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Relative Efficacy of PQ4R Metacognitive Learning Strategy on Students' Academic Achievement in Electrochemistry in Calabar Education Zone, Cross River State, Nigeria

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Abstract: *The study investigated the Relative Effectiveness of PQ4R Metacognitive Learning Strategy on Secondary School Students' Achievement in Electrochemistry in Calabar Education Zone, Cross River State, Nigeria. It adopted pretest, post-test, non-randomized, non-equivalent control group quasi-experimental research design. Two hundred and twenty (220) intact classes of SS2 chemistry students were selected from four (4) schools in four (4) different Local Government Areas within the zone, formed the sample of the study. EXG received treatment with the use of PQ4R metacognitive strategy, while COG did not. EAT's reliability Coefficient value of 0.76 was the only instrument used for obtaining data. Two (2) research questions and two (2) hypotheses were formulated and tested at 0.05 levels of significance. Mean and standard-deviation were used to answer the research questions and independent t-test analysis was used to test the null hypotheses. Results showed that EXG, exposed to treatment, obtained higher mean-gain (29.33), than COG with mean (3.11). Male students, obtained higher mean-gain (16.54) than females (12.79), relative to pretest and post-test scores obtained. The t-test results showed that, significant difference existed between EXG and COG. Also, male students performed academically better than females, in Electrochemistry, when exposed to treatment with PQ4R metacognitive strategy. Conclusion was drawn and recommendations were made, to include among others that, PQ4R metacognitive learning strategy, should be adopted by teachers for classroom instructions to enhance students' academic achievement.*

Key words: *Metacognitive strategy; Achievement; Electrochemistry; Metacognition; teaching-learning process.*

Introduction

One of the major hallmarks of chemistry education among secondary school science students in Nigeria, in recent times, is anchored basically on how to learn chemistry concepts in school with understanding. This can be achieved through innovative teaching strategies, one of which is PQ4R metacognitive strategy. Electrochemistry is a branch of chemistry, which deals mainly with the study and mechanisms of oxidation and reduction reactions phenomena, that is always perceived as the most difficult aspects of chemistry to learn, by both students and teachers (Yousuo, 2005; Njoku, 2007). Electrochemistry concepts require complex mental processes that involved critical visualization, manipulation, analytical abstraction and association of ideas (Ojukuku, 2010). This, however, poses a major challenge for many students to understand with ease, particularly, when either taught or engaged in reading its concepts from prescribed textbooks in school.

Nevertheless, reading plays vital role in human life; because it is not limited by space and time. Most of the various information about science, technology, mathematics, art and culture, are obtained through reading. Reading is usually balanced by active engagement of students in activities or hobbies, either independently or collectively, in the classroom or at home in their private studies. To scientifically understand any chemistry reading material, students are generally constrained by their literal meanings. Consequently, they are rarely encouraged to develop inferential, evaluative and appreciative understanding of what they read. Therefore, pedagogically speaking, the teacher's role as facilitator, mentor and evaluator of the Electrochemistry concepts taught at secondary school, in this regard, is anchored on sustaining the students' willingness to learn by elaborate reading of textbooks either before or after teaching. The willingness to read consistently, through practice by students, would make it an internal force for the development of perpetual reading habit. When students possess these immense willingness and powerful gratitude, they become motivated to learn. This would enable them to organize themselves properly, become eloquent and very responsive in communicating the outcome of their active reading engagements. By implication, they can assess their reading habits by monitoring their process of reading and evaluate their progress of reading as well. Such activities are metacognitive (Sarimanah, 2016). Put into perspectives, an individual who has developed good reading habits would usually be so enthusiastic about a reading material to study, in order to acquire more knowledge. Consequently, becoming very enthusiastic, active and creative in finding out very willingly, any information from the reading material is indicative of good reading habit formed. They would also, review what they have read and try to find out what has not been understood by using their prior knowledge and other skills necessary, to understand the ideas in the reading material (Sarimanah, 2016). Obviously, understanding comes from the effective applications of strategy and skill. The ability to integrate both strategies and skills, would no doubt direct the learner towards active reading, preparatory to all cognitive endeavors (Idiege, Nja&Ugwu, 2017). Accordingly, these strategies and skills require active participation in activities involving mental processes that are metacognitive in nature. This would certainly, enhance and improve the scientific and technological base of the society, boost the economy, provide employment opportunities and stem societal ills of the nation.

In doing so, three (3) learning principles would tremendously play active roles, thus:

(i) The relevance of initial knowledge of the learner in the acquisition of new information to be learned.
(ii) The level of understanding of the text ideas, which could be achieved from the reading material.
(iii) The organization of acquired information, to help in building the long-term memory (LTM) of the learner.

A perfect blend of these learning principles shall, however, be displayed through observation from three (3) phases, namely – pre-reading phase, in-reading or during-reading phase; and post-reading phase (Sarimanah, 2016). Each phase is characterized by different steps followed by activities that constitute the "PQ4R strategy" as: **Preview, Question, Read, Reflect, Recite and Review (PQ4R).** These steps are organized into three (3) major different stages as: planning process, implementation process and evaluation process. The classification is summarized as shown below in table 1:

Table 1: Table of PQ4R Metacognitive Activities.

	Process	Phase	Steps	Activities
1	Planning process	Pre-reading	**Preview** **Question**	- Preview the general concepts of electrochemistry as contained in the prescribed chemistry textbooks. - Connect the ideas that are already familiar. - State the basic objectives. - Draw and direct students attention to key terms in Electrochemistry. - Identify the needed materials for grasping. - Predict what is intended to be learned from each topic. - Ask questions to clarify misconceptions about the topic, sub-topics and general contents.
2	Implementation process	In-reading/during-reading	**Read**	- Read through the processes involved or required in Electrochemistry concepts. -Try to find out more information about the concept from prescribed textbooks. - Organize the information obtained as much as possible to make meaning. - Check if the objectives are attainable or easily achievable. - Monitor the speed of searching answers from the text-material.
			Reflect	- Try to link the information gathered from the textbook with the ideas already known. - Resolve discrepancies or misconceptions (if any), arising from the new ideas generated and link them up with schema owned.
			Recite	- Rehearse all plausible, intelligent and fruitful ideas gained from the reading material/textbooks. - Find out more ideas / information to beef-up or clarify questions or misconceptions raised.
3	Evaluation process	Post-reading	**Review**	- Ask yourself what you have achieved, from each concept taught or read, from the reading material or textbook. - Repeat or go through your salient points, and note down ideas; and if not clearly understood. Please, re-read over and over again, until you make out meanings. - Summarize your points briefly. Explain each point in your own words or meaning, where necessary. - Conduct self-appraisal and discussion of each point or idea gained.

Source: *Adapted from the Analysis of PQ4R developed by Thomas &Robinson (1972, cited in Dixon- Krauss, 1996).*

However, Electrochemistry concepts taught at secondary school level in Nigeria are mostly found in textbooks recommended by the different schools management, as approved by the state and federal Ministry of Education. These books are hardly consulted by students, except prior to terminal examinations or when assignments are given by their teachers. Consequently, most of these students do hardly engage themselves adequately in metacognitive activities as expected of them. The resultant effect is the attendant poor performance at external examinations like West African Senior School Certificate Examination (WASSCE), National Examination Council (NECO), Unified Tertiary Matriculation Examination (UTME), National Board for Technical Examination (NABTE) and many others, over the years. It is expected that, if these students did engage themselves effectively in such metacognitive activities as this, their academic achievement in chemistry would perhaps, be enhanced or improved. Their science process skills would also be developed.

Science and technology initiatives in Nigeria can only be improved upon through active participations in Small and Medium-scale ventures, to boost the Nigeria's economy and create jobs for the teaming youths. These initiatives are actualized through metacognitive activities of students, associated with memory, reasoning and problem-solving, directed towards achieving purposeful objectives as practiced in schools.

Metacognition and PQ4R metacognitive strategy

Metacognition (Flavell, 1976), refers to one's knowledge concerning one's own cognitive processes and products. It is the knowledge and control one has over his or her own thinking and learning activities. It implies the level of awareness and management that a learner have over his/her own thought. Although, many researchers (Martinez, 2006; Kuhn & Dean, 2004; Stone, 1983; cited in Zouhor, Bogdanovic&Segedinac, 2016; Sarimanah, 2016), have asserted that there is no single definition of metacognition, however, metacognition can be defined as the activity of monitoring and control of one's cognition or control of one's thought using the process of learning (Sarimanah, 2016).

Metacognition (Sarimanah, 2016), have been classified into three (3); metacognitive knowledge, metacognitive regulation and metacognitive experiences. The metacognitive knowledge comprised: Declarative knowledge, procedural knowledge and strategic (or conditional) knowledge. The declarative knowledge refers to how to do something. Procedural knowledge implies the skills, strategies and resources needed to perform an intended task, while conditional knowledge refers to when to apply a certain strategy to an intended task. In school, the process of thinking and learning intended tasks may involve planning, management of information, monitoring, evaluation and debugging activities, characterized by conditional knowledge. However, metacognitive experience envelops affective character such as feelings, judgments, estimating outcomes from the cognitive processing that was undertaken by the learner. Consequently, metacognition plays vital role in students' learning by helping students to learn study materials more efficiently, retain their knowledge gained longer and generalize their skills with ease, to solve new problems that may, perhaps, be challenging (Zouhor, Bogdanovic&Segedinac, 2016).

By implication, students with highly developed metacognition would exhibit signs of confidence, take his/her time to reflect on learning activities, remain clearly convinced that he/she can learn, being accurate in evaluating successes in the learning task, reflect on errors that might have occurred while performing anything learning task, show traces of successful connection of new ideas with previous ones already known, and adjust learning strategies for impending tasks at hand with commitment and dexterity (Efklides, 2009; Duman, 2010; Sarimanah, 2016). These qualities are expressed conscientiously with the use of PQ4R metacognitive strategy in schools (Sarimanah, 2016).

Generally, metacognitive strategy are used in helping students to understand the way they learn, think about their thinking and raise awareness about the processes in an ongoing learning task. It is when this awareness is realized that the learner begins to think about how to design, monitor and assess what he/she learns. Possibly too, the learner begins to think on how to evaluate his/her learning outcomes from one's own cognitive process and product (Kumari&Jinto, 2014). This may lead the inquisitive minds in school, towards setting-up entrepreneurial schemes or enterprises that would in turn boost the nation's economy, in line with the tenets of enterprises integrated into the Nigeria's education curriculum. The National Economic Empowerment and Development Strategy (NEEDS) is emphasizing on wealth-creation and poverty eradication, to haul the plethora of unemployed youths, as well as shunning negative vices in our society.

The PQ4R metacognitive strategy, which is simply an acronym, for **preview, questions, read, reflect, recite and review,** was developed by E. L. Thomas and H. A. Robinson (1972, as cited in Dixon-Krauss, 1996). It was used mainly to help students with difficulty in reading comprehension passages, retaining and recalling information in a teaching-learning process in school. These were major challenges to many students, for decades, in the United States of America. Today, in Nigeria, many chemistry secondary school students finds it tremendously difficult to understand electrochemistry concepts taught in schools, most probably too, are faced with similar challenges resulting in poor achievement at external examinations over the years. It is in view of this, that exposing students to this strategy, perhaps, would enhance their achievement in chemistry; and improve the science and technological base of Nigeria through active engagement of students in metacognitive exercise as PQ4R.

Theoretical framework

This study is anchored on Ausubel's (1960 & 1963), theory of meaningful learning and advance organizer. His chronicled piece summarized that, the most important single factor that usually affects learning is primarily what the learner already knows. Essentially, what the learner already knows constitute "prior-knowledge", which has to be harnessed objectively through innovative strategies adopted by teachers, either implicitly or explicitly, to make learning become meaningful. If learning is made meaningful, certainly, it would increase clarity and retention of the learning materials. He further emphasized that, what is most readily learned and retained, is the in-depth knowledge of subject matter. Meaning, the individual's existing cognitive structure or frame of reference (i.e. "subsumer" or advance organizer), can always subsume the newly introduced concepts to be learned. By extension, it leads to meaningful learning. This implies the learner should have appropriated prior- knowledge for production to boost the nation's economy.

Meaningful learning occurs, when there is interaction between the learner's appropriate elements in the knowledge that already exist and the new materials to be learned. The knowledge must be acquired in classrooms (i. e. New- knowledge), which must relate either partially or wholly with the learner's frame of reference in existence, before the learning becomes meaningful. However, when no such interaction or relationships exist, then, rote learning or memorization will take pre-eminence. This rote learning is not healthy for students. It would lead to only short – term form of learning, which is not productive enough. Quality education, usually enable students to acquire and develop the knowledge, skills and values, which are associated capabilities and competencies to lead meaningful and productive lives (Obioma, 2014). The focus of the 'UN Post 2015 Education and Development Agenda' is specifically, on the delivery of quality education, acquisition of 21st century skills, development of global citizenship and many more others(Obioma, 2014).

Nevertheless, the portions of the learner's cognitive structure, which basically, is involved in the organization of knowledge and capable of providing for the interactions necessary for meaningful learning to occur, with ease, are termed "subsumers"(Ausubel, 1960). Consequently, generalized body of knowledge and principles that learners already possessed, which are capable of providing for association or anchorage of the new knowledge is called 'subsumer' (Ausubel, 1960). This form the basis of this theory, about subsumption model of learning, as an instructional strategy which underpins the central and highly unifying ideas stated in terms already familiar to the learner. It makes the learner to meaningfully relate new materials to the existing cognitive reference frame, to create useful or productive meaning. In the absence of subsumers, advance organizers can be used to provide this platform, by providing alternative links or anchors with prior- knowledge.

Apparently, electrochemistry concepts can be learned meaningfully, when the learner visualizes and subsumes them within a cognitive structure. With that, the learner understands more clearly the generic concepts that incorporate the teachers' teaching in classroom when the students read from textbooks, or read from copied notebooks in the classroom. This can be made easily achievable as the chemistry teacher, uses or adopts strategies that would help the students to develop good reading habit, willingly, find out what has not been understood, and using their prior- knowledge and skills, to link-up the new ideas taught in the classrooms. In doing so, they become so enthusiastic, active and creative. Similarly, they would organize themselves properly, to take responsibility of owning their own-knowledge and communicate eloquently with these facts for enhancement of their academic achievement in chemistry. These qualities are embedded in PQ4R metacognitive strategy, as observed by Sarimanah (2016), Duman (2010) and Efklides (2009). Students who are often engaged with PQ4R metacognitive strategy may become more creative and productive in science and technology as well.

However, learning takes place by either doing or practicing the necessary cognitive steps in any social context; and more so, through interactions with one another as students become actively involved in classroom activities (Idiege, Nja&Ugwu, 2017). Invariably, it would lead to establishment of science and technologically-based entrepreneurship that may transform the society into a better place to live in.

Statement of the problems

The poor academic performance in chemistry amongst other factors implied many Nigerian chemistry students, lack understanding and mastery of the content, especially, in electrochemistry. Therefore, they cannot write confidently and pass external examinations easily, due to poor understanding, retention of electrochemistry facts expected of them during examinations. A review of past WASSCE question papers over the years revealed that, the contents of electrochemistry have always featured as test questions, ranging from Electrolysis, Oxidation and Reduction, Redox potentials, Balancing Redox equations etc.

Available evidence of poor achievement of students in WASSCE 'O' level chemistry, particularly, in Calabar Education Zone of Cross River State, from 2010 to 2017, provided by State Secondary Education Board, revealed that, 59.30%, 56.30% and 52.80% were the respective percentage failure in 2010, 2014 and 2017; from the entry enrolment figures of 9,723, 7,104 and 7,998 respectively, for the May/June chemistry examination. From these figures, it implies the percentage passes for each respective year falls below 50, indicating low academic achievement in chemistry, over these years. This high failure rate portends danger and threat, to the advancement of manpower development in science and technology for state and the country at large. Most probably, there would be a drastic short-fall in the number of qualified candidates, to pursue science and technology related disciplines in the tertiary institutions, whose mandatory pre-entry qualifications requirements is pegged at credit pass level in Nigeria.

Reasons attributed to this failure may not be far-fetched, perhaps, not unconnected with poor teaching strategies adopted by the teachers. Can the adoption of PQ4R metacognitive strategy stem this tide? This, however, forms the statement of the problems. Would the adoption of PQ4R metacognitive strategy in this study, help the students over-come their challenges of poor grasping of chemistry concepts? Perhaps, their difficulties in reading comprehension passages in chemistry textbooks, retaining and recalling information required in tests or examinations would become enhanced. Perhaps, the nations' future hope may equally be restored too.

Purpose of the study

The purpose of the study is to determine whether, the use of PQ4R metacognitive strategy, in teaching and learning of electrochemistry concepts, at secondary school level, would have any significant effect on students' academic performance. Specifically, the study sought to determine how:

(i) The use of PQ4R metacognitive strategy in teaching and learning of electrochemistry, would affect SS2 chemistry students' academic performance scores.

(ii) Teaching and learning with PQ4R metacognitive strategy affects the academic performance scores of male and female students in electrochemistry.

Research questions

The following research questions are aimed at providing guidance to the study. How does:

(i) Teaching and learning with or without PQ4R metacognitive strategy affect SS2 chemistry students' mean academic performance scores in electrochemistry?
(ii) The use of PQ4R metacognitive strategy affects the mean academic performance scores of male and female students in electrochemistry?

Statement of hypotheses

The following null hypotheses were formulated to be tested statistically at 0.05 confidence level:

(i) There is no significant difference between the mean academic performance scores of SS2 chemistry students taught electrochemistry concepts using PQ4R metacognitive strategy and those taught with lecture method.
(ii) There is no significant difference between the mean academic performance scores of male and female SS2 chemistry students taught electrochemistry using PQ4R metacognitive strategy.

Research Method

The study was conducted on four (4) co-education secondary schools in Calabar education zone of Cross River State, Nigeria. A pretest – post- test, non-randomized and non-equivalent control group Quasi-experimental research design, was adopted for the study. The sample comprised 220 intact classes of SS2 chemistry students selected purposively from four (4) different schools within the zone. Two classes were assigned to experimental group (EXG), while, the other two (2) to the control group (COG). The experimental group received treatment through teaching and learning of electrochemistry concepts using PQ4R metacognitive strategy, while the control groups did not. The selection of schools from four (4) different Local Government Areas was to avoid possible threat of contamination and compensation arising from interclass interactions. The EXG had 120 students comprising 70 males and 50 females. The COG had 100 students comprising 60 males and 40 females.

The only instrument (i.e. Electrochemistry Achievement Test - EAT) used to obtain data for the study contained a 25 – item structured multiple choice objective questions with options lettered A-D, culled from past question papers of WASSCE, NECO and UTME on electrochemistry topics. The instrument was validated by experts and its reliability coefficient value determined using Cronbach alpha was 0.76. The study was conducted during normal school hours, lasted for six (6) weeks. The researcher assistants' sensitization training lasted for two (2) weeks. The research-assistants were the students' regular chemistry teachers. Before intensive teaching commenced, EAT was administered as pretest. After 6 (six) weeks of intensive lessons, EAT was reshuffled and re-administered as post-test to give a vague impression that it was different from pretest.

Results

(1) Research question 1: How does teaching and learning with or without PQ4R metacognitive strategy affect the students' mean performance scores in electrochemistry?

Table2*: The table of analysis ofmean and standard deviation of pretest and post- test mean scores of students from EXG and COG.*

Group	N	Pre-test mean	Standard deviation (SD)	Post-test mean (x)	Standard deviation (SD)	Mean gained
Experiment (EXG)	120	68.56	14.23	97.89	9.02	29.33
Control (COG)	100	63.74	12.58	66.51	12.95	3.11

Significant at 0.05; df = 218; t critical = 1.97

SOURCE: Analyzed mean-gained results between EXG (experimental group) and COG (control group).

Analysis of the above results showed that EXG obtained higher pretest mean scores from (mean = 68.56) to post-test (mean = 97.89), than the COG with pretest (mean = 63.74) and post-test (mean = 66.51). From the above analysis, the average mean scores gained by EXG (mean = 29.33) is greater than the COG (mean = 3.11). By implications, those taught electrochemistry using PQ4R metacognitive strategy obtained higher mean scores, than those taught electrochemistry with lecture method.

(ii) **Research question 2:**How does the use of PQ4R metacognitive strategy affect the mean performance scores of male and female students in electrochemistry?

Table 3: *The table of analysis of Mean and standard deviation of pretest and post-test mean scores of male and female students in Electrochemistry*

Gender	**N**	**Pre-test mean**	**Standard deviation (SD)**	**Post-test mean (x)**	**Standard deviation (SD)**	**Mean-gain**
Male	70	38.16	8.00	57.89	3.02	16.54
Female	50	30.40	6.23	40.00	6.00	12.79

Significant at 0.05; df = 218; t critical = 1.97
SOURCE: Analyzed mean-gain results between Male and Female students in Electrochemistry.

From the above results, male students obtained higher pretest mean (mean = 38.16) than females (mean =30.40). Also, male students had higher post-test (mean = 57.89) and gained (mean = 16.54), than females post-test scores (mean =40.000) and gained (mean = 12.79). This implied male students achieved higher academically than females, when taught electrochemistry using PQ4R metacognitive strategy.

Statement of Hypotheses

Hypothesis one (1):

(iii) There is no significant difference between the mean academic performance scores of students taught electrochemistry using PQ4R metacognitive strategy and those taught with lecture method.

Table 4: Table of*t-test Analysis of students mean score between EXG and COG in electrochemistry post-test*.

Gender	**N**	**Post-test mean**	**Standard deviation (SD)**	**Degree freedom (df)**	**Standard Error of Deviation.**	**t-cal**	**t-crit**	**p-value**
EXG	120	97.89	9.02	218	0.75	9.28	1.97	0.001
COG	100	66.51	12.95					

Significant at 0.05; df = 218; t critical = 1.97
SOURCE: Analyzed t-test value between experimental(EXG) and control groups(COG).

The analysis of the results above showed that the calculated t-value of 9.28 is greater than the critical t-value of 1.97. Thus, the null hypothesis is rejected. Meaning, there is significant difference between the mean academic performance scores of students taught electrochemistry concepts using PQ4R metacognitive strategy and those taught with lecture method.

Hypothesis two (2):

(iv). There is no significant difference between the mean academic performance scores of male and female students taught electrochemistry using PQ4R metacognitive strategy.

Table 5: Table of *t-test analysis of the mean performance scores of male and female students taught electrochemistry using PQ4R metacognitive strategy*.

Group	N	Post-test Mean.	Standard dev.(SD)	Degree of freedom (df)	Standard Error of Deviation(SED)	t-cal	t-crit	p-value
Male	70	57.89	3.02	118	0.08	2.13	1.97	0.001
Female	50	40.00	6.00					

Significant at 0.05; df = 118; t-critical value = 1.97
SOURCE: Analyzed t-test value between Male and Female students in electrochemistry.

The result of the above analysis showed that the calculated t-value = 2.13; is greater than the tabulated t-value = 1.97 at 0.05 level of significance, with 118 degrees of freedom. Thus, the null hypothesis is rejected. This implied there is significant difference between the mean academic performance scores of male and female students in electrochemistry, when taught using PQ4R metacognitive strategy.

Discussion of findings

The findings of this study as presented from the analyses of data showed that students taught electrochemistry with the use of PQ4R metacognitive strategy performed academically better than those taught without the strategy. The result agrees with the findings of Zouhor, Bogdanovic&Segedinac (2016), Sarimanah (2016), Kumari&Jinto (2014), Thomas and Robinson (1972, cited in Dixon-Krauss, 1996). Accordingly, Zouhor et al. (2016) observed that metacognitive strategy would undoubtedly, improved students' achievement in physics if applied effectively. Similarly, Sarimanah (2016) observed that PQ4R metacognitive strategy enhanced the reading ability of students, as well as their academic achievement, in language lexis and structures. Kumari&Jinto (2014), who researched on the effectiveness of K.W.L metacognitive strategy on achievement in social studies, concluded that, metacognitive strategies are enhancing if effectively applied by teachers in school. It would not only enhance achievement, but also, improve retention ability with respect to students' cognitive style.

These findings have revealed that PQ4R metacognitive strategy, indeed, is a useful strategy for enhancing students' academic performance in electrochemistry. PQ4R metacognitive strategy, like the KWL metacognitive strategy, is one of the innovative teaching strategies aimed at enhancing students' academic performance irrespective of subject discipline. It would make students to become creative, imaginative, productive and industrious in live after schooling. Consequently, the nation's economy will grow in heaps and bounds as the society would be advanced scientifically and technologically.

In this study, male students achieved higher academically than the females, with respect to the application of PQ4R metacognitive strategy. Perhaps, the male students must have grasped the concept of electrochemistry far better than their female counterparts. They seemed to have probably found the strategy more informative than lecture method comparatively with their female folks. Consequently, they were more organized in monitoring their speed for correct answers quickly than the female students. They, perhaps, adequately utilized the steps involved in the PQ4R metacognitive strategy to their advantage by understanding of the electrochemistry concepts more clearly than the females. This led to their obtaining higher mean (57.89) than females (mean = 40.00) in their post-test. Interestingly, it can be concluded that male students are, probably, more hard working and creative than the females in metacognitive activities. So, they are more likely to set-up business ventures quite easily, through their creative and imaginative abilities than do the females to create employment and reduce poverty in the society.

The result is in support of the findings of Kumari&Jinto (2014), where, male students achieved higher mean of 52.27 than females (mean = 40.81). However, the study's findings with regards to gender, is at variance with the results of Sarimanah (2016) and Zouhor et al. (2016), observing no significant difference in academic performance between male and female students. These conflicting results have further opened windows of research studies on the use of this strategy, to be conducted at different locations of our society in order to strengthen the educational system of Nigeria.

Conclusion and recommendations

This study revealed that metacognitive strategies are keys to understanding electrochemistry concepts in school. The PQ4R metacognitive strategy, embedded steps that made it quite, quick and easy for students to connect ideas that were already familiar with the new concepts being learned. It has helped them to have identified, asked, monitored all plausible and fruitful ideas, in order to clear-off misconceptions (if any), that could have prevented their understanding of electrochemistry concepts taught in classrooms. Through their reflections on followed steps, they were able to link information gathered from both the teachers' lessons and textbooks referrals with the ideas already known. By following the steps conscientiously, they were able to conduct self-appraisal/evaluation of knowledge gained, summarized and explained salient points meaningfully using their own words. Thus, it encouraged their retentive ability for higher academic achievement. This strategy also, encouraged co-operative learning and consistent engagement of students in mental activities. Societal well-being is also encouraged by this strategy, reflecting on the shared vision of learning to live together through education. Accordingly, such strategy is at the heart of quality learning, in line with UNESCO international bureau of education, which Nigeria is a signatory (Obioma, 2014).

The following recommendations are proffered:

1. Teachers should adopt the application of PQ4R metacognitive strategy in their daily classrooms instructions to encourage learning and critical thinking amongst students.
2. Curriculum planners should in corporate PQ4R metacognitive strategy into the teacher education program in schools.
3. Government, education-stakeholders, and many other professional bodies; STAN, ICCON, CSN, ICASE and many others, should organize workshops and seminars on PQ4R metacognitive strategy for in-service teachers.

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