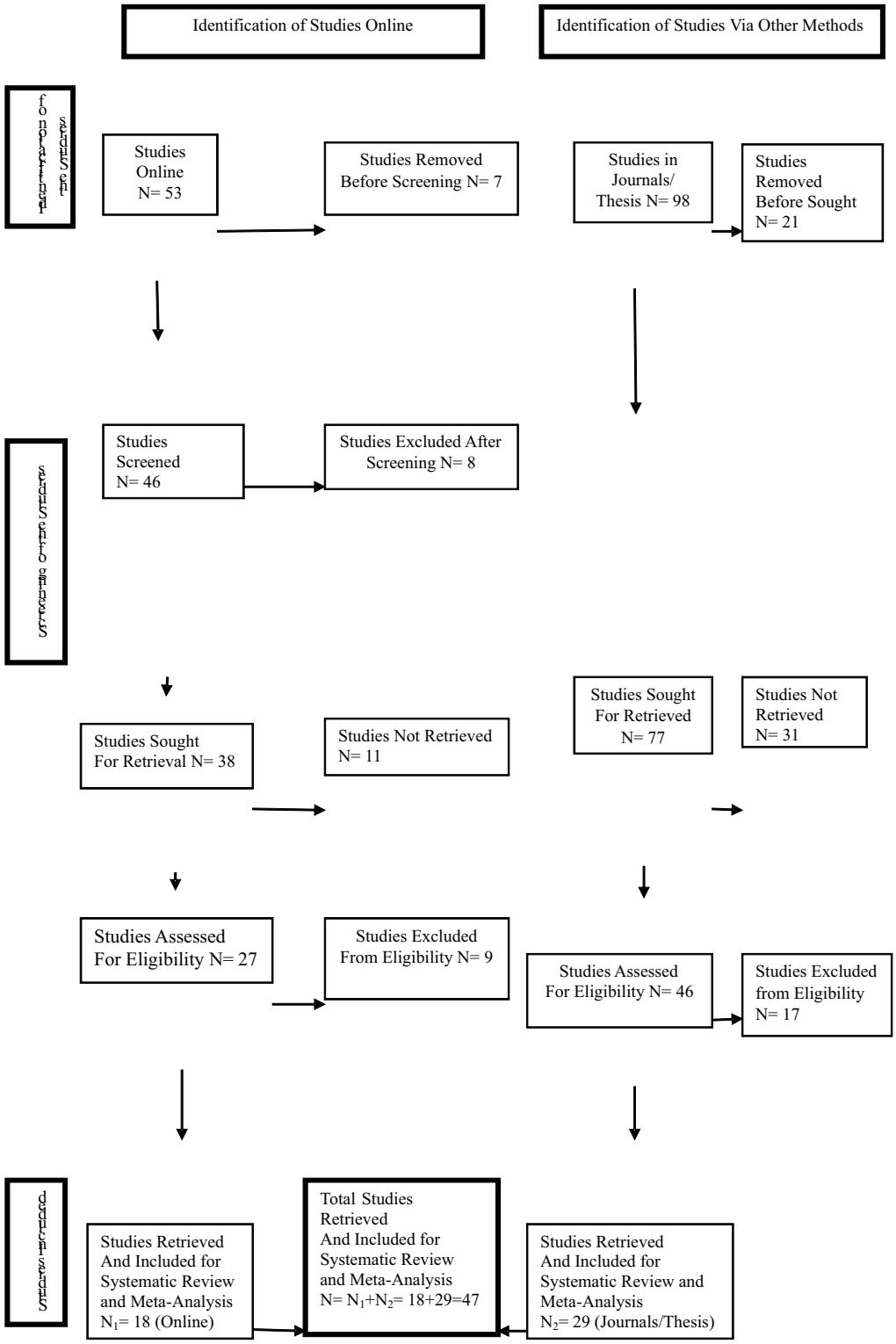
For F-test conversion to t, $t = \frac{2r}{\sqrt{1-r^2}} X \sqrt{N-2}$ - - - 8

Method

The study adopted survey research design of systematic and meta-analytic review using preferred Reporting Items for Systematic and Meta-analysis (PRISMA- See fig 4 below). The area of the study is Nigeria and the population was 47 studies, comprised Secondary School students' academic achievement in Science in Nigeria. The sampling techniques used were purposive and snowballing. The instrument for data collection was pro-forma titled "Coding Sheet for Meta-analysis of the Effectiveness of ICT Teaching Strategies on Secondary School Students' Academic Achievement in Science in Nigeria". The pro-forma was validated by three experts in Measurement and Evaluation and one expert from Mathematics Education. The internal consistency reliability value of 0.96 was obtained using inter-rater reliability. Data were collected by searching published and unpublished studies on effectiveness of ICT teaching strategies on secondary school students' academic achievement in Science in Nigeria. These included online and hard copies articles on journals, Master's and Doctorate Degree Theses as shown Fig. 4 below: This sample was drawn with the aid of PRISMA adaption.

Figure 4

Adapted PRISMA 2020 flow Chart/Diagram for Data Collection in Systematic Review and Meta-Analysis



(Source: Ochei, 2024)

The data collected were analyzed with percentage, average weighted Z, Fisher Transformation Table, effect size using Cohen's (1998) interpretation for the three research questions. The guidelines provided by Cohen for interpretation are: effect size $d < 0.2$ represents a small effect (shows a slight difference between groups); $0.2 \leq d < 0.5$ represents a medium effect size (it is likely noticeable in practical terms) while $d \geq 0.5$ represents a large effect (shows a significant difference between groups). Studies included in the study met the following criteria: the studies were conducted on ICT based teaching on secondary school students' achievement in science within Nigeria (Area of previous studies). The reviewed have comparison groups; were based on test statistics such as t-test, f-test or easily converted to effect size and presented adequate data such as sample size, mean, standard deviation to enable calculation of effect size. Observational studies that reported effect sizes related to ICT interventions as well as studies that reported effect sizes (Cohen's d, Pearson's r, odds ratios) to assess the magnitude and variation of ICT's impact were included in the study. Whereas, studies that were conducted on ICT based teaching on secondary school students' achievement but not in science within Nigeria, those conducted on ICT that were not having comparison groups; not based on test statistics such as t-test, f-test or easily converted to effect size and those that could not present adequate data such as sample size, mean, standard deviation to enable calculation of effect size were excluded from the study. Observational studies that did not reported effect sizes related to ICT interventions as well as those that did not report effect sizes (Cohen's d, Pearson's r, odds ratios) to assess the magnitude and variation of ICT's impact were equally excluded in the study

Results

The results of the study are presented in line with the research questions below:

Research Question 1: What is the summary of the results of the positive and negative statistically significant and non-significant cases of all the studies investigated on ICT teaching strategies (these include computer games, video games, projector, audio like radio, audio-visual television and phones among other) on Junior and Senior Secondary School Students' academic achievement in Science in Nigeria?

Table 1:

Percentage Summary of the Results of Statistically Significant and Non -Significant Cases of Previous Studies Investigated

	Total Studies		Statistically Significant Studies				Statistically Non-significant Studies			
School Category	Number of Studies	(%)	Positive		Negative		Positive		Negative	
			Number	(%)	Number	(%)	Number	(%)	Number	(%)
Junior	22	46.81	15	31.91	0	0	6	12.77	1	2.13
Senior	25	53.19	17	36.17	3	6.38	4	8.51	1	2.13
Total	47	100	32	68.08	3	6.38	10	21.28	2	4.26

The results in Table 1 show the percentages of data collected and analyzed on ICT based teaching strategies on Junior and Senior Secondary School students' academic achievement in Science in Nigeria. Table 1 reveals that 22 studies with 46.81% in Junior Secondary Schools and 25 studies with 53.19% in Senior Secondary Schools were reviewed for statistical significant and non-significant effects on ICT based teaching strategies on Secondary School students' academic achievement in Science in Nigeria. Junior Secondary School had 15(31.91%) positive significant studies and 0(0%) negative significant study and in the Senior Secondary School, 17(36.17%) positive significant studies and 3(6.38%) negative significant studies. In addition, 6(12.77%) from reviewed studies in Junior Secondary School and 4(8.51%) from Senior Secondary School were positively statistically non-significant (this might be due to chance rather that representing a real effect) while 1(2.13%) from both Junior and Senior Secondary Schools were negatively non-significant (this negative effect may have occurred by chance).

Research Question 2: What is the quality of mean effect size (large, medium and small) for the studies investigated on ICT teaching strategies on Junior and Senior Secondary School students' academic achievement in Science in Nigeria?

To answer this research question, data on the quality of mean effect size (large, medium and small) for the studies investigated on ICT based teaching strategies on secondary school students' academic achievement in Science were collected and analyzed using percentage as shown in Table 2.

Table 2:

Percentage of the Quality of Mean Effect Size (Large, Medium and Small) for the Studies Investigated

Quality of Effect Size	School Category					
	Junior	(%)	Senior	(%)	Total	(%)
Small	6(27.27%)	12.77	12(48%)	25.53	18	38.30
Medium	1(4.55%)	2.13	3(12%)	6.38	4	8.51
Large	15(68.18%)	31.91	10(40%)	21.28	25	53.19
Total	22(100%)	46.81	25(100%)	53.19	47	100

The results present in Table 2 reveal the percentage values of the quality of the mean effect size based on small, medium and large from Cohen's d effect size interpretation on Junior and Senior Secondary Schools studies reviewed on ICT based teaching strategies on students' academic achievement in science in Nigeria. Table 2 shows that the Junior Secondary Schools had small effect size 6 (27.27%), medium effect size 1 (4.55%) and large effect size 15 (68.18%) and Senior Secondary Schools had small effect size 12(48%), medium effect size 3(12%) and 10(40%) respectively. These reveal that Junior Schools of 15(68.18%) has high quality large effect size against the Senior Secondary Schools of 10(40%), Junior Schools of 1 (4.55%) had medium quality effect size against the Senior Secondary schools of 3(12%) and Junior Schools has low

quality small effect size of 6(27.27%) against the Senior Schools of 12(48%).

Research Question 3: What is the variation of effect size on all the studies investigated on ICT teaching strategies on Junior and Senior Secondary school students' academic achievement in Science in Nigeria?

Table 3:

Variation of Effect Size on all the Studies Investigated on ICT Based Teaching Strategies on Junior and Senior Secondary School Students

School Category	Number of Studies	$\sum(N-3)$	$\sum$ Weigh	Average Zr	r-value average Zr	d-value of r	Cohen's Interpretation	(%) Variance	Variation (d)	(%) Variation
Junior	22	3515	1221.513	0.348	0.335	0.711	Large	11.200	0.184	4.700
Senior	25	4192	1085.849	0.259	0.255	0.527	Large	6.500		
Total	**47**	**7707**	**2307.362**	0.607	0.590	1.238	Large	11.7	0.184	4.700

The results of the analysis of the data collected on the variation of effect size on all the studies investigated on ICT based teaching strategies on Junior and Senior Secondary School students' academic achievement in Science in Nigeria is presented in Table 3. This table reveals the Cohen's effect size d-value, the variation in the d values and the percentage variation of ICT teaching strategies on Junior and Senior Secondary School students' academic achievement in Science. The results show that the Cohen's d-values of effect sizes of 0.711 for junior and 0.527 for

senior students indicate by Cohen's interpretation that the ICT teaching strategies on Junior and Senior Secondary School students' academic achievement in Science in Nigeria is high, significant and in the positive direction. The results with the values of percentage variations of 11.200% and 6.500% respectively for Junior and Senior Secondary school students deduce that 11.200% and 6.500% quantity of academic achievement in Science in Nigeria are attribute to the utilization of ICT based teaching strategies in sciences in Nigeria. However, the values of the variations of Cohen's d effect size of 0.184 and 4.7% indicate that the effect size variation from Cohen's interpretation is small, non-significant, and in the positive direction, with a lower 4.7% amount of academic achievement in Science attributed to the use of ICT-based teaching strategies in Nigeria. Hence, the variation of effect size on ICT based teaching strategies on junior and senior secondary school students' academic achievement in Science in Nigeria is not significant.

Discussion

The findings show that ICT teaching strategies have positive large effect sizes of 0.711 and 0.527 (Cohen's d effect sizes) for Junior and Senior Secondary School students' academic achievement in Science in Nigeria with the percentage variances of 11.20% and 6.50% respectively attributed to ICT teaching strategies utilization. In other words, students' academic achievement rose by 11.20%, 6.50%, and 8.40%, respectively, when ICT teaching methodologies were used in science classes in junior and senior secondary schools in Nigeria. Sitzmann (2013) metallically found that high-effect-size computer-based simulation games are not passive or stand-alone instructions, but rather a supplement to other teaching tactics. This finding agrees with the finding of this study that reveals that ICT teaching strategies have high impact on students' academic achievement, because it mitigate the learners from sitting down and imbibing from the teacher passively.

ICT teaching strategies make learners/students to be active and to fully participate in the teaching-learning processes. Zohreh, Ali and Mehdi, (2011) analytically confirmed that ICT has a significant effect on educational improvement based on the effect size when it is large. This is because teaching strategies predict numbers of educational outcomes in secondary school levels.

Again, Ugwuanyi, (2014) found positive large effect size of teaching strategies on students' academic achievement in mathematics which is highly applicable in this study as in the area of science. ICT teaching strategies help the students in easy assimilation, understanding and comprehension for long term memories. Ugwuanyi, (2015) discovered positive large effect sizes of different teaching strategies on students' academic achievement, interest and retention in mathematics that can aid easy understanding of science subjects. Therefore, the impact of ICT based teaching strategies especially in science subjects cannot be overemphasized. This concurred with the present study that has discovered high effectiveness of ICT teaching strategies on students' academic achievement in Science.

The results indicate that the percentage variance of 4.7% and the effect size variation of 0.184 are both small. This suggests that ICT teaching methods improve the academic performance of junior and senior secondary school pupils in Nigeria in the subject of science. Schenker, (2007) discovered that technology use, often with video simulation games or tutorial software programmes showed larger effect sizes than other types. This means that technologies teaching strategies are more effective than other teaching strategies like lecture, verbal discussion and explanation among others. Mustapha, (2010) found that video games strategies were pretty more effective than traditional strategies in science due to the large effect size meta-analytically computed. It means, students learn more when instructions are made more real and visible to see and hear for active involvement and participation. Means, Murpy and Karla, (2010) found that the outcome of online learning strategies exceeded that of students who received traditional instructions. This implies that students are more excited in learning when asked to operate these technological devices on their own. In terms of learning, technological strategies are more effective and motivating than conventional strategies (Wouters, Nimegen, Oostendorp, Herre & Erik, 2013). Learners in serious technological instructions learned more relative to those with conventional instructions (Peter, Christof, Herre and Erik, 2013). This is because technological instructions are highly motivating to understanding and retention. However, the variation on effect size in academic achievement on class levels/categories may occur due to different teaching

strategies. Ugwuanyi, (2014) found that variation on effect sizes are associated with five teaching strategies examined under students' academic achievement, retention and interest in science. Consequently, one of the best teaching strategies as in the case of this study is ICT based teaching strategies. All the findings here have confirmed the findings of the present study that ICT based teaching strategies are effective in teaching with high effect size but variations occurred in the comparison of different teaching strategies (computer games, video games, projector, audio like radio, audio-visual television and phones among other). ICT teaching strategies could be supplemented with other teaching strategies in Secondary Schools for students' academic achievement in Science to be enhanced.

Conclusion

In line with the findings of the study, it was concluded that ICT teaching strategies showed positively large magnitude, statistical significant effects and small variation on Secondary School students' academic achievement in Science in Nigeria. It thus means that utilization of ICT-based teaching strategies in Secondary School Science subjects facilitate and enhance the students' academic achievement in Nigeria. Finally, ICT teaching strategies have proven to be significantly effective in teaching and learning of Sciences at both the Junior and Senior Secondary School levels and enhances students' academic achievement in science in Nigeria.

Recommendation

Based on the findings of the study, it is recommended that ICT teaching strategies be utilized in teaching Secondary School students to improve academic achievement in Science in Nigeria. It is also recommended that ICT teaching strategies for students' academic achievement should be advanced through teacher training and development programmes.

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