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Effect of Higher Order Question Types on Students' Creativity in Chemistry

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Abstract

The study investigated the effects of higher-order question types on the improvement of creativity of students in Chemistry. A sample of 201 senior secondary two chemistry students from six secondary schools in Port Harcourt City Local Government Area of Rivers State, Nigeria was used for the study. The sample was constituted using a two-stage sampling technique via simple random sampling technique (by balloting method) and purposive sampling technique. These students were assigned based on their schools to five experimental groups and one control group. The experimental groups were exposed to application, analysis, synthesis, evaluation, and a combination of application, analysis, synthesis, and evaluation question types respectively, while the control group was exposed to factual questions only. The study adopted the pretest-posttest non-equivalent control group quasi-experimental design. Two research questions and two null hypotheses guided the conduct of the study. Data were collected using A 25-item instrument tagged Chemistry Students' Creativity Scale (CSCS), constructed using a four-point Likert scale format of Regularly, Sometimes, Rarely and Never. An internal consistency coefficient of 0.81 was obtained for the scale using Cronbach Alpha method. Data collected were analysed using mean, standard deviation,

dependent sample t-test and Analysis of Covariance were employed where appropriate. The result revealed that application, analysis, synthesis, evaluation and the combination of application, analysis, synthesis, and evaluation question types were significantly effective in the improvement of students' creativity in chemistry. However, the combination of the application, analysis, synthesis, and evaluation question types was the most effective question type followed by synthesis question type, application, analysis, evaluation and then factual knowledge type. Based on the findings, it was recommended that teachers should endeavor to consider the two-question rule when assessing their students. Also, it was recommended that teachers refrain from using items which only aid arrival at the right answer, but also add items that stimulate imaginative thinking for a deeper understanding of both facts and concepts which can lead to better problem-solving in the school and the world beyond.

Key words: Application, analysis, synthesis, evaluation, creativity.

INTRODUCTION

The importance of chemistry cannot be over-emphasized because everything in existence is a product of matter, indicating that chemistry is part of everything in our lives and it helps us to describe the world around us. So better understanding of chemistry is of great importance to every profession. That means, achievement in chemistry is needed in our society mostly because we are living in a world that everything has gone digital, which anchored mostly in chemistry.

Secondly, our society has placed much emphasis on science and technology due to their roles in the rapid development of the society. The science and technological innovation depend so much on chemistry as the central science subject which provides the necessary gateway and technological literacy.

Besides ensuring a sound technological literacy, chemistry is also needed in the preparation of individuals who will be involved in the manufacturing of medicine, treatment of illness, diagnosis of illness, manufacturing of foods and so on. The importance of chemistry to the development of the nation, calls for high

achievements in chemistry. High achievement in chemistry is not achieved by the acquisition of retrieval skills (mere recalling of facts) or the lower order thinking skills but by the acquisition of higher order thinking skills which creativity is one. Tankersley (2005) is of the view that the best goal of literacy is achieved when students are able to demonstrate learning at the higher level which is learning at evaluation, synthesis, analysis and application levels. In other words, high achievement in chemistry requires the acquisition of the higher order thinking skills like creativity.

Creativity is the act of changing new and imaginative ideas into reality. It is derived from the Latin word "creo" meaning to create, produce and make new things. Thus creativity is the ability to generate novel ideas, produce new things. Creativity is not an inherited factor that is present in few individuals but is present in everyone. However, it can be learned, nurtured, practice and awakened as a result of interaction with the environment. Shalini (2010) reported that engagement in external communication or interaction had a strong relationship with creativity. Tanner (2011) stated that creativity is not among some of the thinking abilities that are solely inherited, but creativity is influenced by the students' level of practice and experience Torrance in Ramirez and Ganaden (2008) viewed creativity as the process of sensing gaps or disturbing missing elements, forming ideas or hypotheses concerning them, testing these hypotheses and communicating the results, possibly modifying and retesting the hypothesis. To this end, creativity is the acquired ability that enables individuals to develop new ideas and invent new ways of solving problems and producing things. Schlange and Juttner in Sefertz (2000) stated that the main objectives of creativity include:

- Thinking beyond existing boundaries
- Promoting curiosity
- Considering many alternative ways of solving problems.
- To be imaginative
- To deviate from the known ideas or ways of doing things.

Nevertheless, creativity is one of the needed skills for survival in the 21st century because 21st century is a period our society is seriously becoming entrepreneurial-oriented. Entrepreneurship is dependent on innovation which in turn depends on creativity thus, creativity complements innovation and entrepreneur. In other words, creativity

is an essential ingredient for building the culture of innovation and productivity among individuals. Creativity enhances the development of new ideas, fosters cognitive flexibility and the production of problem-solvers and not just knowledge absorbers. Consequently, in the 21st century, more emphasis is placed on how to help students learn how to think well or use their minds well to create and analyze skillfully and not just on mastery recalling of facts (Tankersley, 2005). Recalling of facts encourages production of knowledge absorbers. Production of knowledge absorbers will not only challenge the survival of the society in the 21st century but will also hinder the attainment of one of the main national goals, which is "to build a united, strong and self-reliance nation". Meanwhile, it is stipulated in the Nigeria philosophy of education that through education acquisition of competencies necessary for the achievement of self-reliance will be obtained. So to achieve this goal, it is very imperative to note that creative ability mostly in chemistry is indispensable.

Despite the importance of creative skills to the self and societal development, it is observed that some individuals mostly students are yet to achieve their full creative potentials. To support this Ishag (2009) stated that human beings have not achieved their full creative potentials primarily due to poor nurturing. Students' poor creative abilities are evident in the way they respond to questions that demands application of knowledge or open-ended questions. Mourtous (2010) reported that students had failed to apply the knowledge they acquired in a new context. That is students only respond to questions that portray recalling of known facts and rarely respond to questions that require diverse ideas and expansion of their imaginations. Thus, there is an urgent need for students to be nurtured to be imaginative and creative.

The nurturing of students is the greatest role of teachers through their teaching methods and questioning techniques. Question is the strongest method of teaching that teachers use to activate students' learning, thinking abilities, study strategies as well as to determine the effectiveness of their own teaching strategies (Shen &Yodkhumlue, 2011). In like manner, Collins (2014) stated that teachers should not just ask any questions but questions that can help to encourage students to identify their thinking strengths and weaknesses. That is only thought-provoking questions that stringer

diversified responses should be asked to help students improve their thinking skills (Elliot, Kratochwill, Cook & Travers, 2000).

To support this Woolkfolk, Hughes, and Wallkup (2008) suggested that irrespective of age and ability all individuals should experience thought-provoking questions because they involve mental manipulation of tasks or learning targets. That means questions play several functions depending on the type and how they are asked. Woolfolk et al (2008) stated that questions can be used to rehearse information, recall information, identify the extent of learning, provoke curiosity and to provoke learners to determine different ways of solving problems.

To Ben-Peretz (2002) questions can initiate cognitive conflict and promote the disequilibrium among learners. However, to Elliot *et al* (2000) the role of questions is determined by the type of questions asked and how they are asked or framed. In other words, the way questions are framed can stifle learning or promote learning to a higher level. Chin (2007) asserted that poor questions confused, intimidate and limit students creative thinking, while Gose (2007) asserted that effective questions asked in psychologically safe learning environment probe students understanding, encourage their creativity, stimulate their critical thinking and then instill a high level of self-confidence in them.

There are knowledge and reasoning questions while knowledge questions are convergent in nature because there is only one correct answer, the reasoning questions are generally divergent since there are various correct or satisfactory responses to a given task. Both knowledge and reasoning questions develop thinking skills but at different levels. Questions that require students to memorize fact or cram do not promote higher order thinking skill as creativity rather questions that will allow students to mentally manipulate what they had acquired Randles (2007) stated that one right-answer questions do not promote creativity and critical thinking but deeper questions that encourage diversity of correct responses. That means teachers who only ask factual or recalling questions will end up producing students who will be like robots that are not capable of doing or thinking by themselves unless they are programmed. Students are encouraged to think more creatively and critically when they are exposed to unfamiliar questions. Unfamiliar questions

deepen students' thinking and penetrate to the core of the matter so that they can create connections to the material presented.

All these boil down to the importance of questioning to the development of creative skills. They also boil down to the consequences or after-effects of the types of questions teachers used while teaching and assessing their students' skillfulness Mcmillian (1997) asserted that one surest way of helping students to acquire the appropriate skills to their fullest potential is the use of questions that reflect the learning targets needed to be acquired. The type of questions asked determine the type of responses to be elicited as well as the thinking skills that will be developed.

In another dimension, Mcmillan (1997) stated that questions that begin with "what", "who" "where" and "when" requires factual and recall responses and will only help to developed remembering level of thinking while questions that begin with "explain" require more than recalling and developed the understanding level of thinking.

Questions that begin with compare, solve, describe, demonstrate, examine, judge and so on demand responses on the ability of learners to use acquired knowledge in different new ways, ability of the students to distinguish the functions of various parts, ability of students to diversify ideas, invent a product, develop new ideas, judge and critic standard. So they can help to develop the applying, analyzing synthesizing and evaluating thinking skills.

In all, to acquire the appropriate competence in any given skill the readiness of the teachers to use artful questions in the classroom is not out of place (Asadullah, 2016). There are many possible techniques proven to motivate students to be skillful in providing diversified ways of solving problems. These proven techniques include teachers' personalities, subject matter expertise, relational competence with students, professional competence, teaching and questioning style and classroom management (Shalini, 2016). Precisely the teachers' questions style which is paramount to this study hinges on the use of higher order questions. Higher order questions encourage the acquisition of complex judgmental skills that help students to be very imaginative and creative. Thus, it is the type of questions needed for survival in both school and non-school life activities especially in this present digital era.

Despite, the impacts of higher-order questions in the development of creative skill and other higher thinking skills, it is observed that most teachers are still using more of the questions that stringer recalling and memorization of facts. Mas-Rosli and Maarof (2010) reported that teachers are found to use more of the lower order questions in the classroom than the higher-order questions. Higher order thinking skills prepare people for good living in the 21st century but the extent to which teachers use higher-order questions in the classroom is questionable (Collins, 2014). This implies that students are taught how to remember and recall facts and not how to acquire knowledge that can be transferred. With lower order questions teachers inform students what to do with no room for them to imagine and create their own ideas. Creativity is a skill that is developed, learned and managed, it starts with a good foundation of knowledge, learning, discipline and then mastery ways of thinking.

To be creative requires much practice that will help to trigger the right skills needed for its proper development. It is also known that excellence is determined by opportunity, encouragement training, motivation, and practice. Questions that demand to recall of facts do not create room for much encouragement, practice, training neither will they be the motivating factor of creativity among students. It is to this end that Edwards, McGoldrick, and Oliver (2006) asserted that education system often discourages the development of creative skills. To support this, Daud, Omar, Turiman and Osman (2012) reported that one of the things that limit students' creativity is teachers teaching and questioning strategy since most teachers' questions triggers students to solely focus on how well they can cram and memorize facts. Information crammed can be forgotten easily hence it can not be retained to enable its' application to other real-life situations. Again Tofade, Elsner & Haines (2013) reported that teachers most often used lower-order questions (closed-ended questions) than the higher-order question (open-ended).

Furthermore, a personal experience and observation of classroom-based instruction during teaching practice supervision revealed that most learning activities in the classroom cover more of the lower order cognitive domain. This is evident in the specific objectives stipulated in the teachers' lesson plans. For instance, most of their specific objectives are;

- Define the term matter

- State the two forms of matter
- Give 2 examples of matter etc.

These levels of thinking are very easy to understand, teach, test but on the other hand do not encourage diversities in thinking, problem solving and innovations. Lower order questions consider prior knowledge and learning within the classroom context and not how acquired knowledge can be applied beyond classroom context.

So considering the limitations of the lower order questions it is obvious that they cannot lead us to the Promised Land which is essential for the survival in the 21st century. It is against this hunch that the present study effect of higher order questions types on students' creativity in chemistry was considered necessary. Questions, used to assess students learning are classified basically as convergent and divergent questions. Convergent question is a closed-end question that demands one best response while a divergent question is an open-ended question that demands a wide range of appropriate responses. Questions classified based on knowledge dimensions are factual, conceptual, procedural and meta-cognition questions (Anderson & Krathwohl, 2001).These knowledge dimensions range from abstract to concrete.

Another way questions are classified was on the complexity of the cognitive level based on Bloom's taxonomy of objectives in the cognitive domain. On this basis we have questions, covering the knowledge, comprehension, application, analysis, synthesis, and evaluation. These six question types are in a progressive climb from the lowest (knowledge) to the highest level (evaluation) of cognitive skills. Although in the revised model of the Bloom's taxonomy of cognitive domain modified by Anderson and Krathwohl (2001) "evaluation" stage was move down a level so the highest level becomes "creating" that replaced the synthesis in the old version of the taxonomy. In the new version, Anderson and Krathwohl (2001) ranked evaluation the fifth instead of the sixth level indicating that creative thinking level is more complex than critical thinking (evaluation).

It is worthy of note that both old and new taxonomies through the provision of the hierarchy of thinking provided a valuable framework for teachers, and curriculum designers on higher order learning in relation to developing performance task, creating

questions or constructing problems. However, due to more familiarity with the old version of the taxonomy of the cognitive domain, among teachers, the present study hinges on the old version of Bloom's taxonomy and the theory of Depth of Knowledge (DOK) developed by Norman Webb in 1997

The Bloom's taxonomy is further divided into two levels based on the learning targets which are knowledge and reasoning target. The questions that matched with the knowledge learning targets are called the lower-order questions while the ones that matched with the reasoning learning targets are called the higher order questioning. In grouping the six levels of the cognitive domain into lower and higher-order questions, there are different consensus. For instance, Ramirez and Ganaden (2008), Ramos, Dolipas, and Villamor (2013) are of the view that the combination of knowledge, comprehension and application questions make up the lower-order questions while the combination of analysis, synthesis, and evaluation make up the higher order questions. Then, on the other hand, Mcmillian (1997) stated that in Bloom's taxonomy the major components of higher-order thinking skills are application, analysis, synthesis, and evaluation. To support this, Elliot et al (2000) asserted that to improve students thinking skills, questions that require application, analysis, synthesis and evaluations are indispensable. To Panicker (2015), Hassan, Rosli and Zakaria (2016) skills involving applying, analyzing evaluation and creating are collectively termed higher-order skills.

Thinking skills are products of question order indicating that lower-and higher thinking skills are the product of lower and higher order questions respectively. McDade (1995:10) defines higher order thinking skill as the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing and evaluating information generated by observation, experience, reflection, reasoning or communication as a rubric to belief and action. Mas Rosli and Maarof (2016) conceived that higher order questions are artful question such as applying, analyzing, evaluating and creating questions that encourage creative and critical thinking. In essence, applying is the first level of higher order questions while creating is the highest level of the higher order questions. Again in the same vein, Tankersley (2005) asserted that most jobs in the 21st century require individuals to use the four highest level of thinking

such as application, analysis, synthesis, and evaluation in order to survive in their career and other potential life activities.

Putting the above various consensuses together the present researchers concluded that questions that dwell on application, analysis, synthesis and evaluation will collectively be termed higher-order questions. Then, the fact that Bloom taxonomy becomes more complex and challenging as one moves up the domain the researchers suspect that their effect on creative abilities may differ, so the higher order questions are treated independently starting from application to evaluation Application was changed to apply in the revised taxonomy and it is the ability of identifying patterns that can transfer acquired knowledge to new or unfamiliar situations. It involves the use of abstract ideas, knowledge, rules in a concrete way (Elliot et al, 2000).

Analysis otherwise known as analyzing in the revised version of Bloom's taxonomy is the ability to break a problem into smaller parts and detecting the relationship that exists among the various parts. Questions focusing on analysis require the learner to distinguish relevant and irrelevant information. Synthesis, also known as creating in the revised version of the taxonomy is the fifth level in the old version while it is the sixth level (highest level) in the revised version; synthesis involves linking new information with the previous ones to build new ideas. It involves the ability to establish a new way of doing things by joining various components together. Evaluation is the level of critical thinking which involves distinguishing important facts from given information. Evaluation skills require students to use a standard to make a judgment. Hence the questions addressing evaluation require students to critic a product and determine the appropriateness of a process (Elliot et al 2000).

Classification of question-based on Bloom's taxonomy of higher order of cognition and students' actions required for achieving specific learning outcomes.

Higher cognitive dimension	**Action required**	**Sample question content area: chlorine and its compounds**
Application	Modify, demonstrates, produces, constructs applies, relates shows, uses, illustrates	With the aid a diagram, demonstrates how chlorine is prepared in the laboratory
Analysis	Distinguish, compare, differentiate, relates classifies, deduces.	Compare and contrast a solution of hydrogen chloride in water and a solution of hydrogen chloride in toluene
Synthesis	Generates, proposes, assembles, constructs, combines, discuss	Discuss on the procedure used in obtaining a gas-jar of dry chlorine starting with sodium cloride
Evaluation	Justifies, criticize, defends, verifies, confirm appraises	Justify the uses of chlorine in industries

Furthermore, the study also anchors on the Theory of Depth of Knowledge (DOK). The DOK is another framework that is used to identify the level of rigor for an assessment. It helps to group learning activities according to the level of complexity in thinking in order to align standards to assessment. To accomplish this, Webb (2005) grouped learning activities into four hierarchical levels from the simplest to the most complex. These levels are

Level 1 – Knowledge acquisition through recalling and reproduction of facts;

Level 2 – Knowledge application tagged skills/concept level;

Level 3 – Strategic thinking level where complex reasoning are used to solve problems

Level 4 – Extended thinking level where learners go beyond standard learning and approach diversified method of applying knowledge into reality.

Nevertheless, several pieces of research related to creativity and/or higher-order questions had been conducted in the past. For instance, Ramirez and Gandaden (2008) investigated the effect of creative activities on higher order thinking skills and found that no significant mean difference existed between group exposed to creative activities and the ones exposed to no creative activities.

Orluwene and Essien (2010) from their study reported that divergent questioning was more effective on the creative achievement of students in chemistry than convergent questioning. On the other hand, Orluwene and Amadi (2012) in their study on the predictive

power of the thinking styles for creative achievement in chemistry found that thinking styles of legislative, executive and judicial jointly predicted creative achievement in chemistry among students. In addition, those legislative thinking styles had the highest predictive power followed by the executive and lastly judicial which even had an insignificant predictive power.

Ramos, Dolipos and Villamor (2013) in another dimension reported that the higher order thinking skills such as analysis, comparison, and evaluation significantly influence the male students' performance in physics while the higher order thinking skill as analysis, inference, and evaluation significantly influence the female students' performance in physics. Mas Rosli and Marrof (2016) reported a significant effect of higher order questions on the improvement of students writing performance.

Considering all the past researches, none was on the specific higher order question types such as application, analysis, synthesis, and evaluation but on the level of higher order or lower order, and convergent or divergent. Sequel to these, the present study is urgently needed. This is because findings from it may promote the use of higher order questioning in the classroom. It will also lead to the high production of graduates who will be capable of facing the challenges of life beyond school.

The study, therefore, sought to determine the effects of higher order question types independently on students' creativity in chemistry. On that basis, the following research questions were answered.

1. How effective are application, analysis, synthesis, evaluation, a combination of application, analysis, synthesis and evaluation questions and factual questions types on students' creativity in chemistry?
2. To what extent do the effects of application, analysis, synthesis, evaluation, a combination of application, analysis, synthesis and evaluation questions and factual question types on students' creativity in chemistry differ.

Consequently, the following two null hypotheses were tested at 0.05 alpha level.

1. Application, analysis, synthesis, evaluation, a combination of application, analysis, synthesis, and evaluation question and

factual questions do not have any significant effect on students' creativity in chemistry independently.

2. Effects of application, analysis, synthesis, evaluation, a combination of application, analysis, synthesis and evaluation question and factual questions independently on students' creativity in chemistry do not differ significantly.

METHOD

The study adopted the pre-test and post-test non-equivalent quasi-experimental design. It was conducted in Port Harcourt City local government area of Rivers State, Nigeria using a sample of 201 senior secondary two chemistry students. It was constituted using a two-stage sampling technique where simple random sampling technique by balloting method was employed to select six senior secondary schools in Port Harcourt city local government area of Rivers State, Nigeria. Then purposive sampling was used to select only the senior secondary two chemistry students from each of the six selected secondary schools. In all six senior secondary II (SS II) chemistry classes were selected because in each school there was only one chemistry class.

Each of the six classes was assigned intact to a group giving a total of six groups - five experimental groups and one control group. The five experimental groups were treated respectively with application, analysis, synthesis, evaluation, a combination of the application, analysis, synthesis, and evaluation question types. On the other hand, the only control group was assigned to only factual (recalling) questions. After constituting the five experimental groups and one control group, all the groups were pretested using an instrument, the Chemistry Students' Creativity scale (CSCS) it contains 25 items constructed using a four-point Likert scale format of regularly, sometimes, rarely, and never. Thus the instrument provided a maximum of 100 marks and a minimum of 25 marks. It was face and content validated by the scrutiny of three experts in the area of educational measurement and evaluation. The instrument had an internal consistency value of 0.81 obtained using Cronbach alpha method. The valid and reliable instrument was administered to the students during the pre-test stage of the study. After which they were treated differently based on their groups. The treatment involved

teaching and formative assessment where all the groups were taught the same topics such as hydrogen, chlorine and its compound but they were assessed on the same topic using different question types based on the Bloom taxonomy of higher order cognitive level that is the groups 1-6 were taught the same topics using the same teaching methods of explanation and discussion but different question types were used during assessment. The question types are application, analysis, synthesis, evaluation, a combination of application, analysis synthesis, and evaluation for the five experimental groups. Then the control group was assessed using factual (recalling) questions. The teaching took a period of 8 weeks while the pre-and post-tests took one week each making a total of 10 weeks. At the end of the post-test, the students' responses on the CSCS were scored and collated for analysis using mean, standard deviation, paired t-test, one-way analysis of covariate (ANCOVA) and post hoc multiple comparisons, test by Bonferroni test appropriately.

RESULTS

The results of the research questions 1 and 2 and that of null hypothesis 1 were presented in the same table 1, while the results of hypothesis 2 were presented in table 2, respectively.

Table 1: Mean, standard deviation and paired t-test on the effect of higher order and factual question types on students' creativity in chemistry.

Question types (Group)	N	Post-test		Pretest		Gained mean	df	t - value	p-value
	N	Mean	SD	Mean	SD				
Application	38	44.45	10.46	30.74	9.22	13.71	37	10.49	0.0005
Analysis	26	42.77	9.50	30.54	7.21	12.23	25	6.11	0.0005
Synthesis	30	55.57	11.61	29.97	5.71	25.60	29	11.28	0.0005
Evaluation	35	41.20	7.03	33.37	7.32	7.83	34	7.03	0.0005
AASE combined	30	63.60	14.18	29.73	7.77	33.87	29	15.66	0.0005
Factual	42	33.37	7.60	32.10	8.86	1.57	41	1.36	0.181

AASE = Combination of application, analysis, synthesis, and evaluation question types.

In table 1, it is revealed that the students exposed to only application questions were 38 in number. They had the mean scores of 30.74 (SD = 9.22) and 44.45 (SD = 10.46) for their pre and post tests respectively. These mean scores indicated that the students exposed to application questions gained the mean score, (post-test mean score-

pretest mean score) of 13.71 from their pre-to post-test. When the mean difference was subjected to a paired t-test, a calculated t-value of 10.49 was obtained at df of 37 at 0.0005 level of significance (P<0.05). Thus application question is significantly effective on the improvement of creativity in chemistry among students.

For the 26 students exposed to only analysis question types, table 1 also shows that they had the mean scores of 30.54 (SD = 7.21) and 42.77 (SD = 9.50) respectively in their pre and post-tests. These mean scores yielded a gained mean score of 12.23. When this mean difference between the pre and post test was subjected to a paired t-test statistics, a calculated t-value of 6.11 was obtained at df of 25 at 0.0005 level of significance (P<0.05). Thus analysis question was also significantly effective in improving creativity in chemistry among students.

Considering the 30 students exposed to synthesis questions table 1 shows that they had the mean scores of 29.97 (SD = 5.71) and 55.57 (SD = 11.61) respectively for their pre and post-tests. It is obvious that from their pretest to post-test they gained a mean score of 25.60. It was also shown in the same table 1 that when the mean difference was subjected to a paired t-test a significant calculated t-value of 11.28 was obtained at df of 29 and at 0.0005 level of significance. Hence synthesis question type significantly improved creativity in chemistry among students.

Furthermore, table 1, revealed that the 35 students exposed to only evaluation type of questions had the mean scores of 33.37 (SD = 7.32) and 41.20 (SD = 7.03) respectively in their pre and post-tests. A critical observation of the mean scores indicated that students exposed to only evaluation type of questions gained a mean score of 7.83 from their pretest to their post-test. When the observed mean difference between the pretest and posttest was subjected to paired t-test, a calculated t-value of 7.03 was obtained at df of 34 and 0.0005 level of significance (P<0.05). Thus evaluation type of question is significantly effective on the improvement of students' creativity in chemistry.

Table 1 also shows that 30 students were exposed to the combination of application, analysis, synthesis and evaluation type of questions. They had a pretest mean score of 29.73 (SD = 7.77) and a post-test mean score of 63.60 (SD = 14.18). Their pre and post-tests mean score indicated that they gained a mean score of 33.87. On

subjecting the mean difference between the pre and posttest to a paired t-test, a significant calculated t-value of 15.66 was obtained at df of 29 and 0.0005 level of significance (P<0.05). Thus the combination of application, analysis, synthesis and evaluation types of question significantly improved students' creativity in chemistry.

In table 1, 42 students exposed to factual questions had the mean score of 32.10 (SD = 8.86) at pre-test and 33.67 (SD = 7.60) at post-test. So they gained a mean score of 1.57 from their pretest to post-test. However, when the mean difference was subjected to paired t-test an insignificant calculated t-value of 1.36 was obtained at df of 41 and at 0.181 level of significance (P> 0.05). Thus factual question type is not significantly effective in promoting creativity in chemistry among students.

A critical observation of table 1 on the gained mean column, revealed that the group exposed to AASE group gained the highest mean score, followed by synthesis, application, analysis and then evaluation group. A further investigation to determine if a significant difference in the levels of creativity in chemistry among students exposed to different higher order question types exist was conducted. Using one-way analysis of covariate (ANCOVA).The results obtained are summarized and presented in table 2.

Table 2: Summary of analysis of covariate on the differential effects of higher order and factual question types on students' creativity in chemistry.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	24175.232[a]	6	4029.205	50.379	.000	.609
Intercept	9173.213	1	9173.213	114.696	.000	.372
CSCSPre	4579.718	1	4579.718	57.262	.000	.228
Group	21672.991	5	4334.598	54.197	.000	.583
Error	15515.792	194	79.978			
Total	463720.000	201				
Corrected Total	39691.025	200				

a. R Squared = .609 (Adjusted R Squared = .597)

Table 2 revealed that after adjusting for pretest scores, there was a significant effect of the between-subjects factor group (F 5, 194 = 54.20, p = 0.0005 < 0.05). An adjusted mean score of students in creativity scale in chemistry suggested that a combination of

application, analysis, synthesis, and evaluation question types impacted the highest level of improvement in students creativity in chemistry followed by synthesis only, application, analysis, evaluation and then factual question type.

The significant difference that was observed in the effect of the higher order question types demands that the direction of the significant difference be determined. This was done by employing post hoc multiple comparison tests via Bonferroni test. The results obtained are displayed in table 3.

Compared groups	Mean difference	P-value
Application and analysis	1.56	1.000
Application and synthesis	11.59	0.000
Application and evaluation	4.86	0.330
Application and AASE combined	19.77	0.000
Application and factual	11.61	0.50
Analysis and synthesis	13.15	0.000
Analysis and evaluation	3.31	1.500
Analysis and AASE combined	21.32	0.000
Analysis and factual	10.06	0.000
Synthesis and evaluation	16.45	0.000
Synthesis and AASE combined	8.18	0.007
Synthesis and factual	23.21	0.000
Evaluation and AASE combined	24.63	0.000
Evaluation and factual	6.75	0.018
AASE combined and factual	31.38	0.000

Table 3 revealed that based on estimated marginal mean scores, the mean difference obtained from all the compared groups means were significant ($P< 0.05$) except for the comparison between application and analysis groups, application and evaluation groups and then analysis and evaluation question types groups.

DISCUSSION OF FINDINGS

The result of the study in table 1 revealed that application, analysis, synthesis evaluation, and a combination of application, analysis, synthesis, and evaluation questions had a significant effect on students' creativity in chemistry among students independently. This finding is not similar to that Orluwene and Essien (2010) since the present study considers the different types of questions at the higher cognitive level instead of the collective question types as the lower and higher order or convergent and divergent questions.

The finding that application question type had a significant effect on creativity in chemistry is traceable to the fact that application question requires students to use their acquired knowledge in a new form. That is changing abstract ideas to concrete ones which entail creative ability. It was also found that analysis question type had significant positive effect on students' creativity in chemistry. This is possible because analysis question demand student to have an in-depth learning by breaking down a given material into several smaller components in order to determine how the structure is organized. It takes one who knows the components of a given material to produce that material in similar or related form.

For the effectiveness of synthesis question type on creativity, it was found to be very effective. This result is traceable to the nature of the question which allows the students to activate their minds to reason critically and deeply into the core of the problem, thereby enabling them to discover new meaning related to a given task. The discovery of new meaning lead to new ways of producing ideas, skills, and things, it was also found that synthesis question type was more effective than evaluation questions. This may suggest why it was placed above evaluation level in the revised Bloom's taxonomy.

The positive effects of evaluation question type on creativity in chemistry are not surprising because with evaluation questions the students are required to judge the value of a given task using certain criteria. It is very obvious that when the quality of a given material is established it will serve as a source of guidance for the students to produce other familiar or unfamiliar things subsequently. That is it takes the understanding of the key themes to authenticate the validity of the obtained information.

Furthermore, it was also found from the study that the combination of application, analysis, synthesis, and evaluation question types was the most significant and effective question types on students' creativity in chemistry. The researchers have no doubt because a mixture of such questions is bound to touch different thinking skills, which when combined, the students will be sound in dealing with situations that require the application or different thinking skills as creativity in chemistry. A combination of application, analysis, synthesis and evaluation question exposed the students to wider experience which is one of the principles of good creative ability. Again the combination of the higher order question

types had developed in the students the ability to explore and expand knowledge from what is already known to what is novel form of it. This finding may also stem from the fact, the combination of the higher order questions make up the divergent question which does not require any specific response but a diversity of responses that are appropriate. This finding is in line with that of Orluwene and Essien (2010) who found that divergent questioning was more effective in creative achievement in chemistry than the convergent questions. The finding is not also similar to that of Orluwene and Amadi (2011), Ramas, Dolipas and Villamor (2013). However, this finding supports the notion that the type of question asked determines the thinking level that will be developed. So since a mixture of all the higher order question types was used, all the thinking skills associated with the different question types were developed leading to creativity in chemistry.

RECOMMENDATIONS

On the basis of the findings from the study, the following recommendations were made.

1. Teachers should apply the two-question rule when assessing their students.
2. Teachers should try to ask questions that address all levels of the cognitive domain, mostly the higher order.
3. Teachers should match their questions with the intended learning targets.
4. Teachers should refrain from using items which only aid arrival at the right answer, but also add items that stimulate imaginative thinking for a deeper understanding of both facts and concepts which can lead to better problem-solving in the school and the world beyond.
5. The teacher should emphases more on the use of higher order questions types so that transfer of learning can be achieved.

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