

# Integrating the 4Cs in the Learning of Science and Mathematics

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## **ABSTRACT**

*The empirical study focused on the extent to which science and mathematics teachers in secondary (Junior & Senior) schools integrate such learning skills as; critical thinking skill, creative thinking skill, communication skill and collaboration skill in their daily lessons. The study was a descriptive survey and an instrument; a 4Cs questionnaire (4CsQ) designed by the researchers was used for the study. Four research questions however guided the survey. The study showed that science and mathematics teachers' integration of critical thinking and creative thinking in their lessons are still low while the presence of communication and collaboration skills is heavily obvious. A major recommendation was that it is high time science and mathematics teachers embraced and integrated critical thinking and creative thinking in their lessons as to make the learning of mathematics more meaningful to the students of the present age.*

**Key words:** *Logical conclusion, innovation, composition, verbal and non-verbal communication, and team work.*

## **Background of Study**

The relevance of the 4Cs in promoting deep learning is attracting the attention of educators in the most recent. In no order of preference, this paragraph focuses on critical thinking skill which is both attitudinal and intellectual skill. It is a skill that enables one to make wise decisions, handle and solve problems as well take appropriate decisions, whenever the need arises. It is in this fashion that Halx and Reyhold (2005) would add that critical thinking skill requires personal reflection and maximum exertion and intellectual capability. Techniques deployed by critical thinking skill includes; being open-minded and objective establishing root causes and viewing problems from multiple perspectives; giving fair hearing on multiple perspectives; suspending judgment until all pertinent information has been heard, listening to critical views and changing a conclusion on the face of compelling information (Walter, Carey & Carey, 2014).in the utilization of techniques and pedagogy to enhance critical thinking, students are said to be better and

able to comprehend why something has occurred as opposed to just understanding what has occurred (Pandey, 2015). This deep understanding obviously allows learners to better analyze the circumstances surrounding the occurrence and differing viewpoints about the occurrence (Tsai, Chen, Chang & Change, 2013). McCollister and Sayle (2010) did maintain that critical thinking skill can be integrated in lesson throughout all disciplines by utilizing in-depth questioning and evolution of both data and resources. This position, it is obvious accommodates probing into initial responses of students (Arend, 2009). The aim is also discouraging rote learning but reinforcing deep learning. The above position or this multi-disciplinary application of critical thinking skill is also buttressed by the works of Henderson-Hurley and Hurley (2013) on enhancing critical thinking skills among authoritarian students, and Kokkidou (2013) on critical thinking and school music education.

Creative thinking skill on the other hand is the ability and initiative to evolve something novel, different from that which existed to promote learning. Creative thinking skill is emphasized in the current perspective of educational technology as an essential element in facilitating learning and improving learners' performance. The underling idea is that there are no processes or resources to use or manage to achieve desired learning unless someone first creates them. Though such elements as design, development and evolution are associated with creating, it is obvious that creating learning resources may not consciously involve these elements. The centre focus of this skill is production and it is obvious that production has given rise to the array of learning resources and processes that we have today in the education sector. Thus, the new media trigger paradigm is a manifest of the practices and theories of creating. This is responsible for the import of educational films, educational radio and television, audio-visual materials, Computer Assisted Instruction (CAI), digital media, the internet and the WorldWide Web (www) Mobile media amongst others, into the teaching/learning scene.

From the picture painted above, we can see that teaching itself is a creative performance or disciplined improvisation (Sawyer, 2004). In this scene, teaching as improvisation emphasizes the interactional and responsive creativity of a teacher when with a unique group of learners, a trait commonly associated with experience of teachers (Borko & Wingstone, 1989; Moore, 1993). In this skill, flexibility and improvisation are key elements as a teacher comes up with something, idea or scenario that is not only new but supports the teaching/learning process. It is that kind of skill which affords students the opportunity to demonstrate creative thinking, construct knowledge and develop innovative products and processes using technology, they develop works as a means of personal or group expression, deploying models and simulations to explore complex systems and issues (Morrison, & Lowrther, 2010). This creativity skill is geared towards composition of novel ideas projects; emphasizes innovation as much as possible; looks at parts and structures of concepts and how they relate; resolves cases as they arise, amongst others. The International Society for Technology in Education (ISTE) as quoted by Lever-Dutty and McDonald (2011), has it that lessons that promote creativity skills should be able to altered learners disposition to apply existing knowledge to generate now ideas, products or processes, create original work as a means of personal or group expression, use models and simulations to explore implore systems while also identifying trends and forecast possibilities.

The place of communication skills in teaching and learning, just as in other sectors of life, is no subject of dispute, for it is obvious that there will be no existence whether human or lower organisms without one form of communication or the other. This position is corroborated by the known truth that even lower animals respond to both internal and extend stimuli which are inherent trait of communication. For larger organisms, and human for instance and by virtue of the complexity of our brain, we are able to display one form of communication skills or the other to respond to environmental and external conditions.

Be that as it may, the use of verbal sounds, which include the use of language and tone of voice; non-verbal (eye-contact, facial expression, body motion, head motion posture and pentadactyle movements); aural (listening and hearing); written (periodicals and non-periodicals) visuals as in signs, symbols, icons and pictures; synchronous and asynchronous are sure indications of the diversity and complexity that human being exploit to achieve effective

communication. This position does not differ too much from the classification of communication into sound (oral), print, visual, non-verbal and mass communication by (Inyang-Abia, 2004). This leading scholar maintain that no matter the type or even levels of communication (personal or non-personal), intrapersonal or interpersonal which are of the former, group, public or mass which are of the latter, their purposes are basically the same. They include management and control, increased certainly and consistency, enhanced morale, error prevention and control, development, critical thinking and creativity, behaviour modification, amongst others. This confirms the very fact that communication itself is a life surviving process.

Non-verbal communication ensures that the use of human voice (teacher and learners) come to bear while learning. This may be in a recorded or natural voice, but whichever way, human voice is key. Non-verbal communication (Williams, 2012) emphasized that they could be generally described as the use of body language in teaching and learning. Usually, it manifests at different fronts styles, and levels.

Communication in the 21<sup>st</sup> century classroom goes beyond the teacher-learners' interaction, courtesy the presence of ICTs and communication software. They have added to the asynchronous and synchronous types of communication that we have today. In former, communication between the teacher and learners via ICT related software does not occur at the same time as in emails and text, while in the latter, communication between both parties occurs at the same time as in Oovoo and Skype.

One of the ways by which teachers can effectively capitalize on the social nature of learning is by integrating small-group learning into their lesson plan and implementation purposes. Leading scholars like Dewey (1916) and Vygotsky (1978) are advocates and practitioners of this social nature of learning, conscious of the very fact that man is a social being. This skill is conscious of the interdependent nature of learners, their heterogeneity, thus emphasizes social skill development, task and group performance, shared leadership and responsibility while the teacher serves as facilitator and observer. Hence class members work as a term with assigned roles and responsibilities. Though class members are grouped, opportunities are provided for each member of a group to contribute maximally evenwhile the groups are regulated by a time frame as they work towards a common goal.

Collaboration skill, a student-centred skill, allows students discuss actively among themselves, just as they congregate for joint intellectual efforts. The inter-dependence among students while harnessing this skill has given rise to such concepts as peer tutoring, team learning, peer learning, learning communities and appreciative learning associated with collaborative skill. Collaborative skill, Okpoyemi (2010) would maintain that it increases students' interest in learning, reason being that the learner is directly involved in learning process. In the works of Williams and Augustine (2015) on collaborative learning in virtual classroom, the researchers discovered that this skill is still low among post graduate students and thus recommended the need for their integration by educators concerned. However, the study show-cased appropriate ways of developing this skill among our learners; growing discussion identification of group leader; class cluster; think – pair – share straits; critical debates, amongst others.

#### **Statement of Problem**

The inability of learners to resolve issues and handle academic tasks with ease is becoming a thing of concern to educators in the most recent. This problem-solving deficiency appears common among science and mathematics students in our secondary schools. Also, there appears to be a decline in composition, innovation and design of experiments among students, a trend that threatens the generation of desired scientists and mathematicians that should boost the desired manpower of a nation. In the same vain, communication skill using appropriate subject language is vital in mastering of subject matter and concepts. However, there appears to be a decline in this trend, as evident in students' inability to being conversant with concept formation and this trend is not different from the still teacher-students one directional approach to learning that we still witness today, an instructional approach that has not allowed learners to make maximum contribution as a group or individuals within a group.

#### **Purpose of Study**

The study sets to resolve such concerns as:

1. To confirm the extent to which science and mathematics teachers emphasize critical thinking in their lessons.
2. To confirm the level of creative skills embedded in the lessons of science and mathematics teachers.

3. To explore the extent of communication skills deployed by science and mathematics teachers in mastering of scientific and mathematical concepts.
4. To ascertain the extent to which science and mathematics teachers incorporate collaboration skills in their lessons.

#### **Research Questions**

Consequently, from research questions guided the study:

1. To what extents do science and mathematics teachers incorporate critical thinking in their lessons?
2. What is the rate at which science and mathematics teachers deploy creative skills in their lessons?
3. To what extent do science and mathematics teachers employ communication skills in mastering scientific and mathematical concepts?
4. What is the level of collaboration skill present in the lessons of science and mathematics teachers?

#### **Significance of Study**

The target and usefulness of this study is the generation of learners who are:

- Problem solvers capable of handling a task as appropriate as possible and whenever the need arises;
- Innovative, versed, imaginative and rich in ideas;
- Literate and fluent in scientific and mathematical languages, having the ability to resolve related concepts, handle tasks and comprehend passages with ease, and finally;
- acknowledge the power of collaboration and team work, being able to depend on alternative and other sources of knowledge to enrich oneself on a subject and on an issue.

#### **Methodology**

##### **Population of Study**

The population of the study was all science and mathematics teachers in secondary schools (Junior & Senior) in Ogba/Egbema/Ndoni Local Government Area of Rivers State, Nigeria.

##### **Sample and Sample Size**

A representative sample covering the science and mathematics teachers formed the sample. The table below shows the composition.

Table 1: Categorization and number of teachers

Subjects	Teachers	%
Mathematics	45	81
Physics	30	54
Chemistry	44	79.2
Biology	45	81
Computer studies	36	64.8
	<b>200</b>	<b>360</b>

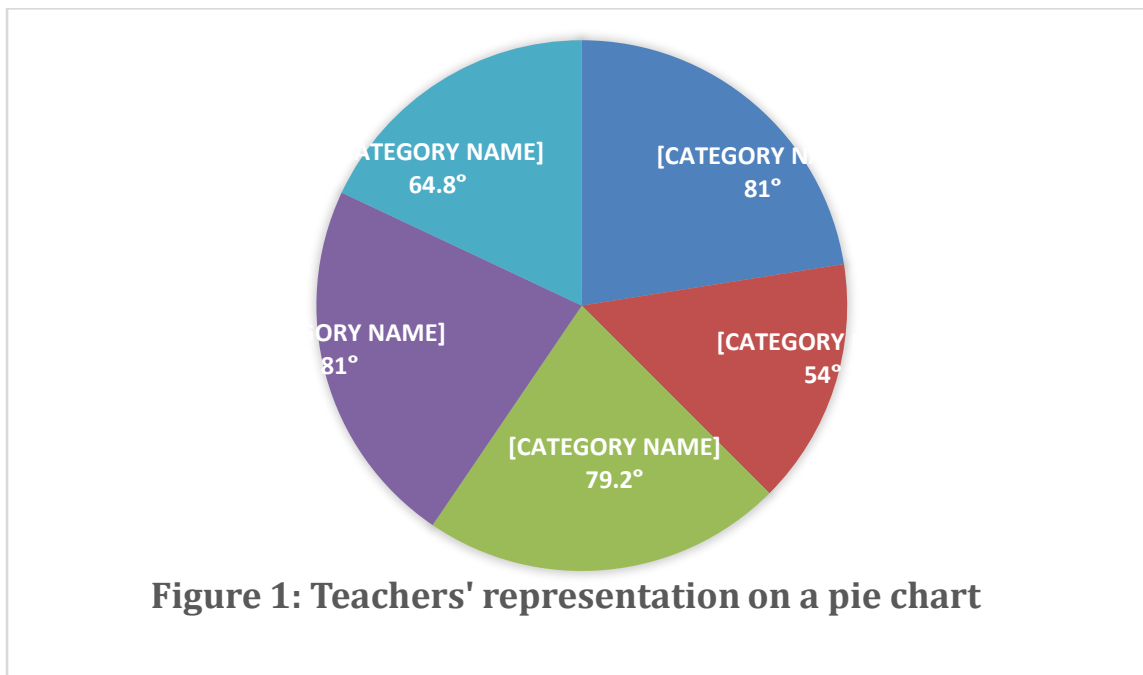


Figure 1: Teachers' representation on a pie chart

**Research Design:** The research design is descriptive survey. The research sets to uncover what obtains on the field and as expressed by the representative sample of the population.

**Instrument:** A 4Cs questionnaire (4CsQ) segmented into four sections made of eight terms per section, totally thirty-two (32), was used for the study. The instrument has four scales; Agree related (4), Often (3), Sometimes (2), and Undecided (1) respectively. An acceptable mean( $\bar{x}$ )value of 2.50 was used as minimum value for an item of acceptable value. Respondents' rating was also expressed in percentages (%).

**Validity of instrument:** To ensure that the instrument met this criterion, peer review of items herein was achieved. This was done to ensure a match between items in relevant sections and the corresponding research questions.

**Reliability of Instrument:** A pilot application of the instrument using a sample different from the same science and mathematics teachers was carried out. However, on successful application after a week interval, the correlation of data gave a split-half correlation value of 0.78, which is close to unity. This closeness suggested that the instrument was reliable and thus was used on the main sample.

Table 2: Critical thinking skill

S/N	Description	A	O	SM	UD	$\bar{x}$
1.	Emphasizes detail explanation of things/events.	70(4)280(35%)	40(3)120(20%)	30(2)60(15%)	60(1)60(30%)	2.60
2.	Identifies features of things/events.	20(4)80(10%)	40(3)120(20%)	40(2)80(20%)	100(1)100(50%)	1.50

3.	Establishes relationship between features things/events.	49(4)196(24.5%)	51(3)153(25.5%)	35(2)70(17.5%)	65(1)65(32.5%)	2.42
4.	Emphasizes logical conclusion in lessons.	50(4)200(25.5%)	30(3)90(15.5%)	80(2)160(40%)	40(1)40(20%)	2.45
5.	Students express themselves on issues of concern.	42(4)168(21%)	58(3)174(29%)	36(2)72(18%)	64(1)64(32%)	2.39
6.	Encourages proving questions.	40(4)160(20%)	60(3)180(30%)	40(2)80(20%)	60(1)60(30%)	2.40
7.	Tries to resolve cause-effect.	60(4)240(30%)	34(3)102(17%)	46(2)92(23%)	60(1)60(30%)	2.50
8.	Lesson emphasizes matching items task.	50(4)200(25%)	48(3)144(24%)	62(2)124(31%)	40(1)40(20%)	2.54
						$\bar{x}$ 18.8

The table 2, above reveals a display of rating of science and mathematics teachers on each of the items. Apart from items (N<sub>0</sub> 1,7, and 8) which had mean( $\bar{x}$ ) values of (2.60, 2.50 and 2.54), the rest items had mean( $\bar{x}$ ) values below the accepted mean( $\bar{x}$ ). However, the grand mean( $\bar{x}$ ) of this section stands at 18.8.

Table 3: Creativity thinking rating

S/N	Description	A	O	SM	UD	$\bar{x}$
1.	Encourages composition of new things.	48(4)192(24%)	52(3)156(26%)	37(2)74(18.5%)	63(1)63(31.5%)	2.43
2.	Emphasizes innovation as much as possible.	49(4)196(24.5%)	51(3)153(25.5%)	40(2)80(20%)	60(1)60(30%)	2.50
3.	Encourages structure and functions of parts.	50(4)200(25%)	48(3)144(24%)	62(2)124(31%)	40(1)40(20%)	2.54
4.	Encourages research on environment.	42(4)168(21%)	58(3)174(29%)	36(2)72(18%)	64(1)64(32%)	2.39
5.	Tries to resolve cases as they crises.	40(4)160(20%)	60(3)180(30%)	40(2)80(20%)	60(1)60(30%)	2.40
6.	Very broad in looking at issues	60(4)240(30%)	34(3)102(17%)	46(2)92(23%)	60(1)60(30%)	2.50
7.	Emphasizes imaginative processes during lesson.	43(4)172(21.5%)	57(3)171(28.5%)	36(2)72(18%)	64(1)64(32%)	2.40
8.	Encourages design projects.	44(4)176(22%)	56(3)168(28%)	38(2)76(19%)	62(1)62(31%)	2.41
						$\bar{x}$ 19.57

Table 3 above shows on indication of science and mathematics teachers’ rating of creativity skills displayed in their lessons. As shown, it is obvious that out of the eight items, only three items No (2, 3 and 6) have mean( $\bar{x}$ ) values of (2.50, 2.54 and 2.50) respectively. The other items (1, 4, 5, 7 and 8), have mean( $\bar{x}$ ) values less than acceptable mean( $\bar{x}$ ) of 2.50. However the grand mean( $\bar{x}$ ) is 19.57, a value higher than critical thinking grand mean( $\bar{x}$ ) value by 0.77.

Table 4: Communication skill

S/N	Description	A	O	SM	UD	$\bar{x}$
1.	Deploys verbal and non-verbal communication.	50(4)200(25%)	50(3)150(25%)	60(2)120(30%)	40(1)40(20%)	2.50
2.	Engages synchronous and asynchronous communication.	40(4)160(20%)	60(3)180(30%)	40(2)80(20%)	60(1)60(30%)	2.40
3.	Look at issues from comprehensive view.	60(4)240(30%)	45(3)135(22.5%)	50(2)100(25%)	45(1)45(12.5%)	2.60
2.60	Clarity of ideas expressed	50(4)200(25%)	50(3)150(25%)	62(2)124(31%)	38(19%)	2.56
5.	Ensures relevance of content of message.	49(4)196(24.5%)	51(3)153(25.56%)	40(2)80(20%)	60(1)60(30%)	2.50
6.	Feedback is given its place.	60(4)240(30%)	34(3)102(17%)	46(2)92(23%)	60(1)60(30%)	2.50
7.	Employs alternative channels of communication.	50(4)200(25%)	48(3)144(24%)	62(2)124(31%)	40(1)40(20%)	2.54
8.	Encourages alternative sources of knowledge.	62(4)248(31%)	32(3)96(16%)	48(2)96(24%)	58(1)58(26%)	2.50
						$\bar{x} = 20.1$

Table 4 is an indication of science and mathematics teachers’ rating of communication skill. The table shows real presence of this skill as evident in items (1,3,4,5,7 and 8) with recorded mean( $\bar{x}$ ) values of (2.50, 2.60, 2.56, 2.50, 2.54 and 2.50), respectively. The grand mean( $\bar{x}$ ) of this category stands at 20.1, the highest grand mean( $\bar{x}$ ) higher than the preceding skills.

Table 5: Collaboration skill rating

S/N	Description	A	O	SM	UD	$\bar{x}$
1.	Class members work as a team	40(4)160(20%)	60(3)180(30%)	40(2)80(20%)	60(1)60(30%)	2.40
2.	Assigns roles at responsibilities equally	50(4)200(25%)	50(3)150(25%)	60(2)120(30%)	40(1)40(20%)	2.55
3.	Class members are grouped	50(4)200(25%)	52(3)156(26%)	38(2)76(19%)	60(1)60(30%)	2.40
4.	Groups opinions are encouraged	60(4)240(30%)	48(3)144(24%)	40(2)80(20%)	52(1)52(26%)	2.58
5.	Each group member is a potential leader	50(4)200(25%)	50(3)150(25%)	62(2)124(31%)	38(1)38(19%)	2.56
6.	Every group member is allowed to express himself/herself	60(4)240(30%)	45(3)135(22.5%)	50(2)100(25%)	45(1)45(12.5%)	2.60
7.	Groups work	40(4)160	60(3)180(30%)	38(2)76(19%)	62(1)62(31%)	2.39

	within a given time frame	(20%)				
8.	Groups work toward a common goal.	42(4)168(21%)	58(3)174(29%)	36(2)72(18%)	64(1)64(32%)	2.39
	Grand mean					$\bar{x}$ 19,5

Table 5 shows presence of collaboration as out of the eight items, five items (No. 2, 3, 4, 5 and 6) have mean( $\bar{x}$ ) values of (2.55, 2.50, 2.58, 2.56 and 2.60) respectively, above the acceptable mean( $\bar{x}$ ) of 2.50. The grand mean( $\bar{x}$ ) of this category stands at 19.95, also close to the preceding category, that is, communication skill.

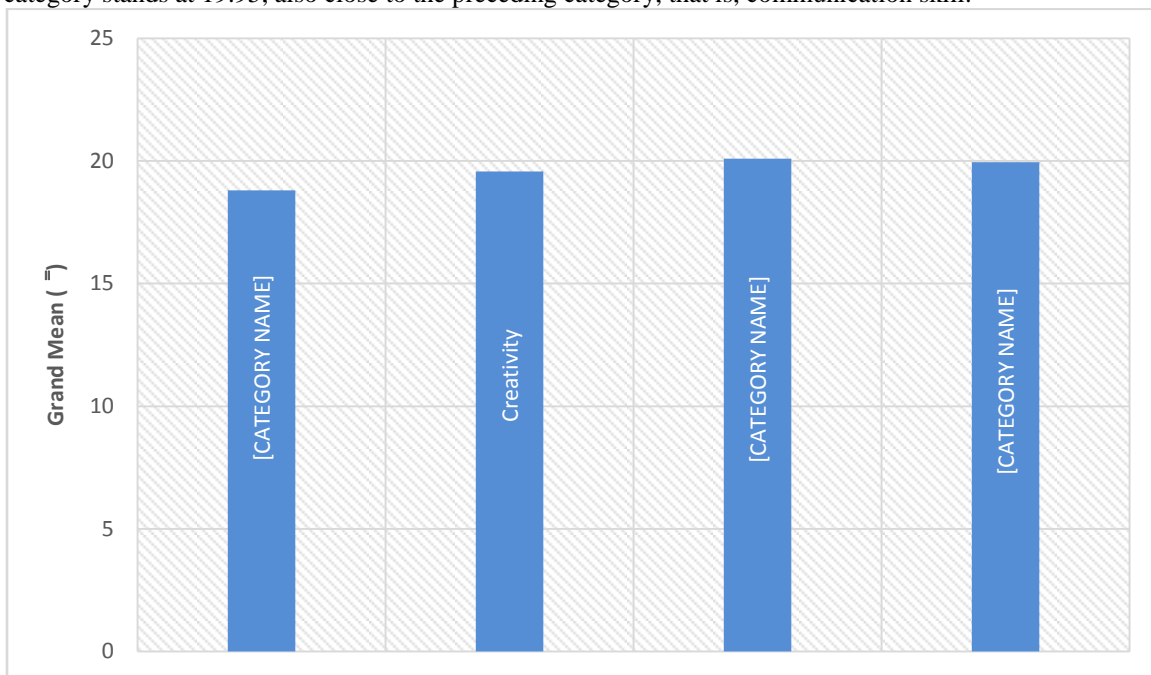


Fig. 2: Representation of Grand Mean ( $\bar{x}$ ) of 4Cs

Discussions of finding

The first finding is that science and mathematics teachers are yet to fully integrate critical skills in their daily lesson. This is not a good development in the attainment of the right type of learners that we so desire. This picture contrasts the relevance of critical skill (Halx & Reynolds, 2005; Walter, Carey & Carey, 2014). Therefore, it is high time for lessons of our science and mathematics teachers be embedded with activities and techniques that would promote this inevitable skill if meaningful and deep learning must be achieved. The positions of Tsai, Chen, Chang and Chong (2013); Arend (2009) and Kokkiduo(2013), lend credence to the indispensable place of critical thinking in building a student that is a problem solver with rational mind and that sees issues from a broader perspective.

The second finding is that creative skill integration in the daily lessons of the teachers is in the same fashion as the previous skill. That means, creative skill is yet to be given the right place in the teachers' daily lesson. Where this is the case, it is observed that

ingenuity, innovative traits that will make them function effectively in and outside school. The school's role should be inculcating into our learners the right mental attitude of exploring, inventing and coming up with novel ideas that are capable of solving inaudible needs. Thus, our teachers' lessons fail to involve the disciplined improvisation, Sawyer (2004), and fails to bring their wealth of experience to bear (Borko & Wingshne; Moore, 1993). This creative skill is necessary as it will enable learners use prior knowledge to generate new ideas and products (McDonald, 2011).

Communication skills is heavily displayed by learners in their daily lessons. This is the third findings of the study. Teachers make adequate use of both verbal and non-verbal, and material resources, but are yet to explore modern communication forms (synchronous and asynchronous), courtesy the presence of modern ICT facilities in teaching and learning. All the same heavy reliance on the conventional communication types could be linked to

their instructional approaches. Where orthodox or not, it is obvious that science and mathematics teachers acknowledge the place of effective communication skill in the attainment of desired instructional objectives (Inyang-Abia, 2004; Williams, 2012)

Finally, the study finds that collaboration skill is finding its desired status in the daily lesson of science and mathematics teachers. The implication is that that the competitive classroom is giving way gradually to the collaborative classroom where cooperation and the value of team work is more acknowledged. No one man is an island, so this skill will instil on students that concept of interdependence, a kind of symbiotic relationship which will carry solution even while out of school. The meaning is that the position of Dewey (1916); Vygotsky (1978), and Bonwell and Eison (1991), on the power of collaboration is being explored by the today science and mathematics teachers. The impart of this skill on our learners is equally supported by the positions of Williams and Augustine (2015).

#### Conclusion

The study has gone to confirm the status of the 4Cs as evident in the daily instructional designs and implementation of science and mathematics teachers. It is true that for us to be able to build students that will be problem – solvers that deep learning which can be achieved via integration of critical, creative, communication and collaborative skills should be explored to its fullness.

#### Recommendations

Three recommendations that stem from the findings are put forth here:

1. Science and mathematics teachers should desist from factual learning but encourage deep learning that will develop the desired excited mind in our students.
2. Science and mathematics teachers should endeavour to display creatively in their daily lessons. The reason is that this new way of doing things will become part and parcel of their students, for after all observations is a rare way of learning.
3. Thirdly, science and mathematics teachers should explore the gains of ICT in the modern day classroom. The reason is that synchronous and asynchronous forms of communication is the in thing, courtesy the skype, Oovoo and like application.

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