Original Research Article

Impacts of Concept Map and Concept Test on Critical Thinking Ability for Quality Education among Undergraduate Students

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Abstract

The study examined the impact of concept map and concept test on critical thinking ability of undergraduate students of University of Port Harcourt, Rivers State, Nigeria. A sample of 307 fourth year students from three departments in the university was chosen using simple random, purposive and accidental sampling techniques. These students were assigned to three different groups, two experimental treatment groups and one control group. One group was treated using concept mapping, the second group was treated with concept test while the control group received the conventional method of assessment. To guide the study, two research questions and two null hypotheses were developed. The study adopted a quasi-experimental research design by pretest, post-test non-equivalent control group design. The pre- and post-tests data were collected using an adopted 52 item instrument named Cornell Critical Thinking Test (CCTT) Level Z. It is a 3- option (A-C) multiple-choice test with 7 subscales measuring induction, deduction, value judgment, observation, credibility, assumption and meaning. Using Kuder-Richardson 20 formula (K-R$_{20}$) their internal consistency estimates were 0.81, 0.76, 0.66, 0.71, 0.70, 072 and 0.68 respectively for the subscales, while internal consistency of 0.74 was obtained for the total scale. Data were analyzed using mean, standard deviation, paired t-test, and analysis of covariance. The results obtained indicated that concept map, concepts test and the conventional assessment method independently had positive impacts on critical thinking ability of the students. However, concept test was the most effective, followed by concept map and lastly the conventional method. On the basis of the findings, it was recommended amongst others that school administrators, curriculum developers and faculties should update their curricula by integrating concept test and concept map assessment methods in their instruction as this can improve critical thinking ability of their students.
Keywords: Critical thinking, Concept map, concept test, Quality education.

INTRODUCTION

Universities are the embodiment of knowledge, productivity and socio-economic growth of the individual and that of the society. Universities are the engines of knowledge where graduates are developed and produced. In the past, universities focused their teaching only on content-based knowledge to the detriment of the non-content-based knowledge. This approach leads to the acquisition of surface learning at the detriment of deep learning by our graduates, this, in turn, resulted in graduates who do not have a good command of the discipline in which they were awarded degrees. Similarly, the traditional teaching approach yielded graduates who perform well academically but are inefficient in their career duties. Meanwhile, Harrison

(2017) asserted that employers of labour expect recent graduates to have a commendable grip of their degrees as well as the preparedness, experience, professional values and mental abilities required to work effectively in the world of work.

Supporting this, Wood (2018) asserted that employers of labour are currently giving more attention to soft skills (non-content based knowledge) than hard skills (content-based knowledge such as Grade Point Average, GPA). This is because GPA has been shown to be a poor predictor of graduates and new hirees efficiencies in the world of work as a result of its negative correlation with efficiency in career duties (Talley in Wood, 2018). In this regard, Wood (2018) opined that the success of graduates in higher institutions and

workplaces is dependent on their mastery of content in the core subject areas (content-based-knowledge) as well as the soft skills (non-content-based knowledge) such as creativity, critical thinking and problem-solving. However, on the contrary, it has been observed that recent graduates lack certain soft skills needed for success in both school and non-school settings.

Furthermore, there are indications that advances of technology had affected many aspects of our lives such as our way of communicating, collaborating, learning, teaching and assessing. For instance, universities mission which was primarily a teacher-centred approach is changing to a student-centred approach. Again, there is a transition from surface learning to deeper learning - mastering of both content-based knowledge (hard skills) and non-contest based knowledge (soft skills). These advances of technology on the economy has also changed the demands on graduates from knowledge-absorber to knowledge-implementers, while the teacher/lecturer is no longer seen as the 'sage on the stage' rather as mentor, adviser and co-facilitator with students.

To address these changes, according to Igbal (2011) the National Curriculum of nations like Pakistan is undergoing a paradigm shift from behaviourism to constructivism in order to promote conceptual and deeper learning among students. This is believed to develop teaching, learning and assessment strategies to actively involve students in their own knowledge construction thereby placing them at the centre of learning while teachers act as facilitators. Igbal (2011) further stated that the theory of behaviourism is popularly applied in schools and classroom where students are passive and classroom activities are mostly teacher-centred. So any school or classroom that is ready to develop in students proper skills for meaningful learning must move away from theories that support teacher-centred instruction to those that promote student-centred instruction.

To actualize the present and future demand on the graduates, West (2016) advised that, university as the engine and key drivers of knowledge and socio-economic development should move away from providing only functional skills (content-based-knowledge) to providing of both content and non-content based knowledge. The reason is that content-based-knowledge are difficult to transfer or apply to other situations of life activities. Hence they are almost out-dated as soon they are learned. Secondly, they do little to prepare graduates with a flexible mindset and employability skills required outside their area of specialization. On the other hand, non-content-based-knowledge promotes the acquisition of key skills needed for progressive education, pedagogical movement and career efficiency (Graham, 2015).

There are some transferable skills that would-be graduates need for lifelong learning as well as their passport to career success. These skills include but not limited to creativity, communication, collaboration, flexibility and critical thinking skills (Wood, 2018; Graham, 2015 and Elkana & Klopper, 2016). From these skills mentioned, critical thinking is the focus of the study.

LITERATURE REVIEW
Critical Thinking
Critical thinking is a complex cognitive process. It is the use of purposeful and insightful judgement that involves the effective use of multiple cognitive aspects to interpret and analyze a situation in order to arrive at a better conclusion (Facione, 2013). To Omran (2017), it is the making of a rational, thoughtful and logical decision. It is a way of thinking that prevents one to just accept ideas, argument and conclusion like that but to investigate the authenticity of the point with proven evidence. In the words of Ennis, Millman and Tomko (2005:1) "critical thinking is reasonable and reflective thinking that focuses on deciding what to believe or do".

To this end, the researchers viewed critical thinking as rational, scientific and deep thinking that is related to all facets of life in order to arrive at the informed and right decision. Considering the various definitions of critical thinking, it could be deduced that it is not the mere compilation or gathering of information, knowledge and ideas but it is deep and effective thinking that deduces consequences from a known premise. It is a thinking that separate facts from opinion. Hence it is a very important skill needed by everybody without border mostly graduates and the would-be-graduates of the 21st century. This is because the 21st century is characterized by abundant information reaching us through many many such as teachers, friends, parents and politicians and through different media such as digital and non-digital means. Every information need not be accepted immediately because many may be fake and need to be discerned in order to extract facts from opinion. Tomaszewski (2019) suggested that critical thinking should be adopted by individuals in this era of surplus fake news and contrasting opinion in order to make sense of the world. This implies that critical thinking skills will help an individual to ascertain the information to be accepted, why it should be accepted and sometimes when to question some of the information.

Secondly, 21st-century demand students to acquire different skills of the higher order thinking abilities that will promote lifelong learning, reflective practitioners and self-reliant citizens. Therefore, critical thinking ability is a key learning outcome of undergraduates for the 21st century (Bok, 2006, Partnership for 21st Century Skills, 2009). Islam (2015) asserted that critical thinking is a domain-general skill needed by all, mostly students, in order to succeed in the

world of school and beyond. Critical thinking is among the first group of abilities needed to effectively face the challenges of formal schooling and beyond.

This position accorded to critical thinking may be due to the following. Firstly, it is the foundation of strategic thinking, creative thinking, and good judgement (Zulfigar, 2016). It is the skill that promotes self-confidence among individuals (Jones, 2016). Critical thinking skills are the cornerstone of self-development and its improvement (Tomaszewskie, 2019). It helps for better communication flow among individuals. Good acquisition of critical thinking skills helps students better absorb reading done by themselves and other students in the classroom. In other words, critical thinking helps one to better understand the feeling and perspective of others. Critical thinking enables a person to become an effective communicator and one with good oral presentation skills (Jones, 2016). This is because the individuals will develop critical points to back his/her ideas.

Critical thinking skills enhances the development of decisive personality which in turn promotes employability and stability in an individual's professional life. This is through the improvement of decision making and ideas that can be used to resolve conflicting information or conflict among friends or associates. The acquisition of critical thinking skill propels individuals' ability to map out better alternative means of solving problems instead of depending only on the regular method or the existing means. Critical thinking, therefore, helps the minds to grow to the extent they can create ideas that facilitate their ability to solve problems.

Indeed, the importance of critical thinking to the development of self and society in relation to the actualization of the mission of higher institution cannot be overemphasized. However, despite its role, it is observed that many graduates and graduates-to-be lack this important skill. This is evidence in the way most of them ask wrong questions during class sessions. Zulfiger (2016) asserted that critical thinkers are characterised with the ability to ask the right questions. Poor critical thinking is evidenced in the inability of most students to defend their research projects and dissertations. Again, many of the students avoid responding to questions that demand application of acquired knowledge. In another angle, most students show a negative attitude to item formats like essay question that requires critical thinking. For instance, Nwede and Orluwene (2019) reported that students hold a negative attitude towards essay item format due to the demand it places on their critical thinking abilities.

The low acquisition of critical thinking skills is also shown in the way most of our students' responses to questions wrongly or in a different perspective other than what the question requires, due to their inabilities to understand the appropriate direction to respond. This is what is popularly tagged "out of point" or "OP", which lead to low academic achievement. With critical thinking, one should be able to ascertain what the question requires. Situations like these have negatively affected the academic achievement of students and their performance in the world of work.

This situation had also hindered the acquisition of skills to create alternative ways of solving problems. Therefore we rely on the existing method that has kept the development of our economy stagnant. If this trend continues, the actualization of the Vision 2020 will only be a mirage. To achieve these, there is an urgent need for a study like this present one to be conducted because traditional teaching and assessment methods are becoming obsolete in developed society that advocates for creativity and critical thinking abilities (Hainline, Gaines, Feather, Padilla & Terry, 2010).

The nature of assessment is known to affect students approach to learning. The way students are assessed contributes significantly to determining what they can achieve. It is reported that assessment of students that focused on the regurgitation of knowledge involves students in surface learning than deep learning. Thus, educators have realized that "one size" does not fit all learning (Halinline, *et al.*, 2010). In recognition of this, educators are now mapping out better ways of transforming our teaching, learning and assessment from traditional methods to innovative ways.

To innovate is to develop a novel way of doing things outside the regular way in order to produce a positive transformative effect on either quality or quantity or both. Comins (2015) stated that innovative assessment is assessment geared towards effective and improvement of learning and other skills that prepare young people for school life, work and citizenship.

Traditional teaching and assessment impair learning, so universities are urged to revamp their teaching methodology in order to foster higher-order thinking skills like critical thinking that sustains students beyond the school requirements (Elkana & Klopper, 2016). In a bid to change the traditional method of assessment to the innovative ways/methods of assessment such as creating an assignment, creating examination, using classroom assessment techniques, concept maps, concept test, group work assessment, creating and using rubrics were suggested (Croasdell, Freeman & Urbanczewski, 2003). However, among the innovative strategies suggested, the present study focused on the impact of concept maps and concept tests on the critical thinking ability of undergraduates.

Concept Map
The concept map is one of the graphic organizers that can be used to show the association or link that exist between and within concepts, ideas, processes, theories and structures etc (Alexander, 2014).

It is a visual representation of connections between concepts that the student learnt. It is a very effective tool that provides a clear picture of what the students had understood and the ones they had misconceptions. Concept maps provide an effective way of assessing more complex learning and also help in identifying areas where student are confused. More so it serves both as a teaching tool and assessment tool. Thus, Alexander (2014) stated that concept maps can be used as a visual teaching tool as well as an assessment tool. To Croasdell *et al*., (2003) concept map is a learning tool is an alternative to traditional note taking by building an association of non-linear key concept than as an assessment tool. The use concept map as an assessment tool helps students to think holistically as they go through the interrelatedness between ideas, processes and concepts. Specifically, a concept map provides an innovative, multifunctional, evidence-based assessment method that provides very insightful information about the level to which students understand complex concepts (Alexander, 2014). To this end, a concept map is a teaching and assessment strategy that promote deep learning among students.

The skeleton of concept map takes different forms such as spider web, flow chart and hierarchical concept maps (University of Illinois in Kilic & Cakmak, 2013). Spider web concept map organizes ideas in a logical manner; flow chart concept map organizes information in a linear format; while hierarchical concept map organizes information in descending order of importance. One thing that is certain is that no matter the shape or form of the concept map, they all have nodes and arc. The nodes are the concepts, or ideas represented in rectangles or circle based on interest or the desire of the individual. The arc/links are lines that describe the relationship between nodes using a word or phrase. See Figure 1 for a detailed example.
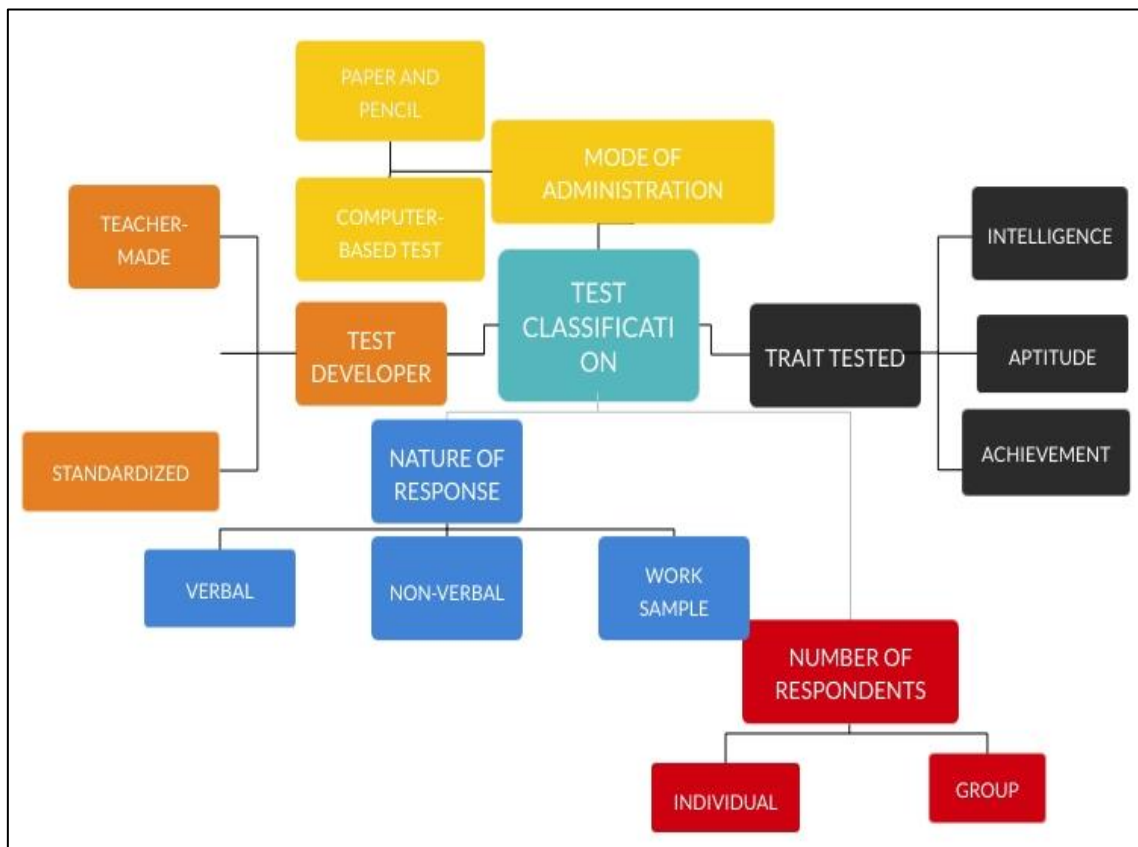

Fig 1: Sample Concept Map on Classification of Test (Orluwene, 2012)

Concept mapping to Wheeler and Collins (2013) is among the assessment strategies developed to improve critical thinking among students. In addition, the use of concept map in assessing the students triggers their cognitive skills of analysis, evaluation, synthesis and reasoning.

Nevertheless, previous studies related to concept mapping and critical thinking conducted yielded mix result about the impact of concept mapping on the critical thinking of students. For instance, Kadudoura (2016), Moaitari, Soleimani, Moghaddam and Mehbodi (2013), Nirmala and Shakuntala (2011) reported a significant positive impact of concept mapping on students' critical thinking. Again another study conducted in 2018 using Phayo university students found that critical thinking level of the students at post-test was significantly higher than their level at pre-test. On the other hand, a study conducted by Zepure (2006) using Nursing students found no significant difference in the

critical thinking ability of the students before and after treatment with concept mapping assessment strategy. So, on the basis of this mix results, the researchers were compelled to carry out the present study.

Concept Test

Another variable considered in the study is the concept test, which was first developed as a form of peer instruction technique to teach physics (Crouch & Mazuar, 2001). Concept tests are conceptual multiple-choice questions designed to determine students' level of understanding in a given concept. They are part of the peer instruction technique adopted by different faculties including education (Crouch & Mazur, 2001). Concept tests do not focus on a simple content-based question that requires students to recite their lecture notes or memorization of facts or definition. Rather, they are questions that demand the students' deep understanding of key concepts related to the topic covered hence they are mostly application questions.

The application of the concept test involves the division of the lecture time, into short lectures period and conceptual multiple-choice questioning period. Concept test in the classroom involves writing giving the multiple-choice question on the chalkboard, allowing the students to independently provide the answer, evaluation of the student's responses by the teacher/lecturer, grouping the students to discuss and interact on the correctness of their responses to the question and then the group's spokesman explains why and how they fell their responses are correct. These steps help students develop self-confidence in their responses, which also help to increase their achievement and deepen their learning. Concept tests approach help students to be deeply involved in class activities. Thus, it promotes a high level of acquisition of course material. This is because it fosters effective interaction among students through cooperative learning.

Concept test can be done at the beginning of the class; intermittently or at the end of the class. The time chosen depends on the purpose of the testing. If the purpose is to determine the students' level of understanding and understanding of past lessons, then concept testing will be given at the beginning of the class. If the purpose is to determine what the teacher will do next after a learning module, concept testing is conducted intermittently. However when the teachers' purpose is to determine how the day's lesson was understood, then it will be done at the end of the class to serve as the lesson evaluation.

Concept tests are higher order multiple-choice question that focuses on one key concept. It is a very effective formative assessment of students' deep learning. The uses of concept tests assist students to obtain deeper learning, improve their understanding and ability to apply acquired knowledge to other related situations. They also enhance students' critical thinking

and enthusiasm for learning. The concept serves as a tool that guides the identification of areas and concept students had erroneously understood as well as areas/concepts they had mastery. Thakur (2016) opined that concept testing gives students the greater opportunity to articulate their reasoning for a given response because it usually probes students' level of understanding and application of concept learnt. Dyson, Linehan and Hastie (2010) reported that any teaching-learning method that promotes teamwork helps to improve critical thinking. In the same vein, Brennan, Brownson, Kelly, Ivey and Leviton (2012) also asserted that building team-learning groups for solving problems contribute meaningfully to the improvement of critical thinking among students.

Furthermore, concept testing is a form of cooperative learning in which students are allowed to work together in small groups. On this basis, student-student interaction that promotes problem-solving abilities (Chen, 2001). Practically the researchers viewed concept testing as a good technique for both small and large class sizes and promote Socratic questioning strategies. Socratic questioning is the act of presenting higher-order questions that propel students to think, discuss, debate, evaluate and analyse their own thinking and that of others in the class (Intel Corporation, 2007). It is a student-centred approach of questioning that propels students to develop critical thinking skills through self-reflection and analytical discussion (Paul & Elder, 2006) Thus, Paul and Elder (2006) asserted that any testing that takes Socratic questioning strategies is at the core of critical thinking. Considering the features of the concept test, the researchers hypothesized that it may contribute positively to the critical thinking ability of undergraduates.

Conventional/traditional assessment technique mostly promote memorization of facts, which does not help students to think critically. This is contrary to the finding of Aluta (2015) that innovative teaching and assessment strategies enhanced students' achievement and creativity than the traditional techniques that retard mastery of course material. Furthermore, Cheema and Mirza (2013) reported a significant mean difference between students taught science with concept mapping and traditional method of teaching. Specifically, a higher mean achievement score was obtained by students in the concept mapping group than those in the traditional method group. Huang, Tu, Wang, Chien, Yu and Chou (2017) reported that the critical thinking of students is better achieved with the use of peer-cooperative and concept mapping than with the use of traditional assessment practice methods.

Theoretical Framework

The present study is anchored on two theories namely assimilation theory of memory and constructivism theory of learning. Concept mapping strategy was developed by Joseph D Novoka and his

associates at Carnell University in the 1970s on the basis of the meaningful theory of learning propounded by David Paul Ausubel. The theory posits that one of the most important factors that influence learning is what the learner already knows. Secondly, that meaningful learning involves the assimilation of new concept and propositions into existing structures. Thirdly that meaningful learning takes place only with sound developed skills associated with learning.

The second theory the present study hinges on is the theory of constructivism. This is on the basis that the concept map originated from the philosophy of knowledge called constructivism. The constructivism believed that knowledge does not come merely but must be constructed by learners. Again that new knowledge is dependent on the already existing ones. In other words, teachers must create an enabling environment that will allow students to be actively involved in the construction of knowledge. The theory also assumed that collaborative groups should be created during the teaching-learning process for students to interact and determine their level of understanding as well as to expand the existing level of understanding. Finally, teachers must challenge their students thinking and problem-solving abilities through the use of appropriate questioning or assessment techniques.

Succinctly, since concept mapping create room for the students to be very active in constructing knowledge through drawing of the maps individually and concept testing involves the use of probing question, grouping and peer instruction, it is pertinent that the present study hinges on the theory of constructivism and assimilation theory of learning.

On the basis of the aforementioned assertions and the fact that none of the previous studies was conducted using students in Rivers State, Nigeria. In addition, none of the previous studies focused on the impact of concept map and concept test. This has therefore made a study like the present one is indispensable. Therefore, the study is aimed at investigating the impact of concept map and concept test assessment strategies on critical thinking ability of undergraduate students of University of Port Harcourt, Rivers State, Nigeria. Specifically, the study investigated the following;

- The impact of concept mapping, concept testing and conventional testing on the critical thinking ability of the undergraduate students as determined by their pretest and post-test mean scores.
- The differential impacts of concept mapping concept testing and conventional testing on critical thinking ability of the students.

Research Questions

1. What is the impact of concept mapping, concept testing and conventional testing on the critical thinking ability of the undergraduate students as determined by their pretest and post-test mean scores?
2. What is the differential impacts of concept mapping, concept testing and conventional testing on critical thinking ability of the students?

Hypotheses

The following null hypotheses were tested at 0.05 level of statistical significance

1. There is no significant difference in the pretest and posttest critical thinking ability of undergraduate students assessed using concept mapping, concept testing and conventional testing.
2. There is no significant differential impacts concept mapping, concept testing and conventional testing on critical thinking ability of the undergraduate students.

METHODS

The study adopted a pre-test post-test non-equivalent control group quasi-experimental research design. A sample of 307 fourth-year students was selected using a two-stage sampling method. In the first stage, the researchers purposively selected three departments out of 8 departments in the Faculty of Education, University of Port Harcourt, Rivers State, Nigeria. Thereafter, the researchers purposively selected 307 students who were admitted in the 2014/2015 academic session that is presently in their final year were chosen for the study. Students from three departments were conveniently assigned to three different groups of concept mapping, concept testing and conventional testing technique respectively.

Instrument:

An adopted instrument tagged Cornell Critical Thinking Test (CCTT) developed by Ennis *et al*., (2005) was used for this study. This instrument has two levels (X and Z) but the researchers utilized Level Z of the CCTT designed for advanced and gifted high school students, college students, graduate students and other adults. The instrument was made up of 52 items formatted using 3-option (A-C) multiple-choice test items. It is made up of 7 subscales that elicited information on the skills of induction, deduction, value judging, observation, credibility, assumptions and meaning. The researchers made use of the total CCTT scale of 52 items that were dichotomously scored, giving a minimum and maximum score of 0 and 52 respectively. Internal consistency estimate of 0.74 was obtained for the overall scale using Kuder-Richardson formula 20 (K_R 20).

The instrument was administered on the three groups, two experimental groups and one control groups at pre-and post-tests stages. During the administration at

pre and post-test stages, students were given 50 minutes to complete and submit their responses.

Experimental procedure:

The undergraduate students were assigned conveniently into three different groups (two experimental and one control group) based on their departments. Students in Experimental Group One were assessed using concept mapping. Students in Experimental Group Two were assessed using concept testing while students in the control group were assessed using the conventional method. Both the experimental and control groups were pre-tested using the CCTT. Thereafter, all the groups received instruction on the same topics in a faculty-based course titled Test and Measurement (EDU 401.1). The topics considered included:

- Test and it's meaning
- Classification and types of test
- Functions of test
- Social and psychological implication of testing.
- Qualities of test with emphasis on validity and its types
- Qualities of a test, emphasis on the reliability of a test.
- Non-cognitive testing tools-observation method.
- Non-cognitive testing tools-inquiry method.

After instruction, the subjects were assessed using different techniques considered in this study. The teaching and assessment were done for eight weeks with three hours for each session. In each session, two hours 15 minutes was used for teaching, while 45 minutes was used to assess the groups immediately after each lesson.

Experimental Treatments

Group A: Each day after two hours and fifteen minutes used for instruction, forty-five minutes was used to ask students to develop a one-page paper on concept map in line with the topic taught for the day. This gave a total of eight concepts maps constructed during the eight-week instruction. The concept maps constructed by students were ungraded but were used to gather information on their level of understanding as well as providing feedback on areas of misconception.

Group B: This group was assessed using concept testing after each day teaching for about two hours and fifteen minutes. The assessment took place within the remaining 45 minutes. During the assessment session, the following steps were used:

- The teacher posed five options multiple choice test question on the chalkboard.
- Every student was allowed to at first work independently to answer the question by choosing any of the five options (lettered A, B, C, D and E) considered the correct option.

- Evaluation of students' response and determination of the optimum percentage of correct responses.

The researcher who was also taught the group evaluated the students' responses and determined the percentage of the students that gave the correct answer. This is because the optimum percentage of correct responses is 35-70% of the students. This optimum range indicates that the student had understood the topic taught, above the optimum range, indicated that the student has a good understanding level of the topics. On the other hand below the optimum range indicates that the student did not understand the topic taught, so something needs to be done for better understanding of the topic to take place among such students.

- **Formation of groups for peer instruction**.

Whenever the researcher discovered that the range of the correct students' responses falls below the optimum per cent (35-70%) of the students, the students are grouped based on their choice of options. That is all those who choose option A were grouped together, those who chose option B also grouped together in like manner. That means the number of groups formed depends on the number of options giving in a question and/or the number of options chosen by the students (55).

- **Presentation of the response supportive reasons by each interactive group leader.**

The groups formed are allowed to deliberate, interact, discuss and brainstorm and come up with supportive reasons why they feel their responses are correct. Later, each group leader or spokesman summarized their supportive reasons for their responses to the entire class.

Group C:

Students in the third group were assessed using the conventional/traditional method after the day lecture, the lecturer asked some oral questions that can be responded by any of the students based on the student's desire or by the appointment by the lecturer. After the students' response to each question, the lecturer emphasized on the correctness of the responses.

At the end of the treatment, all the groups were post-tested using the CCTT level Z instrument and time limits of 50 minutes was allowed. Thereafter, copies of the instruments were retrieved, scored and collated for data analysis using mean, standard deviation, paired t-test and one-way analysis of covariate (ANCOVA).

RESULTS
After the data analysis, the results obtained for research questions 1 and 2 as well as hypotheses 1 were displayed in Table 1 while that of hypothesis 2 was presented in Table 2.

Table 1: Mean, Standard Deviation and paired t-test on the impact of concept mapping, concept testing and conventional testing   on critical thinking ability of undergraduate students

Assessment strategies	N	Post-test		Pretest		Grand mean	df	t-value	p-value
		Mean	SD	Mean	SD				
Concept map	111	35.72	6.76	15.52	5.05	20.20	110	26.62	0.0005
Concept test	97	39.23	6.77	17.14	4.73	22.08	96	23.58	0.0005
Conventional Test	99	32.67	5.84	16.35	5.45	16.31	98	20.02	0.0005

Table 1 revealed that the students assessed using concept mapping had the mean scores of 15.52 (SD = 5.05) and 35.72 (SD = 6.78) respectively for pretest and post-test respectively. That means from the pretest to post-test the students in the concept map group gained a mean value of 20.20. This gained mean score was statistically significant when tested with paired t-test because it yielded t-value of 26.62 at df of 110 at 0.0005 level of significance (p< 0.05).

Considering the students assessed using concept test, Table 1 also shows that their pretest and post-test mean scores are 17.14 (SD = 4.73) and 39.23 (SD = 6.77) respectively. Thus they gained a mean value of 22.08 from the pre-test to the post-test period. The test with paired t-test statistics yielded a t-value of 23.58 at df of 96 at 0.0005 level of significance (p< 0.05). Thus concept testing had a significant impact on critical thinking ability among undergraduate students.

Furthermore, it was displayed in Table 1 that 99 undergraduate students assessed using the conventional strategy had the means scores of 16.35 (SD = 5.45) in their pretest while they had 32.67 (SD = 5.84) in their posttest on critical thinking ability. So from the pretest to the post-test treatment period, they gained a mean value of 16.31. It was also revealed in Table 1 that after the test with paired t-test statistics, a t-value of 20.20 was obtained at df of 98 at 0.0005 level of significance (p< 0.0005). This traditional method of assessment also had a significant impact on critical thinking ability of the undergraduates. Comparatively, the information in Table 1 shows that students in the concept test group gained the highest mean score followed by the concept map group and then the conventional test group.

To determine if the observed gained mean differences among the three groups of undergraduates (concept mapping, concept test and conventional assessment strategies) was significant, a one-way analysis of covariance (ANCOVA) was performed. The results obtained are presented in Table 2.

Table 2: Summary of ANCOVA on the impacts of concept map, concept test and conventional testing strategies on critical thinking ability of undergraduates

Sources of variation	type 111 sum of squares	df	Mean square	F	P-value	Partial eta squared
Corrected model	2142.400	3	714.16	16.948	0.0005	0.144
Intercept	36572.30	1	36572.30	867.90	0.0005	0.741
Pretest CCTT	31.338	1	31.338	0.714	0.389	0.002
Assessment strategies	2136.124	2	1068.062	25.35	0.0005	0.143
Error	12768.018	303	42.139			
Total	409334.00	307				
Corrected total	14910.495	306				

Information in Table 2 indicates that the F-value 25.35 was obtained at df of 2 and 303 at 0.0005 (P< 0.05). Thus, there was a significant difference in the impacts of concept map, concept test and conventional testing strategies on the critical thinking ability of the undergraduate students. The significant difference in their impacts was of little effect as indicated by the low value of partial eta squared of 0.143.

Nevertheless, since there are three groups of students that differ significantly, a post-hoc multiple comparison test through the use of Least Square Difference (LSD) was conducted to determine the pairwise comparison group that contributed to the significant difference. The results are displayed in Table 3.

Table 3: Group means comparison for detection of the direction of significance difference

Compared group mean	Absolute mean difference	P-value
Concept map and concept test	3.608	0.0005
Concept map and traditional	3.002	0.001
Concept test and traditional	6.610	0.0005

A critical look at Table 3 revealed that all the compared groups yielded a mean difference that was significant at a level lower than 0.05, the chosen, level of probability (p< 0.05). Thus the direction of the

significant difference resulted from all the mean difference between all the compared groups.

DISCUSSION OF FINDING
One of the findings from the study indicated that concept map, concept test and conventional testing strategies independently impacted positively on the critical thinking abilities of the students. However, concept testing mostly impacted on the students followed by concept map and then conventional testing strategy. The significant effect of concept mapping on the critical thinking ability of undergraduates suggests that it is an effective tool that encourages deeper learning. It also suggests that concept mapping is an assessment technique that triggers students to self-assess their learning and as such promote a positive way of thinking. In a way, this finding supports that of Nirmale and Shakuntala (2011) who found a significant improvement in the critical thinking scores among nurses at post-test stages. This may be possible because concept map help students to apply learnt knowledge to other similar situations.

The second finding from the study is that concept testing had a significant impact on critical thinking ability among undergraduates. This finding could be traceable to the fact that it involves the use of higher order questions framed in multiple-choice format and it creates room for self-assessment and brainstorming among classmates. Through brainstorming the brighter ones can sharpen the less intelligent students among the group as it is said: "Iron sharpens Iron". Again concept test promotes long-lasting learning that is transferable within the school setting and life beyond. This finding of a significant impact of concept testing on critical thinking ability supports the view of Thakur (2016) that concept testing provides students with the opportunity to reason very well and express their thought meaningfully.

Furthermore, it was also found that conventional testing had a significant impact on the critical thinking ability of the undergraduates. This could be that the students were exposed to thought-provoking higher order questions that trigger reasoning and deep thinking. Orluwene and Okorie (2018) reported that higher order questioning promotes creativity which is a watchdog to critical thinking is among students. That is most of the questions asked do not assesses recalling ability but reasoning abilities and applicability of knowledge.

Another finding from the study revealed the existence of significant differential impacts of concept mapping, concept testing and conventional testing on the critical thinking ability of undergraduate students. Specifically, it was found that concept testing had the most effective and significant impact on critical thinking ability of the undergraduates followed by the concept mapping and lastly, the conventional testing. This result

is quite expected due to the following reasons. Firstly, concept testing involves the use of Socratic questioning, which is focused on thought-provoking questions that trigger deep and logical reasoning. This implies that the use of concept testing in the class create a good environment for the application of think-before-execute learning technique. Again, concept testing involves the combination of self-reflection and peer instruction strategy; which is geared towards brainstorming, group/team discussion, collaborative and cooperative learning. All these help students to be actively involved in the teaching-learning processes and become active thinkers and self-reliant students.

The involvement of peer/team learning makes it possible for students in the same team/group to help each other to internalize knowledge and facilitate problem-solving ability. This is because through peer/team interaction students have the opportunity to see one another reflections and performance critically and then brainstorm with each other to identify and correct any misconception.

Comparatively, concept mapping as used in this study involved the students drawing the maps individually, without grouping of students for group/team discussion, hence no peer instruction, interaction and cooperative learning on the issues related to the correctness or otherwise of the concept/course content. Meanwhile, Dyson et al., (2010) reported that teaching-learning that is geared towards team learning contributes significantly to a high level of critical thinking ability among students.

Again, considering the conventional testing technique, it involves the independent reflection of each student without creating room for cooperative learning through brainstorming and peer interaction. Thus, the conventional testing technique cannot promote long-lasting effect on learning transferable skills like critical thinking but only content-based knowledge skills. This is in support of the assertion made by West (2016) that content-based knowledge easily gets obsolete as soon as they are acquired.

Succinctly, this finding of significant differential effects between concept mapping concept testing and conventional testing supports the finding of Huang et al., (2017) who reported a significant difference between the effect of peer-cooperation, concept mapping and traditional assessment technique. On the other hand, the finding of a significant mean difference score of the students in concept mapping and conventional testing supports that of Cheema and Mirza (2013). They reported that concept mapping enhanced students science achievement significantly more than traditional testing.

Moreso, the finding that both concept mapping and concept testing independently and significantly

improve on critical thinking ability among undergraduates than the conventional approach supports the finding of Aluta (2015) that innovative teaching, learning and assessment strategies promote soft skills such as creativity.

CONCLUSION

Despite the significant differential improvement in the critical thinking ability of undergraduate students in all the groups their overall scores were very poor. The reason for the poor critical thinking scores mostly among the students in the two experimental groups may be attributed to the student's unfamiliarity with the assessment strategy. Many students are yet to adjust fully with the strategies. Some students in the concept map group found it difficult to draw the maps while some of the students in the concept testing group found it difficult to share ideas and follow up.

However, on the part of the control group (conventional method group), it hinges on the theory of behaviourism hence it is teacher-centred while concept mapping and concept testing assessments are student-centred and anchors on constructivism. Thus, the conventional method of assessing students is not too productive mostly in relation to soft-skills. In other words, students found it difficult to adjust from their conventional testing strategy to the innovative ones as they had mostly experienced the conventional method of assessment. To this end, the researchers conclude that the continued use of concept mapping and concept testing in the classroom for a long time would yield very high scores among undergraduates.

RECOMMENDATIONS

Based on the findings, the researchers made the following recommendation:

1) Teachers should embrace multiple assessment methods by using innovative assessment methods such as concept testing and concept mapping in addition to the conventional technique.
2) Teachers should also be encouraged to use Socratic questioning strategies when assessing their students.
3) The use of peer/team learning should be incorporated in concept mapping strategy by allowing students to draw maps individually but latter interact with their peers on the correctness of their maps in relation to concept learnt.
4) Government and non-governmental agencies should endeavour to organize workshops, seminars and conferences so as to create forums where teachers will acquire or update their knowledge on how to apply concept testing and concept mapping in their teaching.

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