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Enhancing Metacognitive Practices in Science Education Students Using the Intelligencies for Nation Building

Ibe, N. Helen, *Ph.D.*
Department of Life Science Education, Faculty of Education,
Imo State University, Owerri, Nigeria
E-mail: ibe.helen@yahoo.com
+2348033399024

Abstract

This study investigated how to enhance metacognitive practices in science education students using the intelligencies for nation building. The study adopted the survey design.180 undergraduate students were randomly sampled from the faculty of Education, Imo state university, Owerri. Seventeen item rating scale was used for data collection. The instrument was structured on a four point scale of Most Often (MO), Often (O), Rarely Often (RO) and Never (N). Three experts from Measurement and Evaluation (2) and one from Science Education scrutinized the instrument to ensure validity. The Cronbach Alpha Reliability Co-efficient was used to determine the reliability of the instrument and it yielded a reliability index of 0.78. The mean and standard deviation was used for answering the research questions. Any mean score below 2.50 was not upheld while a mean of 2.50 and above was accepted. Findings from the study show the following: the use of Linguistic intelligence to enhance metacognitive practices show that the learners are yet to use such strategy often since 13 out of the 14 items that elicited responses were below the cut-off mean while the use of Kinesthetic intelligence to enhance metacognitive practices show that the learners often use such strategy often since 2 out of the 3 items that elicited *responses were above the cut-off mean. It was recommended that teachers provide Questions for students to ask themselves as they plan, monitor, and evaluate their thinking within four learning contexts—in class, assignments, quizzes/exams, and the course as a whole. Also prompts for integrating metacognition into discussions of pairs during clicker activities, assignments, and quiz or exam preparation should be encouraged.*

Introduction

In one of the recommendations by Akpan (2010) on Science Education in Nigeria, the scholar recommended among others that Science and Technology teaching methods should be modernized to bring life back into science. This implies that teachers and trainee teachers maintain a reasonable level of pedagogical content knowledge and skills for nation building. Science and Technology hold the key to sustainable development and the corollary is that prominence must be given to science education in the nation's schools (Mbah, 2011). This capability has been defined as the extent to which countries access, utilize, and create science and technology for the solution of socio-economic problems. One of the most important goals of science education learning is to enhance science education knowledge, which includes biology concepts and skills in problem solving. Concerns have been raised by employers that most science graduates lack practical skills, team working as well as interpersonal skills. It is important that science graduates develop such skills since the majority of employers insist that the institutions educate all young people to be scientifically literate citizens who use scientific knowledge to solve the nations' problems thereby enhancing nation building.

It is clear that nations at the forefront of modern development, are those that have invested enormous resources over considerable time in three major areas: first in the establishment and nurturing of a stable, well-supported science and technology system; second, in the promotion of mission- oriented research in the basic sciences, coupled with long-term strategy for technology development; and third, in the institution of well-articulated programmes for the education of a large scientifically and technologically literate 'work force (Brown and Sarewitz, 2011).

To meet the needs of the 21st century learner and achieve the student outcomes described in its Framework, the Partnership calls on schools

- to adopt a 21st century curriculum that blends thinking and innovation skills; information, media, and ICT literacy; and life and career skills in context of core academic subjects and across interdisciplinary themes, and
- to employ methods of 21st century instruction that integrate innovative and research-proven teaching strategies, modern learning technologies, and real world resources and contexts.

- The 21st century learner must have skills for Reasoning which include analytical, critical thinking, and problem solving skills, Resilience which encompasses life skills such as flexibility, adaptability, self-reliance, and Responsibility.

As with curriculum, any number of pedagogical approaches may be successfully employed to build student competence in the skills and knowledge. One such approach is metacognitive strategy (practices) an instructional strategy in which "students investigate rich and challenging issues and topics, often in the context of real world problems." Metacognitive practice models may also include other aspects of 21st century instruction such as the use of interdisciplinary content, cooperative learning groups, and student reflection. Research has shown that because working with problems requires students to generate ideas and provide explanations, it promotes learning. Metacognitive practices learning also have been shown to increase students' active engagement with content, as well as their capacity for self-directed learning, collaboration, and social interaction.

Metacognition refers to awareness of one's own knowledge—what one does and does not know—and one's ability to understand, control, and manipulate one's cognitive processes (Meichenbaum, 2010). It includes knowing when and where to use particular strategies for learning and problem solving as well as how and why to use specific strategies. Metacognition is the ability to use prior knowledge to plan a strategy for approaching a learning task; take necessary steps to problem solve, reflect on and evaluate results, and modify one's approach as needed. Flavell (1976), who first used the term, offers the following example: I am engaging in Metacognition if I notice that I am having more trouble learning A than B; if it strikes me that I should double check C before accepting it as fact.

Metacognitive practices can be taught (Halpern, 2006), they are associated with successful learning. Successful learners have a repertoire of strategies to select from and can transfer them to new settings. Instructors need to set tasks at an appropriate level of difficulty (i.e., challenging enough so that students need to apply metacognitive practices to monitor success but not so challenging that students become overwhelmed or frustrated), and instructors need to prompt learners to think about what they are doing as they complete these tasks. Instructors should take care not to do the thinking for learners or tell them what to do because this runs the risk of making students experts at seeking help rather than experts at thinking about and directing their own learning. Instead, effective instructors continually prompt learners, asking *"What should you do next?"*

McKeachie (2008) found that few university teachers explicitly teach strategies for monitoring learning. They assume that students have already learned these strategies in secondary school. But many have not and are unaware of the metacognitive process and its importance to learning. Rote memorization is the usual—and often the only—learning strategy employed by secondary school students when they enter university (Nist, 2013). Simpson and Nist (2013), in a review of the literature on strategic learning, emphasize that teachers need to provide explicit instruction on the use of study strategies. They need to know that they have choices about the strategies they can employ in different contexts, and they need to monitor their use of and success with these strategies.

Teachers can encourage learners to become more strategic thinkers by helping them focus on the ways they process information. Self-questioning, reflective journal writing, and discussing their thought processes with other learners are among the ways that teachers can encourage learners to examine and develop their metacognitive processes. Fogarty (2014) suggests that Metacognition is a process that spans three distinct phases, and that, to be successful thinkers, students must do the following: Develop a ***plan*** before approaching a learning task; such as solving a science problem; ***Monitor*** their understanding; use "fix-up" strategies when meaning breaks down and ***evaluate*** their thinking after completing the task.

Teachers can model the application of questions, and they can prompt learners to ask themselves questions during each phase. They can incorporate into lesson plans opportunities for learners to practice using these questions during learning tasks, as illustratetd in the following examples:

- **During the planning phase,** learners can ask, *What am I supposed to learn? What prior knowledge will help me with this task? What should I do first? What should I look for in this reading? How much time do I have to complete this? In what direction do I want my thinking to take me?*
- **During the monitoring phase,** learners can ask, *How am I doing? Am I on the right track? How should I proceed? What information is important to remember? Should I move in a different direction? Should I adjust the pace because of the difficulty? What can I do if I do not understand?*
- **During the evaluation phase,** learners can ask, Ho*w well did I do? What did I learn? Did I get the results I expected? What could I have done differently? Can I apply this way of thinking to other problems or situations? Is there anything I don't understand—any gaps in my knowledge? Do I need to go back through the task to fill in any gaps in understanding? How might I apply this line of thinking to other problems?*

The goal of teaching metacognitive practices is to help learners become comfortable with these strategies so that they employ them automatically to learning tasks, focusing their attention, deriving meaning, and making adjustments if something goes wrong. They do not think about these skills while performing them but, if asked what they are doing, they can usually accurately describe their metacognitive processes. The stress should be on applying the five senses to expand into about *ten unique intelligences* not just three traditional categories (written language, mathematics and non-verbal/visual IQ) but more...spatial, interpersonal, intrapersonal, musical, kinesthetic, naturistic and existential. Recognize the key points of Metacognition is think in "multiple representations" for critical thinking -- not just words, but learning experiences through a set of activities that help students think about their learning.

Metacognitive experiences are student's experiences that involve one's current, on-going cognitive endeavor-using the process of thinking in learning situations. Metacognitive practices include planning the approach to a learning task, checking on comprehension, evaluating progress on a task and maintaining motivation to see a task to completion to become aware of distracting stimuli -- both internal and external -- and so to sustain effort over time**.** In metacognition -- student will use prior knowledge to plan a strategy for successful learning, in steps to problem solve, using necessary tools, reflecting on, monitoring and evaluating their results, and modifying their approach as needed. These the learners do by using the intelligencies. This study made use of Linguistic and Kinesthetic/bodily intelligencies.

- **Seek "linguistic intelligence" (word smart):** deal with improving the language for imparting knowledge, accurate word use, selection of phrases, and pauses (such as wait time for student reaction and to answer questions) in oral and written forms, where strategies like thinking aloud while performing a task include self-questioning, such as:

  Planning - *What do I already know about this topic? How have I solved problems like this before? What should I do first?* Monitoring - *What should I look for in this reading? How should I proceed? What information is important to remember?*

  Evaluating - *What did I learn? Did I get the results I expected? What could I have done differently? Can I apply this way of thinking to other problems or situations? Is there anything I don't understand—any gaps in my knowledge? Do I need to go back through the task to fill in any gaps in understanding?*

  What should I do first? Monitoring - *What should I look for in this reading? How should I proceed? What information is important to remember?*

Use Bodily-Kinesthetic intelligence ("body smart"): physical action and interaction, physical stimulus and robust body activities are the best pathways to help them learn. Acting out learning as much as possible, activities to walk around when they are learning.[3]

- Role play as planets, moon, sun, etc., as atoms: electrons, nucleus, neutrons, protons and more by drawing and taping an atom, the nucleus and its orbits on the floor. Let your child move around on it to learn the role of all of the particles. Place objects within their sight and reach.
- Use hand gestures, body action, miming of information, etc.,
- Display and use the world globe, math shapes such as cube, pyramid, cone, etc. Use manipulative objects: construction sets, Legos, modeling clay, science experiments, props to use in dramatizations, outdoors gear (work shoes, bags to collect rocks, leaves, feathers, plants, flowers, etc.), storage for keeping the specimens they collect, sports equipment, puzzles, dance music. The Metacognitive components of the activity involve describing one's thoughts to another person, requires the problem-solver to listen and attend to their own thoughts as well. The questions and clarifications that the listener describes is yet another window into the problem-solver's thinking. The Metacognitive goals for this activity involve promote reflective thinking, communication skills, better reasoning, listening skills, and better problem-solving and conceptual understanding.

Metacognitive practices increase students' abilities to transfer or adapt their learning to new contexts and tasks (Bransford, Brown, & Cocking, 2010). They do this by gaining a level of awareness *above the subject matter*: they also think about the tasks and contexts of different learning situations and themselves as learners in these different contexts. When Pintrich (2012) asserts that Students who know about the different kinds of strategies for learning, thinking, and problem solving will be more likely to use them, notice the students must "know about" these strategies, not just practice them. As Zohar and David (2013) explain, there must be a "*conscious* meta-strategic level of H[igher] O[rder] T[hinking]".

Metacognitive practices help students become aware of their strengths and weaknesses as learners, writers, readers, test-takers, group members, etc. A key element is recognizing the limit of one's knowledge or ability and then figuring out how to expand that knowledge or extend the ability. Those who know their strengths and weaknesses in these areas will be more likely to "actively monitor their learning strategies and resources and assess their readiness for particular tasks and performances" (Bransford, Brown, & Cocking, 2010).

The absence of metacognition connects to the research by Chick, Nancy, Terri (2011) on "Why People Fail to Recognize Their Own Incompetence". They found that "people tend to be blissfully unaware of their incompetence," lacking "insight about deficiencies in their intellectual and social skills." In "Promoting Student Metacognition," Tanner (2012), opines that it is important that teachers in explicit and concerted ways make students aware of themselves as learners. Teachers must regularly ask, not only 'What are you learning?' but 'How are you learning?' We must confront them with the effectiveness (more often ineffectiveness) of their approaches. We must offer alternatives and then challenge students to test the efficacy of those approaches. Stanger-Hall (2012) in her work developed strategies for the students to identify their study strategies, which she divided into "cognitively passive" *("I previewed the reading before class," "I came to class," "I read the assigned text," "I highlighted the text," et al)* and "cognitively active study behaviors" *("I asked myself: 'How does it work?' and 'Why does it work this way?'" "I wrote my own study questions," "I fit all the facts into a bigger picture," "I closed my notes and tested how much I remembered," et al)*.

As these examples illustrate, for students to become more metacognitive, they must be taught the concept and its language explicitly (Pintrich, Tanner, 2012), though not in a content-delivery model (simply a reading or a lecture) and not in one lesson. Instead, the explicit instruction should be "designed according to a knowledge construction approach," or students need to recognize, assess, and connect new skills to old ones, "and it needs to take place over an extended period of time" (Zohar & David, 2013). This kind of explicit instruction will help students expand or replace existing learning strategies with new and more effective ones, give students a way to talk about learning and thinking, compare strategies with their classmates' and make more informed choices, and render learning "less opaque to students, rather than being something that happens mysteriously or that some students 'get' and learn and others struggle and don't learn" (Pintrich, 2012).

Students can even be metacognitively prepared (and then prepare themselves) for the overarching learning experiences expected in specific contexts**.** Salvatori and Donahue's *The Elements (and Pleasures) of Difficulty* (2010) encourages students to embrace difficult texts (and tasks) as part of deep learning, rather than an obstacle. Ultimately, metacognition requires students to "externalize mental events" (Bransford, Brown, & Cocking, p. 67), such as what it means to learn, awareness of one's strengths and weaknesses with specific skills or in a given learning context, plan what's required to accomplish a specific learning goal or activity, identifying and correcting errors, and preparing ahead for learning processes.

Specifically, the study did the following:

- ascertained how the science education learners use linguistic intelligence in their metacognitive practices ;
- ascertained how the science education learners use Kinesthetic intelligence in their metacognitive practices. The objectives were raised as questions.

- How do the science education learners use linguistic intelligence in their metacognitive practices?
- How do the science education learners use kinesthetic intelligence in their metacognitive practices?

Method

The researcher adopted a descriptive survey design. This design enabled the researcher to ascertain the metacognitive skills in science education students using the intelligencies that enhance nation building. Metacognitive practices help learners become comfortable with the strategies so that the learners employ the strategies to learning tasks, by applying the intelligences where applicable (Ibe, 2013). The sample consists of one hundred and eighty subjects (180) drawn randomly from three-hundred level students of the faculty of education, Imo state university, Owerri. The researcher developed some items for the undergraduate students based on the purpose of the study. The instrument used to collect data were the structured questions on a four point scale of Most Often (MO), Often (O) Rarely Often (RO), and Never (N) for the clusters A-B. The instrument was validated by two experts of Measurement and Evaluation and three experts of Science Education. The Kuder-Richardson formula 21 (K-R 21) for estimating the internal consistency of non-test items was calculated and the coefficient of 0.78 was got.

Results

Table 1: Mean and Standard Deviation of Subjects on use of Linguistic Intelligence to enhance Metacognitive practices

S/N	Item	MO	O	RO	N	$\bar{X}$	SD	REMARK
A	Apply Linguistic Intelligence							
	While performing a task, I think aloud such as Self-questioning. I ascertain:							
1	what I already know about the topic	40	46	66	26	2.10	.792	Reject
2	How I have solved problems like this before	34	48	54	45	2.27	.648	,,
3	What I should do before	60	32	60	28	2.18	.678	Reject
4	What I look should for in this activity	54	38	59	29	2.43	.623	,,

5	How I should proceed	62	55	40	23	2.51	.673	Upheld
6	What information is important to remember	29	65	50	36	2.48	.989	Reject
7	What I learnt	32	60	49	39	2.47	1.02	,,
8	Whether I got the results expected	35	49	53	44	2.27	.648	,,
9	What I should have done differently	29	65	50	36	2.48	.989	,,
10	Whether I can apply this way of thinking to other problems/situations	28	64	52	36	2.48	.989	,,
11	If there is any gap in knowledge (anything I do not understand)	27	67	52	35	2.48	.989	,,
12	My strength and weaknesses	32	39	71	38	2.18	.758	,,
13	Identifying and correcting errors	32	42	68	38	2.18	.758	,,
14	If I need to go back through the task to fill in gaps in understanding	22	44	66	48	2.10	.792	,,

Data presented on table 1 show that 13 items that elicited responses on how linguistic intelligence enhance metacognitive practices have mean scores below the cut-off mean of 2.50 and were rejected while item 5 had mean score of 2.51 above the cut-off of 2.50 and was upheld. The items indicated standard deviation (SD) ranging from .64 to 1.02 of undergraduate students' responses which indicated close agreement of ratings on the items. The highest mean score is 2.77 which show do experiments using materials and projects to learn science while the least mean is 2.10 which indicated what I already know about the topic as well as if I need to go back through the task to fill in gaps in understanding. This suggests that the learners are yet to use linguistic intelligence in the metacognitive practice.

Table 2: Mean and Standard Deviation of Subjects on use of Kinesthetic Intelligence to enhance Metacognitive practices

S/N	Item	MO	O	RO	N	$\overline{X}$	SD	REMARK
A	Use Bodily-Kinaesthetic intelligence Physical action and interaction, acting out learning as much as possible. Activities to walk around when learning.							
1	Do experiments using materials and Projects to learn science	43	69	52	16	2.77	.914	Upheld
2	Manipulate objects for science learning	28	42	60	50	2.51	.673	,,
3	Conduct science experiments-Practice home science	32	50	49	49	2.47	1.02	Reject

Data presented on table 2 show that items 1 and 2 that elicited responses on how kinesthetic intelligence enhance metacognitive practices have mean scores above the cut-off mean of 2.50 and were upheld while item 3 had mean score of 2.47 below the cut-off of 2.50 and was rejected. The items indicated standard deviation (SD) ranging from .67 to 1.02 of undergraduate students' responses which indicated close agreement of ratings on the items. The highest mean score is 2.51 which show how I should proceed and p while the least mean is 2.47 which indicated practice home science. This suggests that the learners use the kinesthetic intelligence in the metacognitive practice moderately.

Discussion

Findings of the study on the use of Linguistic intelligence to enhance metacognitive practices show that the learners are yet to use such strategy often since 13 out of the 14 items that elicited responses were below the cut-off mean. This finding suggests that actually, It is important that in explicit and concerted ways learners are made aware of themselves as learners. Teachers must regularly ask, not only 'What are you learning?' but 'How are you learning?' Teachers must confront the learners with the effectiveness (more often ineffectiveness) of their approaches. Teachers must offer alternatives and then challenge learners to test the efficacy of those approaches. This finding corroborates with the findings of Stanger-Hall (2012) where students identified their study strategies, which was divided into "cognitively passive" ("I previewed the reading before class," "I came to class," "I read the assigned text," "I highlighted the text," et al) *and "cognitively active study behaviors"* ("I asked myself: 'How does it work?' and 'Why does it work this way?'" "I wrote my own study questions," "I fit all the facts into a bigger picture," "I closed my notes and tested how much I remembered," et al).

Findings of the study on the use of Kinesthetic intelligence to enhance metacognitive practices show that the learners often use such strategy often since 2 out of the 3 items that elicited responses were above the cut-off mean. This finding suggests that actually Metacognitive practices increase learners' abilities to transfer or adapt their learning to new contexts and tasks. The learners do this by gaining a level of awareness above the subject matter*:* the learners also think about the tasks and contexts of different learning situations and themselves as learners in these different contexts. This finding agrees with (Bransford, Brown, & Cocking, 2010) as well as Pintrich (2012) findings where these authors assert that Students who know about the different kinds of strategies for learning, thinking, and problem solving will be more likely to use them, notice the students must "know about" these strategies, not just practice them.

Conclusion

The low mean score of the use of Linguistic intelligence in enhancing metacognitive practices in science education students as responded by the undergraduate students has been discussed. The absence of metacognition connects to why learners fail to recognize their own Incompetence". Learners tend to be blissfully unaware of their incompetence lacking "insight about deficiencies in their intellectual and social skills. Learners fail to think logically, recognize humour, and problem-solving skills. In simple term, "if people lack the skills to produce correct answers, they are also unable to know when their answers or anyone else's, are right or wrong. Increased metacognitive abilities—to learn specific (and correct) skills, how to recognize them, and how to practice them—is needed in many contexts.

Recommendations

Based on the findings of this study, the researcher proffers the following recommendations for developing a classroom culture grounded in metacognition: Students should be given License to identify confusions within the Classroom Culture: *ask students what they find confusing, acknowledge the difficulties.* To facilitate these activities, these are to be offered students:

- Questions for students to ask themselves as they plan, monitor, and evaluate their thinking within four learning contexts—in class, assignments, quizzes/exams, and the course as a whole;

- Prompts for integrating metacognition into discussions of pairs during clicker activities, assignments, and quiz or exam preparation;
- Questions to help faculty metacognitively assess their own teaching.
- Integrating Reflection into Credited Course Work: *integrate short reflection (oral or written) that ask students what they found challenging or what questions arose during an assignment/exam/project*
- Metacognitive Modeling by the Instructor for Students: *model the thinking processes involved in your field and sought in your course by being explicit about "how you start, how you decide what to do first and then next, how you check your work, how you know when you are done" (p. 118)*

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