Innovations

# Effects ofMetacognition on theLearning OutcomesofBiology StudentsinSecondary SchoolsinDelta State, Nigeria

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**Abstract**

This study examined the effects of meta-cognition on the learning outcomes of biology students in secondary schools in Delta State, Nigeria. The study was a pretest-posttest control group quasi-experimental study. The study population comprised all biology students in public senior secondary schools. Using a stratified random sampling technique, the study sample was three hundred and sixty (360) biology students drawn from six (6) schools. The Biology Learning Outcomes Test (BLOT) and Metacognitive Prompt were used to aid data collection. Data gathered were analysed employing mean, standard deviation and t-test. The study's major findings are that; there is significant difference between the posttest of biology students instructed with the meta-cognitive method and those instructed with the lecture method. Furthermore, there is no significant statistical difference between female and male biology students' posttest marks with meta-cognitive strategy. Thus, the study concluded that meta-cognition is a major variable that affects biology students' learning outcomes in secondary schools. The study recommends that the government, through the Education Ministry, should train teachers to acquire the meta-cognitive skill to help them teach more effectively, efficiently and make the teaching-learning process more meaningful and, as a result, improve biology students learning outcomes.

**Keywords:** 1.Metacognition 2.Biology;Biology Students 3. Learning Outcome 4.Secondary Schools

## Introduction

Biology is a branch or subdivision of science that deals with studying life (living things). The significance of Biology to the nation or society cannot be overemphasised. This is why All students offer biology as a subject in senior secondary schools. Biology is part of the core/compulsory science subjects students are exposed to in all Nigeria secondary schools. Biology teaching begins from kindergarten through primaryor lower basic to secondary and tertiary institutions. The Biology curriculum as a teaching syllabus has its objectives derived from the Federal Republic of Nigeria  (2013) in her national policy on education. The objectives of Biology curriculum in secondary school in Nigeria are as follows:

i. To enable the children to appreciate how their environments are related to them and are related to their environment;
ii. To prepare the students for higher education and to have an interest in a Biology career, for example, medicine;
iii. To enable the individuals to understand their body, their functions, for example, circulation of blood, respiration, excretion, etc.
iv. To enable the children to acquire scientific skills. These include field skills and laboratory
v. To enable the individual to understand specific essential Biology contents necessary for a successful living
vi. To inculcate the habit of critical observation
vii. To enable the individual to question some superstitious beliefs
viii. To illuminate the problem of sex, reproduction, population, growth, pollution, disease control, health, food production for societal benefit
ix. To make room for technological advancement
x. To increase the students' aesthetic appreciation of nature.

Cognitive goals are defined mainly by the school systems that cut across several or multiple subject areas or attain understanding and knowledge in a definite intellectual domain (history, literacy, numeracy, science). Meta-cognition is seen as "thinking about your thinking". Metacognition is one thinking ability and the control of one's learning and mental processes. It is essential all aspects of school and life, as it has to do with self-reflection on one's strategies, future goals, present position, potential actions, and results. At its centre, it is a fundamental survival strategy. It typically depends on reflecting on one's skills, knowledge and modifying the vital approaches to learning. It is an evident fact that better meta-cognitive skills improve the problem-solving skills and abilities of the individual. It involves the entire or total mental processes comprising:

- Problem-solving
- Gaining knowledge
- Thinking
- Being comprehensive

Metacognition has also implied the process of pulling back and appraising one's performance or action. Metacognition is of great importance in teaching and learning. It helps teachers convey the responsibility to students to watch their learning. This helps the students or learners to become self-directed learners and take control of their learning. Metacognition helps students develop helpful problem-solving strategies or skills. In the teaching-learning process, metacognition helps students unlock their brains' tremendous power and take control of their learning. Metacognitive skills help students acquire creative problem-solving skills, think analytically, communicate effectively and collaborate with others. It makes the students active in class and also makes the teaching-learning process enjoyable.

Zohar and Barzilai (2013) stated that self-regulated learners have the cognitive and metacognitive abilities, skills, attitudes, and motivational beliefs needed to directly monitor and understand their learning. Zohar and Barzilai, amongst others, argued that for a student to learn and successfully achieve, he must act and be involvedin the learning process and monitor, plan, and regulate his cognitive processes. Therefore,the focus is drawn to the significance of metacognitive capabilities in learning (Efklides, 2009). The significance of meta-cognition for high-quality learning and problem-solving is generally accepted (Zimmerman, 2000), and this has resulted in interest in learning experiences creation beneficial for developing the use of meta-cognitive prompting. Metacognition connotes the ability and the skill to scrutinise or ascertain how one processes feelings and judgement. This ability or skill helps students understand or comprehend how best to learn, develop self-awareness skills, and work best to become vital as they grow older.

Mevarech and Fridkin (2006) studied the impact of metacognitive intervention on learners' metacognitive regulation and mathematics achievement, while Nashon and Nielsen (2011) investigated the link between students' analytical thinking in physics problem-solving and their self-regulation and metacognition. Both studies concluded that metacognitive awareness could improve students' learning and, accordingly, learning outcomes. The diverse or various reflective methods such as guided reflection, self-reflection, and metacognitive stimulation help empower the students' learning, achievement, and awareness level (Lai, 2011; Davis, 2003). Davis (2003) studied generic role (stop and think) and directed reflection or prompts (hints about what to think about) of 180 students of middle school after a unit in physics about heat flow and energy conversion. The students were made to reflect eleven times after analysing and critiquing a news article about the topic. The study reported that students that did not reflect or whose reflections lacked quality obtained less successful results. According to Nietfield, Cao and Osborne (2005) and Narang and Saini (2013), metacognition significantly correlates with students' learning outcomes. Some of these researchers reported that explicit metacognitive training could enhance students' metacognition and promote learning. They view that students/learners who exhibit a wide array of meta-cognitive skills and possess meta-cognitive knowledge appear to be successful for they can self-regulate their learning, retain or recall information longer, and improve in their learning outcome.

Learning outcomes signifies performance that indicates the degree to which an individual or a person has accomplished specific set goals/objectives that emphasise or centre of activities/actions in instructional environment and atmospheres, especially in schools. Thus, learning outcomescould be seen as a multifaceted or multidimensional construct encompassing different domains or areas of learning. This is due to the fact that learning outcome is vast and covers several educational outcomes or performance areas. The description of learning outcome rest on the indicators of measurement used. Among the various criteria or conditions that specify learning outcome, the general or common indicators include declarative and procedural knowledge attained in an educational sector or system, curricula-based criteria, grades on an achievement test, and cumulative/aggregate achievement like educational certificates and degrees(Obro, Ogheneaokoke&Akpochafo, 2021). Learning outcomes are generally measured through continuous assessments or examinations, but there is no agreement on how best to evaluate it or which areas are most vital – procedural knowledge, declarative knowledge or skills, for example, facts. There are two (2) main factors affecting or hindering learning outcomes. These are:

- Cognitive factors- intelligence
- Non-Cognitive skills/factors: These are sets of "attitudes, strategies and behaviours" that promote and stimulate professional and academic enhancement, namely academic expectancy, self-control, self-efficacy, emotional intelligence and determination goal-setting and motivation theories.

The term non-cognitive factors are dissimilar to cognitive factors/elements that teachers measured using quizzes and tests. However, non-cognitive skills and knowledge are progressively attaining popularity, for they offer a better explanation for professional and academic outcomes (Heckman, Stixrud& Sergio, 2006).

This study provided empirical proof by investigating the effect of meta-cognition on biology students learning outcomes. This study used sex as an intervening variable.

**Research Questions**

These research questions directed the study:

1. Is there a difference in the posttest markss of Biology students instructed with the metacognitive method and those instructed with the lecture method?
2. Is there a difference in the posttest marks between male and female Biology students exposed to the metacognitive method?

**Hypotheses**

i. There will be no significant difference in the posttest scores of biology students instructed with the metacognitive method and those instructed with the lecture method.

ii. There will be no statistically significant difference in posttest scores between male and female biology students instructed with the metacognitive method.

## Literature Review

### Concept of Metacognition

Metacognition is derived from two words, 'meta' meaning 'beyond' or 'at a higher level' and cognition, meaning 'the process/course of understanding, knowing, or learning something. Therefore, metacognition is defined as 'cognition about cognition', 'knowing about knowing', 'becoming aware of one's awareness and 'higher-order thinking skills (Hunt, 2006). Metacognition which means cognition about cognition, came into being as an essential mental ability for solving problems when psychologists began to probe children's intelligence, how they involve in and learning problem-solving.

The conception of metacognition was introduced by John Hurley Flavell, in 1976 when he used the term "metacognition aspects of problem-solving". After a few years, Brown, a developmental psychologist, adopted the term in his study.

Researchers and scholars in cognitive psychology have presented the following definitions:

- Awareness and management of individual's thought (Kuhn & Dean, 2004),
- The thought control and monitoring

Metacognition, according to Kuhn and Dean (2004), enables students to be taught with a particular strategy or method in a specific problem or situation context to retrieve or recall and deploy that method in a related but new way and context. Theyasserted that metacognition in cognitive psychology is a method or kind of executive control encompassing self-regulation/control and monitoring, a point echoed by other researchers (Schneider & Locke, 2002).

### MetacognitionComponents

Schraw, Crippen and Hartley (2006) and Whitebreadet al (2009) classified metacognition into two main components:

i. Metacognitive knowledge or knowledge about cognition
ii. Metacognitive regulation or control/monitoring of cognition

Numerous frameworks/structures have been advanced for categorising types of metacognitive components. For instance, lots of researchers and scholars have applied the concepts/terms of conditional knowledge, procedural and declarative, to distinguish metacognitive knowledge types (Kuhn & Dean, 2004; Schraw et al., 2006).

It is characteriseby declarative knowledge primarily as epistemological understanding or the understanding or comprehension of thinking and knowledge generally (Kuhn & Dean, 2004). Schraw et al. (2006) describe declarative knowledge as onesknowledge as a learner and the factors that might impact one's productivity or achievement. Alternatively, procedural knowledge implied management and awareness of cognition, comprising knowledge about strategies (Kuhn & Dean, 2004; Schraw, etal., 2006). Schraw, etal. (2006) also differentiate conditional or restrictive knowledge, which is knowing when and why to utilise a given strategy. The other metacognition component is metacognitive regulation which numerous researchers argued includes three regulatory skills of planning, monitoring and evaluating (Schraw, etal, 2006; Whitebread et al., 2009).

**Planning:** This involves identifying and choosing appropriate strategies and resources. It can comprise activating background knowledge, goalsetting and budgeting time.

**Monitoring:** This involves awareness of comprehension and task performance. It can include self-testing or self-questioning.

**Evaluating:** This involves appraisal of the judgment of outcomes and the efficacy of the regulation process if it matched the task goals. It includes revisiting and revising one's goals.

**Metacognitive Methods/Prompts**

These methods or sequential processes control cognitive activities/actions and guarantee that a cognitive goal (an example is text understanding) has been attained. These processes help to control and manage learning. It consists of planning and monitoring cognitive activities actions and checking the effects or outcomes of those activities. An example is that after reading or studying a text paragraph, the student may ask herself about the concept deliberated on or discussed in a paragraph. The cognitive goal is for her to comprehend the text. One or part of the common metacognitive comprehension monitoring strategies is the self-questioning strategy. If she discovers that her own questions cannot be answered or does not understand or comprehend the material discussed or deliberated on, she would then determine or ascertain the actions to take toensure she meets the cognitive objective or goal of comprehending the text. She may choose to return to re-read the paragraph to offer answers to the questions generated. If she can now answer the questions after re-reading the text, she may determine that she understands the materials. Thus, metacognition is a method strategy of self-questioning applied to confirm that the aim or goal of comprehension is attained.

A diversity of strategies for stimulating meta-cognition have been explored (Davis, 2003; Kauffman, 2004; Kramarski&Gutman, 2006; Veeman, Kersebrom&Imthorn, 2000). Several of these approaches could be categorised into the broader classification of Metacognitive Prompting (M.P.), defined by Hoffman and Spatariu (2008) as "an externally made stimulus that triggers reflective cognition/ understanding and arouses strategy usage intending to stimulate and improve learning. Metacognitive Prompting (M.P.) has been denoted as metacognitive cueing (Veeman et al., 2000), reflective prompting (Davis, 2003), self-metacognitive questioning (Kramarski&Gutman, 2006). Metacognitive approach or strategy help students inculcate creative problem-solving skills, collaboration with others, think analytically, and effectively communicate. When metacognitive is applied by students/learners, they can reflect back and observe or discern their thinking/thought. This is sometimes described as a "reflective process". When this approach is in use, they tend to ask themselves these questions like these:

- What is the problem/issue to be solved?
- How will the problem be solved?
- How well and successful am I doing?
- How well and successful did I do?
- How can I solve the problem better successive time?

**Metacognition and Learning Outcomes**

Metacognition has been recounted to influence students learning outcomes. The work of some researchers on metacognition proves that metacognition relates with students' learning outcomes (Nierfield, Cao & Osborne, 2005,Narang& Saini, 2013). These researchers reported that students/learners who have metacognitive skills and knowledge exhibit a broad range of thinking or metacognitive abilities and skills incline to achieve or perform better. Metacognition is precisely that instrument that supports students in unlocking their brains' incredible power and being in control of their learning (Donna & Marcus, 2016). Students who exhibit metacognitive slills and knowledge accomplish more in examinations and complete tasks more effectively. This is due to the fact that they are self-regulated learners who utilise the "appropriate tool for the job" and adjust or modify their learning methods and skills based on their awareness of effectiveness. Individuals or persons with a high degree or intensity of metacognitive knowledge identify obstacles to learning quickly and change methods to ensure the realisation of stated objectives.

Convincing proof and data from the metacognition literature of researchers suggest that it is a powerful influencer of scholastic success and that aware learners are very strategic and do better than unaware learners (Ruban, 2000; Smitely, 2001). Researchers such as Dunning and Kruger (2003) showed that meta-cognition is avital influencer of studentslearning outcomes; students can effectively differentiate information known and unknown to them and are more probable to appraise and retain new information. Several studies (Lai, 2011) have indicated that meaningfulness of learning can be endowed by metacognition. Nashon and Nielsen (2011) have shown that metacognition is teachable and can enhance learning outcomes, self-regulation and problem-solving skills. The correlation between it (metacognition) and learning has been extensively examined in cognitive and educational psychology and classroom pedagogy.

Mevarech and Fridkin (2006) studied metacognitive intervention on learners' metacognitive regulation and mathematics learning outcome, while Nashon and Nielsen (2011) investigated the link between high school students' analytical thinking in physics problem-solving and their self-regulation and metacognition. Both studies concluded that metacognitive awareness could improve students' learning and, accordingly, learning outcomes. In addition, the different methods of reflection such as guided reflection, self-reflection and metacognitive help empower the students' learning, metacognitive awarenessleveland learning outcome (Lai, 2011; Davis, 2003).

Davis (2003) studied generic role (stop and think) and directed reflection or prompts (hints about what to think about) of 180 students after a unit in physics about heat flow and energy conversion. The study reported that students that did not reflect or whose reflections lacked quality obtained less successful results. Some researchers contended that metacognition relates with students' learning outcomes(Nietfield, Cao & Osborne, 2005,Narang& Saini, 2013). Therefore, some researchers believe that explicit metacognitive training can increaseor enrich students' learning outcome. Furthermore, they trust that students/learners with metacognitive knowledge who exhibit wide-ranging metacognitive skills seem to perform better.

**Metacognition and the Classroom**

Metacognition is essential in the learning and in the classroom for improve learning and learning outcome. Teachers can assist students in developing metacognitive capacities or skills and knowledge in the classroom using numerous methodscalled metacognitive prompts. Some metacognitive strategies that can be utilised to promote metacognition are:

- Self-questioning
- Reflective prompts
- Self – explanation
- Self-monitoring

Students/learners should be taught how to use these strategies.

To help students recognise their best learning strategy, the teacher should:

- Schedule or arrange a time for the students/learners to ponder the learning progression and observe how their skills/abilities and knowledge have changed or transformed.

- Provide opportunities and means for students/learners to ponder on the challenges for what to learn and what was less challenging or easy for them to learn or assimilate, and why, the study habit or strategy worked and the one that does not work and why;
- Inspire students to fathom how people develop answers/solutions (both right and wrong answers/solutions) and the procedures applied to get the answers.
- Provide activities that motivate or stimulate students to mirror their thinking.

Teachers should help students to advance metacognitive skills by using “prompts”, which are probing questions. In addition, teachers should monitor students’ progress and provide practices that enhance cognitive flexibility.

**Metacognitionand Science Education**

Science and Mathematics learning benefit various cognitive processes encompassed in problem-solving, reading and writing, inquiry learning (Veeman, 2012). Learning mathematics and science requires reading textbooks to gain conceptual knowledge, solve problems using reasoning, and apply formulas besides planning and conducting laboratory experiments. Supported with shreds of evidence of learning challenges or difficulties shows that specific issues are addressed in science education, precisely underdeveloped problem-solving skills, poor conceptualisation, and difficulty applying knowledge across disciplines. The literature regarding metacognition in science education supports several definitions of metacognition as the awareness of the learning process and the learners’ ability to think about thinking (Mevarech&Fridkin, 2006; Nashon& Nielsen, 2011).

However, little is done about metacognition processes in reading and problem-solving in science education (Lai, 2011). Learning by doing in the sciences and mathematics domain means learning to acquire content knowledge and to apply this knowledge to solve problems (Kramarski&Mevareh, 2003; Mevarech&Fridkin, 2006; Nashon& Nielsen, 2011; Veeman, 2012). Studies on the effect of metacognition in Sciences are mainly focused on problem-solving in physics, specifically to compare experts versus novice learners (Nashon& Nielsen, 2011). The issue of learners in Sciences and Mathematics is the superficial problem of analysis and the lack of other orientation activities that lead to losing track of problem-solving steps and strategies and being unsystematic with memory traces (Veeman, 2012).

## Gender Disparities in Science Learning Outcomes

Several researches and studies have concentrated on gender differences/disparities in science learning outcomes (Kauffman, 2004, Britner&Pajares, 2006,Abu-Hola, 2005,Kaure, 2010). However, present assessments prove that gender differences have narrowed down (Britner&Pajares, 2006). Abu-Hola (2005) established a difference between male and female students' achievement in science, being that the females outperformed the male students.

## Methodology

This study employed aquasi-experimental design. The study population comprised13,882 biology students in all Senior Secondary IIin 2017/2018 academic year. The study made use of the stratified random sampling technique. This technique was used to arrive at a sample size of 360 students from six selected schools in the locality. The data collection instrument/tool was the Biology Learning Outcome Test (BLOT) and Metacognitive Prompts (M.P.). The statistics utilisedfor the analysis of data were mean, standard deviation and t-test.

# Results

**Research Question 1:**
Is there a difference between students' posttest marks exposed to the metacognitive method and those exposed to the lecture method?

**Table 1: Difference in posttest marks of students taught with the metacognitive method and those taught with lecture method**

| Teaching Method | N | ($\bar{x}$) | SD |
|---|---|---|---|
| Metacognitive Teaching Method | 115 | 68.47 | 9.35 |
| Lecture Method | 115 | 45.15 | 4.31 |

Table 1 shows the difference in posttest marks between students exposed to the metacognitive method and those exposed to the lecture method. The result shows that students exposed to the metacognitive method had a mean score of 68.47, while those exposed to the lecture method had a mean score of 45.15. This indicates a difference in learning outcomes between the two teaching methods in favour of the metacognitive method.

**Hypothesis 1:**
There will be no significant difference between posttest marks of students instructed with the metacognitive method and those instructed with the lecture method

**Table 2: t-test analysis of the difference between posttest marks of students instructed with the metacognitive method and those instructed with lecture method**

| Teaching Method | N | ($\bar{x}$) | SD | T | P | Decision |
|---|---|---|---|---|---|---|
| Metacognitive Method | 115 | 68.47 | 9.35 | 40.87 | 0.000 | Significant |
| Lecture Method | 115 | 45.15 | 4.31 | | | |

$P<.05$

Table 2 shows an analysis of the difference between posttest marks of students instructed with the metacognitive method and those instructed with the lecture method. From the result, the p-value is less than 0.05 level of significance. Hence, the null hypothesis is rejected. This connotes a significant difference between posttest marks of students instructed with the metacognitive method and those instructed with the lecture method, favouring those instructed with the metacognitive method.

**Research Question 2:**
Is there a difference in the posttest marks between male and female students instructed with the metacognitive method?

**Table 3: Difference in the posttest marks between male and female students instructed with the metacognitive method**

| Sex | N | Mean ($\bar{x}$) | SD |
|---|---|---|---|
| Male | 57 | 67.84 | 9.24 |
| Female | 58 | 69.09 | 9.46 |

Table 3 shows posttest marks between male and female students taught with the metacognitive method. Male students had a mean score of 67.84, while female students had a mean score of 69.09. This means a difference in learning outcomes between male and female students taught with the metacognitive methodfavouring female students.

**Hypothesis 2:**
There will be no significant difference in the posttest marks between male and female students instructed with the metacognitive method.

**Table 4: t-test analysis of the difference in the posttest marks between male and female students instructedwith the metacognitive method**

| Sex | N | ($\bar{x}$) | SD | T | p | Decision |
|---|---|---|---|---|---|---|
| Male | 57 | 67.84 | 9.24 | 1.54 | 0.13 | Not Significant |
| Female | 58 | 69.09 | 9.46 | | | |

$P>.05$

The result of table 4 shows an independent-samples t-test, which was conducted to compare the difference in the posttest between male and female students instructed with the metacognitive method. The result showed that t=1.54, p>0.05. Hence the null hypothesis is accepted. This implies that no significant difference in the posttest marks existed between male and female students instructed with the metacognitive method.

## Discussion of Findings

### Metacognition and Biology Students' Learning Outcomes

The data analysed (research question 1 and hypothesis 1) on tables 1 and 2 showed a significant difference between the posttest marks of biology students exposed to the metacognitive method and those exposed to the lecture method. The results demonstrated a clear difference in the posttest marks of biology students in the metacognition group and those in the control group. The biology students in the metacognition group performed better than those in the lecture method group. This may be because as students in the metacognition group are exposed to the metacognitive method, their ability to think, reflect, monitor and control their learning increases, and as a result, their learning outcomes increased as well as can be seen in their posttest marks. This finding is in line with the work of Nietfield, Cao and Osborne (2005), Nzewi and Ibeneme (2011); Narang and Saini (2013); Donna and Marcus (2016), who concluded that metacognition is a strong predictor of learning outcomes.

### Sex differences and Biology Learning Outcomes

Results from research question 2 and hypothesis 2 on tables 3 and 4 show no significant difference between the marks of male and female biology students instructed with metacognitive teaching strategy and lecture method. This showed that the learning outcomesof male and female biology students instructed using the metacognitive method did not differ. Furthermore, self-efficacy strategy and lecture method were not affected by students gender. This finding agreed with that of David and Stanley (2000), Arigbabu and Mji (2004); Nwagbo and Obiekwe (2010);Nbina (2012),Ogheneakoke, Obro andBenike (2019), who revealed that there is no significant difference between male and female students' learning outcomes in science.

### Conclusion

The study examined the effects of metacognition on the learning outcomes of biology students in secondary schools in Delta State. From the study findings, the following conclusions were drawn

- Metacognitive strategy influenced biology students learning outcomes.
- Students gender has no significant effect on the learning outcomes of biology students in secondary schools.

**Recommendations**

Arising from the conclusion, the following recommendations are made:

i. Biology teachers should teach their students using metacognitive methods/strategies. This strategy will help the students to think, reflect, monitor and take charge of their learning, boost students confidence in their ability to perform a task successfully, understand the importance of effort and persistence, spend longer time in their school work and not give up in the face of difficulties. These strategies will help them to achieve better results academically.

ii. Irrespective of gender, Students should be encouraged and sensitised to offer science subjects.

iii. Through the Ministry of Education, the government should organise seminars and workshops to train teachers on metacognitive instructional strategy. Once these teachers have acquired these skills, they will teach efficiently and help their students perform better academically. This will help improve the teaching-learning process and produce students who are skilful thinkers and able to self-regulate their learning.

**References**


1. *Abu-Hola, I. (2005). Uncovering gender differences in science achievement and attitude towards Science for Jordanian primary pupils. Damascus University Journal, 21(1), 19- 40.*
2. *Arigbabu, A.A.,&Mji, A. (2004). Is gender a factor in mathematics performance among Nigerian pre-service teachers? Sex Role, 51(11 & 12), 749.*
3. *Britner, S.L.,&Pajares, F. (2006). Sources of Science self-efficacy beliefs of middle school students. Journal of Research in Science Teaching, 43(5), 485.*
4. *Brown, A.L. (1978) Knowing when, where and how to remember: A problem of metacognition. Advances in Instructional Psychology, 7(1), 22-28.*
5. *Carr, M., Kurtz, B. E., Schneider, W., Turner, L.A.,&Borkowski, J.G. (1989). Strategy acquisition and transfer among German and American children; environmental influences on metacognitive development. Developmental Psychology, 25, 765-771.*
6. *Davis, E.A. (2003) Prompting middle school science students for reflection: Generic and directed prompts. The Journal of the Learning Sciences. 12(1), 91-142.*
7. *Donna, W.,& Marcus, C. (2016). Teaching students to drive their brains: Metacognitive strategies, activities and lesson ideas. ASCE: 1903 North Beauregard St Alexandria, Va.22311-1714.*
8. *Dunning, D.,& Kruger, J.(2003). Why people fail to recognise their own incompetence. Current Directions Psychology in Science,12(3), 83-87.*
9. *Efklides, A. (2009). The Roles of metacognition experiences in the learning process: psicothema, 21CD. 76-82.*
10. *Federal Republic of Nigeria (2013). National policy on education (6$^{th}$ edition). Abuja. Federal Government Press.*
11. *Flavell, J.H. (1976). Metacognitive aspect of problem-solving. In L.B. Resnick (Ed). The nature of intelligence. New Jersey: Lawrence Eribaum. Pp 231- 235*
12. *Heckman, J., Stixrud, J. & Sergio, U. (2006). The effect of cognitive and non-cognitive abilities on labour market outcomes and social behaviour. Journal of Labour Economics,24(3), 411-482.*

13. *Hoffman, B.,&Spatariu, A. (2008). The influence of self-efficacy and metacognitive prompting on mathematics problem-solving efficiency. Contemporary Educational Psychology,33, 875-893.*
14. *Kauffman, D. F. (2004). Self-regulated learning in web-based environments: Instructional tools designed to facilitate cognitive strategy use; metacognitive processing and motivational beliefs. Journal of Educational Computing Research,30, 139-161.*
15. *Kramarski, B.,&Gutman, M. (2006). How can self-regulated learning be supported in mathematical E-learning environments? Journal of Computer Assisted Learning,22, 24-33.*
16. *Kuhn, D.,& Dean, D. (2004). A bridge between cognitive psychology and educational practice. Theory into Practice, 43(4), 268-273.*
17. *Lai, E. R. (2011). Metacognition: A literature review. U.K.: Pearson.*
18. *Mevarech, Z.,&Fridkin, S. (2006). The effects of improve on mathematical knowledge, mathematical reasoning and metacognition. Metacognition and Learning, 1(1), 85-97.*
19. *Narang, D.,& Saini, S. (2013). Metacognition and Academic achievement in rural adolescents. Study Home Computer Science, 7(3), 167-175.*
20. *Nashon, S., & Nielsen, W. (2011). Connecting student self-regulation, metacognition and learning to analogical thinking in a physics problem-solving discourse. Educational Research Journal, 1(5), 68-83.*
21. *Nbina, J. B. (2012). The effect of instruction in metacognitive self-assessment strategy on chemistry self-efficacy and achievement of senior secondary school students in Rivers State, Nigeria. Journal of Research in Education, 3(2), 83-94.*
22. *Nietfield, J.L., Cao, L.,& Osborne, J.W (2005).Metacognitive. monitoring accuracy and student performance in the post-secondary classroom. The Journal of Experimental Education,74(1), 7-28*
23. *Nwagbo, C., & Obiekwe, C. (2010). Effect of constructivist instructional approach on students' achievement in basic ecological concepts in Biology. Journal of Science Teachers Association of Nigeria, 45(1&2), 26-35.*
24. *Nzewi, U.,&Ibeneme, A.N. (2011). The effect of cueing as instructional scaffolding on students achievement in Biology. Journal of the Science Teachers Association of Nigeria46(1), 35-44.*
25. *Obro, S., Ogheneaokoke, C. E., &Akpochafo, W. P. (2021). Effective social studiespedagogy: Effect of simulation games and brainstorming strategies on students'learning outcome. International Journal of Learning, Teaching and Educational Research, 20(3), 1-17.*
26. *Ogheneakoke, C. E., Obro, S., &Benike, J. (2019). In search of a more effective strategy: Using simulation games instructional strategy for the teaching and learning of social studies in secondary school. Journal of International Social Studies, 9(1), 53-71.*
27. *Ruban. L.M. (2000). Patterns of self-regulated learning and academic achievement among university students with and without learning disabilities. Unpublished Doctoral, Dissertation, University of Connecticut, U.S.A.*
28. *Schnieder, W.,& Locke, K. (2002). The development of metacognitive knowledge in children and adolescents. In Perfect, T. & Schwartz, B. (Eds). Applied metacognition. Cambridge, UK: Cambridge University Press.*
29. *Schraw, G., Crippen, K. J.,& Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. Research in Science Education, 36(2), 111-139.*
30. *Smitely, B. I. (2001). Factors predicting academic adjustment among college students with learning disabilities. Unpublished Doctoral Dissertation, University of Miami.*

31. *Veeman, M. (2012). Metacognition in science education: Definitions, constituents and their intricate relation with cognition. In A. Zohar & Y. Dori (Eds). Metacognition in science education; Trends in current research, Berkeley, C.A: Springer, CH2*
32. *Veeman, M.V.J., Hout-Wolters, B.H.A.M.,&Afflerbach, P.(2006). Metacognition and Learning: Conceptual and Methodological Considerations, Metacognition and Learning,1, 3-14.*
33. *Whitebread, D., Coltman, P., Pasternak, D., Sangster, C., Grau, V., Bingham, S., Almeqdad, Q.,&Demetriou, D. (2009). The development of two observational tools for assessing metacognition and self-regulated learning in young children. Metacognition and Learning, 4(1), 63-85.*
34. *Zimmerman, B. (2008). Investigating self-regulation and motivation: Historical background, methodological developments and future prospects. American Educational Research Journal, 45, 166-183.*
35. *Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In P.R.P. Boekaerts& M. Zeidner (Eds), Handbook of self regulation(PP 13-41). San Diego, CA, Academic Press.*
36. *Zohar, A.,&Barzilai, S. (2013). A review of research on metacognition in science education: Current and future directions. Studies in Science Education, 49(2), 121-169.*