Promoting critical thinking skills of secondary school chemistry students’ through 7e-learning cycle model

1Okafor Ngozi and 2Nwonu Hyacinth
Department of Science and Technology Education
Faculty of Education
University of Lagos, Nigeria
E-mail: 1nokafor@unilag.edu.ng
Cell: 1+2347081619469

Abstract
The purpose of the study was to examine the effect of 7E-Learning Cycle Model (7ELCM) and Lecture Method (LEM) as well as gender influence in promoting secondary school students’ critical thinking skills in chemistry. Two research questions and one hypothesis guided the study. The study adopted a quasi-experimental research design with an overall sample of 146 (66 boys & 80 girls) Senior Secondary Two (SS2) chemistry students of public schools in Lagos State of Nigeria. Data were collected using Lesson Plan on 7ELCM and LEM (LP7L) and adapted Cornell Critical Thinking Test (CCTT). Validity of LP7L and CCTT were determined by two experts in chemistry education. KR 21 was used to determine the reliability of CCTT which gave a reliability coefficient of 0.87. Mean and ANCOVA were used in data analyses. The results showed that secondary school chemistry students exposed to 7E Learning Cycle Model (7ELCM) had higher mean score than students exposed to Lecture Method (LEM) in promoting critical thinking skills. Also, male students taught with 7ELCM and LEM had the highest mean scores than the females in promoting Critical Thinking Skills in chemistry. The study equally showed a significant interactive effect of 7ELCM and LEM on secondary school chemistry students but there was no significant interactive influence of male and female (gender) in promoting critical thinking skills among the secondary school chemistry students taught using 7ELCM and LEM respectively. The paper concludes that chemistry teachers should provide learning opportunities that would make students take ownership of their learning by compelling them to learn meaningfully, think critically, and criticize constructively as a team in solving problematic tasks through the application of 7ELCM irrespective of gender roles and recommends that Ministry of Education and school administrators should organize Train-the-Trainers workshop for all the secondary school chemistry teachers on how to incorporate 7ELCM pedagogy in promoting 21st century skills and improving chemistry students learning outcomes in Lagos State of Nigeria.

Keywords: Critical thinking skills, lecture-method, gender

Introduction
Chemistry is one of the science subjects recognized as an engine room for national development and its role in daily life, industry and society is limitless (Okafor, 2013; 2012 & 2002). Chemistry concepts are taught and assessed at all levels of education with emphasis on critical thinking skills (Rahmayan, Jatmiko & Susantini, 2016). To think critically entails that student should have conceptual knowledge of contents taught with innovative pedagogies that could improve their understanding of difficult science concepts such as electrolysis (Oduol, 2018). Electrolysis is identified as a difficult topic to comprehend by secondary school chemistry students though its knowledge could help in fostering critical thinking skills (Oduol, 2018 & Okafor, 2012). Knowledge of electrolysis is very essential due to its roles in the metallurgical processes such as extraction or purification of metals from ores or compounds in metals deposition from solution (electroplating) (More, 2019). Its abstract nature in comprehension has been one of the reasons why secondary school students perform poorly during external examinations (West African Examination Council (WAEC), 2015). Blair, Schwartz, Biswas and Leelawong (2007) study revealed that conventional method of teaching does not foster students’ critical, creative and problem-solving skills due to teachers outdated lesson notes. Okafor (2012) assessed critical thinking abilities acquired by senior secondary school chemistry students. The result revealed low level of students’ critical thinking abilities. Dow
and Wood (2006) reported that critical thinking skills are not perceived differently according to gender because female students acquire critical thinking skills and problem-solving ability equitably with the male counterpart. Healey and Jenkins (2000) suggested the exploration of different learning styles in attainment of high educational standard. Okafor (2016) asserted that the learning cycle and inquiry teaching approach could help male and female students in meaningful understanding of chemistry concepts. This study therefore examined the effect of 7E-Learning Cycle Model pedagogy and gender influence in promoting secondary school students’ critical thinking skills in chemistry.

**7E learning cycle model for teaching science**

Learning cycles are controlled instructional methods in examining students’ prior knowledge and beliefs (Dogru & Tekkaya, 2008). The 7E Learning Cycle Model (7ELCM) is an extension of 5E learning developed by Eisenkraft (2003) which is an instructional strategy that assesses students’ misconceptions for scientific understanding and thinking ability (Sharma, 2018). The adoption of 7ELCM was to elicit prior knowledge and transfer it to the learning of new concepts (Eisenkraft, 2003). The cycle follows seven steps of elicit, engage, explore, explain, elaborate, extend and evaluate (Marfilinda & Apfani, 2020). Ozlem (2006) explored the effect of 7E-learning cycle on improving 5th grade students critical thinking skills. The study showed that 7ELCM significantly improved students’ critical thinking skills. Balci, Cakiroglu and Tekkaya (2006) studied 8th grade students understanding of photosynthesis and respiration using 5E learning cycle and demonstration strategy. The result revealed that students in 5E learning performed better than those in the demonstration group. Several researchers have recommended the use of 7ELCM in science classrooms which could make science learning interesting, meaningful and applicable in authentic situation (Dogru et al.,2008; Eisenkraft, 2003; Rahmayan et.al., 2016).

**Conventional method of teaching science**

The teaching of secondary school science is basically teacher-centred whereby the teacher provides examples, solves few problems, and demonstrates experiments while the learners listen, write notes but hardly ask questions (Thompson & Soyibo, 2002; Kang & Wallace, 2005). Lyons (2006) found that science teaching at the secondary school level involves transmission of knowledge to the passive recipients. Onwu and Stoffels (2005) posited that science teaching is basically teacher-centred and instruction dominated by lecturing, note copying, factual knowledge and cookbook practical. McCarthy and Anderson (2000) and Allen (2008) indicated that the traditional method of teaching has disengaged learners to meaningful understanding of science concepts. Taasoobshirazi and Carr (2008) explained that conventional approach involved memorization of concepts whereby learners fail to acquire skills and can hardly have deep understanding of chemistry concepts.

**Critical thinking skills in education**

Learning involves interactions with learners’ prior knowledge for further learning to take place. There has been a global shift over the last century towards information and knowledge services with specific emphasis on learning skills which cut across critical thinking, communication, collaboration, and creativity (Okafor, 2012). The 21st Century learning skills is a broad set of knowledge, skills, work habits and character traits required to attain success in today’s world of Information and Technology (Gordon, 2021; Sulaiman, 2011) stated that critical thinking is the ability to examine information rationally.
and make reasoned judgement based on personal analyses. Martins (2021) further explained that skills developed can boosts data-driven decision-making ability and give methodology in tackling complex problem in science education. Critical thinking is a deliberate thought process for making judgement on validity of an action in multiple perspectives, examining implications and consequences with reasons and evidence in resolving disagreement by re-evaluating any viewpoint (Gordon, 2021; Martins, 2021). A critical thinker uses evidence in decision making and communicates beliefs clearly and accurately (Sulaiman, 2011). Cotton (2011) assessed students critical and creativity skills during laboratory activity and found that very few students were critical thinkers and can hardly solve higher order thinking problem. Okafor (2012) and Ennis; Millman and Tomko (2005) assessed the critical thinking skills of secondary school chemistry students and found that two dimensions of critical thinking skills exist such as cognitive skills which relate to students ability to engage in activities such as analysis, inference, evaluation, explanations, self-correction, decisions on judgement while disposition skills involve habit of minds in students beliefs or action to effectively use cognitive skills when engaged in higher order thinking such as problem solving, decision making and problem based learning. However, an understanding of critical thinking skills could help students in self-regulatory and explanatory judgements. Therefore, strategies that could enhance students’ critical thinking skills and reflective learning should be investigated to ensure that they are not left behind in achieving their potentials.

**Gender awareness in science education**

Gender is a cultural construct that distinguishes the role, behavior, merits and emotional characteristics between female and male developed by the society (Ojo, 2017). It distinguishes organism on their reproductive role as male and female. Gender does not suggest the domination of male over female or vice versa in academics but enhances recognitions, development, utilization of competences and endowed capacities of both sexes (Anderson, 2017). Nzewi (2010) reported that more female than male students had difficulties and held misconceptions in senior secondary school science. Studies have shown several gender biases in chemistry education (Dow & Wood, 2006; Okafor, 2016, Okafor & Yewande, 2015). Gender equality and equity is underscored in Nigeria although women make up over 50% of the population (Okafor & Okewale, 2016). Okafor (2012) assessed critical thinking abilities of secondary school chemistry students and found that effective teaching strategies could enhance female students’ critical thinking abilities than the male counterpart. Okafor and Okewale (2016) stated that gender is a predictor of students’ achievement in chemistry but found no significant difference in the achievement of male and female students in chemistry. Anaso and Anao (2000) reported that boys outperformed girls in science achievement while another study by Dogru and Tekkaya (2008) indicated a non-significant difference between boys and girls in science achievement and critical thinking skills acquisition. Dow et al., (2006) concluded that females are critical thinkers and problem solvers in less confrontational style than the males. Healy and Jekins (2000) observed that women and men have different cognitive strengths in complex relations of nature and nurture. A gender study on problem solving by the Organization for Economic Cooperation and Development (2009) on Programme International Students Assessment (PISA) found that gender differences in problem solving for adolescents were few though men indicated greater strength in mathematics and had the highest range of scores than females. These may be
attributable to gender inequity that has become a norm in Nigeria educational system. Many studies have also shown that male students achieve higher than their female counterparts in science while some showed no significant gender influence on students’ achievement in science (Okafor & Okewale, 2016). Fairlie, Millhauser; Oliver and Roland (2020) conducted a study on the effects of male peers on educational outcomes of female STEM students’ and found that academically weaker female students were not negatively affected by male students. They also found that female students are not negatively affected when paired with academically stronger male students. This finding provides hope in future trend on female representation in STEM fields.

**Theoretical framework**

Vygotsky (1978) theoretical framework is focused on social interaction from guided learning within the ‘zone’ of proximal development. This ‘zone’ is the area of exploration in which student is cognitively prepared but requires help and social interaction to fully develop (Majiwa; Njoroge & Cheseto, 2020). He recognized that social settings and learning were closely entwined, therefore one must identify and implement strategies that are effective in a social context. Piaget (1952) emphasized that one of the ways students gain knowledge is through collaboration with peers or mentors on cognitive activities that involve problem solving skills and real-life tasks at different developmental levels. Vygotsky maintained that the social world did not only involve peers and teachers but also consisted of outside influences within the community as well as prior knowledge learned at home and in the classroom environment. Vygotsky (1978) outlined three concepts that are related to cognitive development such as culture and language since individuals learn and develop within their community as children and co-construct knowledge. Vygotsky believed that everything is learned on two levels such as through interaction with others, and integration into individuals’ mental structure. Every function in the child’s cultural development appears twice: On the social and individual levels respectively. The Zone of Proximal Development according to Vygotsky is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through adult problem-solving. However, 7ELCM pedagogy could be learned through interaction with the teachers, peers and learning materials to ascertain the extent students critical thinking skills could be enhanced independently. Therefore, parents and teachers can foster learning by providing educational opportunities that lie within a child's zone of proximal development.

**Problem**

Chemistry has been taught using several strategies like problem-based learning, concept mapping and lecture method but students still find it difficult to link some concepts to daily activities when confronted with abstract tasks that require critical thinking (Okafor, 2012). The West African Examination Council (WAEC) chief examiner’s report (2015) and subsequent years revealed that secondary school students had difficulties in answering chemistry questions that involve critical thinking skills. Some of the reasons are due to poor understanding of chemistry concepts, misconceptions, unscientific reasoning, teacher-dominated instruction, and students’ inability to think critically (Okafor, 2012; Onwu & Stoffels, 2005; Osborne & Collins, 2001). Blair, Schwartz, Bismas and Leelawong (2007) revealed that conventional method of teaching does not foster critical and creative thinking abilities of students due to teachers outdated lesson plan. The researchers’ interactions with the
secondary school chemistry teachers showed students poor knowledge and inability to apply 7E learning cycle pedagogy in chemistry classrooms (Oduol, 2018; Sharma, 2018). It was reported that women have impediments in accessing chemistry concepts in the tertiary institutions (Okafor, 2013). The purpose of the study was to examine the effect of 7E-learning cycle model, Lecture method and influence of gender in promoting secondary school students’ critical thinking skills in chemistry. Two research questions and one null hypothesis guided the study to include:

RQ₁: What is/are the mean gain scores of secondary school students exposed to 7E Learning Cycle Model (7ELCM) and Lecture Method (LEM) in promoting critical thinking skills in chemistry?

RQ₂: What is the influence of male and female (gender) in promoting secondary school students’ critical thinking skills in chemistry when exposed to 7ELCM and LEM respectively?

HO₁: There is no significant interactive effect of 7E Learning Cycle Model, Lecture Method (LEM) and gender influence in promoting critical thinking skills in chemistry.

Methods
The study employed a quasi-experimental research design where intact classes were subjected to 7E-Learning Cycle Model (7ELCM) (treatment) and Lecture Method (LEM) (control). The study involved pre-post-tests to ascertain baseline treatment effects on a 2x2 factorial matrices. All the public co-educational Senior Secondary Year Two (SS II) chemistry students in Education District V of Lagos State, Nigeria participated in the study. The choice of SS II students was considered appropriate because they have been exposed to some basic chemistry concepts in SS I and are not preparing for any external examinations. Electrolysis concept was used in the study. Six schools were randomly selected from Education District V based on the adequately equipped laboratory and teachers with Masters’ Degree in Chemistry Education. All the arms of SS II chemistry students in each of the six eligible schools participated in the study. Overall, the sample is comprised of 146 students (66 boys & 80 girls) with average age of 14 years. Two instruments were used in data collection to include: Lesson Plan on 7ELCM and LEM (LP7L) and Cornell Critical Thinking Test (CCTT). For LP7L, lesson plan was written on each of the 7ELCM and LEM using the concept of electrolysis and vetted by chemistry teachers at the sampled schools to ascertain its validity. The CCTT in chemistry was adapted from Cornell Critical Thinking Test (Ennis, Millman & Tomko, 2005) which consists of 30 multiple choice objective items. The pre-post CCTT were administered to chemistry students of two private schools that did not form part of the study to determine the initial performance and the effect of treatment and control in promoting critical thinking skills in chemistry. The face and content validated of CCTT was determined and its reliability established using KR21. A reliability coefficient of 0.87 was obtained for CCTT. The chemistry teachers that assisted in the teaching were trained for one week using LP7L instrument which served as the training manual for the treatment and control groups respectively. The eligible participants from each of the two schools were taught for Three Weeks with 7E Learning Cycle Model (7ELCM) and Lecture Method (LEM). The lesson plan specified the teachers and students’ activities for both the treatments and control groups respectively. Two days...
Okafor Ngozi and Nwonu Hyacinth: Promoting critical thinking skills of secondary school chemistry students’ through 7e-learning cycle model

before the commencement of instructions, pre-tests on Cornell Critical Thinking Test (CCTT) were given to the respondents for 7ELCM and LEM to determine the equivalence of the groups before treatment. After the treatment, post-tests were administered using the same instrument on the respondents exposed to 7ELCM and LEM. Data collected were analyzed using descriptive statistics, mean and Analysis of Covariance (ANCOVA).

Results
The results of the study are delineated based on the research questions and hypothesis stated.

RQ1: What is/are the mean gain scores of secondary school students exposed to 7E Learning Cycle Model(7ELCM) and Lecture Method (LEM) in promoting critical thinking skills in chemistry?

Table 1: Descriptive Statistics of Pre-test, Post-test Mean Gains on Secondary School Students exposed to 7ELCM (Treatment) and LEM(Control) in Promoting Critical Thinking Skills (CTS) in Chemistry

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Pretest Mean</th>
<th>Posttest Mean</th>
<th>Mean Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>66</td>
<td>8.71</td>
<td>8.91</td>
<td>0.20</td>
</tr>
<tr>
<td>Experimental</td>
<td>80</td>
<td>11.03</td>
<td>13.24</td>
<td>2.21</td>
</tr>
</tbody>
</table>

The data presented in Table 1 shows that the experimental group taught with 7E Learning Cycle Model (7ELCM) had a mean score of 11.03 in the pre-test and a mean score of 13.24 in the post-test, thereby making a pre-test, post-test mean gain of 2.21. The Control group had a mean score of 8.71 in the pre-test and a post-test mean of 8.91 with a pre-test, post-test mean gain of 0.20. The finding shows that chemistry students taught using 7ELCM had a higher mean score in promoting Critical Thinking Skills (CTS) than the students taught with LEM with the mean gains of 2.21 and 0.20 respectively.

RQ 2: What is the influence of male and female (gender) in promoting secondary school students ‘critical thinking skills in chemistry when exposed to 7ELCM and LEM respectively?

Table 2: Mean of Pre-test and Post-test Scores of Students based on Gender in Promoting Critical Thinking Skills in Chemistry when exposed to 7ELCM and LEM respectively

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>N</th>
<th>Pre-test Mean</th>
<th>Post-test Mean</th>
<th>Mean Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>7ELCM</td>
<td>Male</td>
<td>66</td>
<td>10.58</td>
<td>12.17</td>
<td>1.59</td>
</tr>
<tr>
<td>7ELCM</td>
<td>Female</td>
<td>80</td>
<td>9.51</td>
<td>10.60</td>
<td>1.09</td>
</tr>
<tr>
<td>LEM</td>
<td>Male</td>
<td>66</td>
<td>10.09</td>
<td>11.15</td>
<td>1.06</td>
</tr>
<tr>
<td>LEM</td>
<td>Female</td>
<td>80</td>
<td>8.41</td>
<td>9.46</td>
<td>1.05</td>
</tr>
</tbody>
</table>
Table 2 shows that male students taught with 7E Learning Cycle Model (7ELCM) had mean scores of 10.58 and 12.17 in the pre-test and post-test respectively with a mean gain of 1.59. Meanwhile, the female students taught using 7ELCM had a mean score of 9.51 and 10.60 in the pre-test and a post-test respectively with a mean gain of 1.09 in promoting Critical Thinking Skills (CTS) in chemistry. There was an attributable influence of gender in promoting Critical Thinking Skills (CTS) in chemistry on students taught using 7ELCM in favour of male. In addition, male students taught with Lecture Method (LEM) had mean scores of 10.09 and 11.15 on pre-test and post-test respectively making a mean gain of 1.06 while female students taught with LEM had mean scores of 8.41 and 9.46 on pre-test and post-test respectively with a mean gain of 1.05. Thus, an influence of gender in favour of male in promoting CTS in chemistry on students taught with LEM. Thus, a gender influence in promoting secondary school students ‘critical thinking skills in chemistry is obtained among male and female students taught with 7ELCM and LEM in favour of male students.

**HO1:** There is no significant interactive effect of 7E Learning Cycle Model, Lecture Method (LEM) and gender influence in promoting critical thinking skills in chemistry

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>1875.108</td>
<td>8</td>
<td>234.389</td>
<td>255.195</td>
<td>.000</td>
</tr>
<tr>
<td>Intercept</td>
<td>34.252</td>
<td>1</td>
<td>34.252</td>
<td>37.292</td>
<td>.000</td>
</tr>
<tr>
<td>Post Test</td>
<td>1399.053</td>
<td>1</td>
<td>1399.053</td>
<td>1523.245</td>
<td>.000</td>
</tr>
<tr>
<td>Group</td>
<td>133.096</td>
<td>1</td>
<td>133.096</td>
<td>144.911</td>
<td>.000</td>
</tr>
<tr>
<td>Gender</td>
<td>1.369</td>
<td>1</td>
<td>1.369</td>
<td>1.490</td>
<td>.224</td>
</tr>
<tr>
<td>Error</td>
<td>125.830</td>
<td>137</td>
<td>918</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>16541.000</td>
<td>146</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>2000.938</td>
<td>145</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at sig of F<.05

The data on Table 3 shows F-calculated values for groups and gender in promoting critical thinking skills in chemistry among secondary school students. The F-calculated value for groups is 144.99 with a significance of F at .000 which is less than .05. The null hypothesis is therefore rejected at .05 level of significance. This showed a significant effect of 7ELCM and LEM on students in promoting critical thinking skills in chemistry. The F-calculated value for gender is 1.49 with a significance of F at .224 which is greater than .05. This means that there was no significant interactive influence of gender in promoting critical thinking skills in chemistry among secondary school students taught with the two pedagogies (7ELCM and LEM). The null hypothesis of no significant interactive influence of gender in promoting critical thinking skills in chemistry among secondary school students was accepted at .05 level of significance.

**Discussions**

Tropical Journal of Education, Volume 3, Numbers 1/2, 2021 22
Effects of 7E learning cycle model (7ELCM) and lecture method (LEM) on secondary school chemistry students in promoting critical thinking skills (CTS)

Result in Table 1 shows that secondary school chemistry students exposed to 7E Learning Cycle Model (7ELCM) had higher mean score than students exposed to Lecture Method (LEM) in promoting critical thinking skills. This corroborates with Okafor (2012) who stated that innovative pedagogies could enhance secondary school students’ critical thinking abilities in chemistry, give corrective feedback and decreases cognitive load in the activity-oriented classroom. The finding is also in line with Marfilinda and Apfani (2020) and Ozlem (2006) who stated that 7ELCM can significantly improve students’ critical thinking skills and its application in authentic science classrooms. It further agrees with Eisenkraft (2003) and Sharma (2018) who affirmed that 7ELCM is an instructional strategy that assesses students’ misconceptions and thinking ability when eliciting prior knowledge and transferring it to the new concepts to be learned. One of the reasons for the effectiveness of 7ELCM over LEM in promoting critical thinking skills among secondary school chemistry students could be its involvement of students during hands-on activities. Lecture method (LM) was not very effective, and this was supported by McCarthy and Anderson (2000) and Allen (2008) who indicated that the traditional method of teaching has disengaged learners in meaningful understanding of concepts. The finding is also in line with Taasoobshirazi and Carr (2008) who explained that conventional approach involved memorization of concepts that hardly promotes deep understanding and skills acquisition.

Influence of male and female (Gender) in promoting secondary school chemistry students critical thinking skills (CTS)

when exposed to 7ELCM and LEM respectively

Result in Table 2 shows gender influence in promoting CTS on secondary school chemistry students taught with 7ELCM than LEM in favour of male students. The better performance of male over female students exposed to 7ELCM is supported by Nzewi (2010) and Organization for Economic Cooperation and Development (2009) who reported that female students had difficulties in problem solving and skills development but male students are favoured specially in mathematics. It is also in agreement with Anaso and Anao (2000) and Okafor (2013) who reported that boys outperformed girls in science achievement and girls have impediments in accessing chemistry concepts. The finding negates the works of Dow and Wood (2006) and Dogru and Tekkaya (2008) who indicated that females are critical thinkers and problem solvers with a non-significant difference between girls and boys in critical thinking skills acquisition. This is an evidence of male students’ intellectual superiority over females in promoting critical thinking skills and reasoning abilities when exposed to 7ELCM. Hence the influence of gender in promoting critical thinking skills on secondary school chemistry students in favour of male.

Interactive effects of 7E learning cycle model(7ELCM), lecture method (LEM) and gender (male and female) influence in promoting critical thinking skills in chemistry

The result in Table 3 shows a significant interactive effect of 7ELCM and LEM on secondary school chemistry students in promoting critical thinking skills but there was no significant interactive influence of gender in promoting critical thinking skills among secondary school chemistry students taught with the two pedagogies (7ELCM and LEM). 7ELCM is a pedagogical strategy that assesses students’ scientific understanding and thinking ability (Sharma
The effect of the pedagogy corroborates with Ozlem (2006) who stated that 7ELCM significantly improved 5th grade students critical thinking skills. Due to its positive effect, several researchers have recommended its use in science classrooms (Rahmayani, Jatmiko & Susantini, 2016). The result is not in agreement with Ojo (2017) proposition on non-significant interactive effect of innovative pedagogical strategies on chemistry students’ learning outcomes. More so, Thompson and Soyibo (2002) posited that LEM is teacher-centred whereby the teacher solves few problems and demonstrates experiments for learners to listen, write notes without asking questions. In addition, the non-significant interactive influence of gender is supported by Okafor and Yewande (2015) who found that gender is a predictor of students’ achievement in chemistry but found no significant interactive difference in the achievement of male and female students in chemistry. The result also corroborates with Fairlie, Millhauser; Oliver and Roland (2020) who observed that there is no significant difference in the achievement of male and female students taught using problem solving and lecture methods in mole concept. They also found that weaker female students were not negatively affected when paired with academically stronger male students. This finding provides hope for future trends on equitable representations of male and female in Science, Technology, Engineering and Mathematics (STEM) fields.

**Conclusion**

Critical thinking is an essential tool in education that nurtures open-mindedness, prudent judgement, and critical reasoning in learners’ daily activities. Promoting critical thinking skills in the secondary school requires application of innovative pedagogies during teaching and learning that would guide individuals in deciding how to accept, reject or reserve judgmental ideas. Its promotion among the students will help them in making informed decisions, solving problems, taking actions, and deciding what to believe or not to believe. Promoting students’ critical thinking skills has been a challenge to many educators over a decade but with the application of innovative pedagogical strategies, its dividends will be reaped dimensionally. The contribution of the 7E Learning Cycle Model (7ELCM) in promoting secondary school chemistry students critical thinking skills has motivated some teachers in bringing out the best from their students as independent learners, and critical thinkers in solving difficult chemistry concepts. However, current researchers are seeking for the most effective pedagogies that could enhance male and female students’ conceptual knowledge and acquisition of the 21st century skills. It is only by their practical application in a meaningful way that chemistry students can construct their own personal meaning on what to be learnt. It is also observed that each phase of the 7ELCM encourages students to think critically and acquire meaningful knowledge of chemistry concepts by raising their curiosity. Anderson (2017) warned that gender does not suggest the domination of male over female or vice versa in academics or other spheres of life but a recognition that enhances competences and endowed capacities of both sexes. It becomes imperative that chemistry teachers should provide learning opportunities that would make students take ownership of their learning by compelling them to learn meaningfully, think critically, and criticize constructively as a team in solving problematic tasks through the application of 7ELCM irrespective of gender roles.

**Suggestion**

Based on the findings of the study, the following recommendations are made:

- The 7E Learning Cycle Model (7ELCM) should be incorporated...
Okafor Ngozi and Nwonu Hyacinth: Promoting critical thinking skills of secondary school chemistry students’ through 7E-learning cycle model

into the senior secondary school chemistry curriculum with emphasis on its implementation to ensure that chemistry students’ critical thinking skills are enhanced and sustained.

- Remuneration and incentives could be given to every male and female chemistry student who demonstrates excellent performance in fostering 21st Century learning skills in the classroom setting.
- Ministry of Education and school administrators should organize Train-the-Trainers workshop for all the secondary school chemistry teachers on how to incorporate 7ELCM pedagogy in promoting 21st century skills and improving students learning outcomes in chemistry. Less emphasis should be on the LEM strategy.
- Chemistry textbooks that are gender fair should be written using the features of 7ELCM to complement teachers’ work in the classrooms.
- Lesson plan should be developed on most difficult concepts in secondary school chemistry using 7ELCM and should be adapted in the teaching of any science subjects at all levels for multiplier effect.
- Secondary school teachers should ensure that male and female chemistry students are engaged in hands-on-activities during practical activities that foster problem solving and critical thinking skills.

References


Nzewi, U. (2010). It’s all in the brain of gender and achievement inscience and technology. Education. 51st Inaugural Lecture of the University of Nigeria, Nsukka.


