

## RESEARCH ARTICLE

## Effect of Regular Classroom Tests on Learning and Understanding of Concepts in Chemistry

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This study employed regular classroom tests as an intervention to help students learn and understand the concepts periodicity and chemical bonds in chemistry. The participants of the study were thirty four second year science students at Swedru Senior High School in the Central Region of Ghana. These students were taught for eight weeks and at the end of each week made to take an essay-type test on the concepts they have learnt within the week and the previous weeks. Questions asked were constructed with increasing cognitive demand to challenge students to reason and apply the principles learnt in solving them. Descriptive feedback in the form of written comments was provided against any incorrect responses which did not reflect understanding of concepts learnt. These strategies adopted improved the performance of students in the weekly tests as most of the responses students provided in the weekly tests reflected understanding of the concepts learnt. The regular classroom tests made students revised their notes throughout the term and hence improved their performance in chemistry.

**Keywords:** Regular Classroom Tests; Motivation; Intervention; Descriptive Feedback

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### Introduction

Testing in the classroom is one of the routine activities that engage teachers and students. The use of classroom tests in Ghanaian classrooms appears to be limited to determining students' learning only. However, tests may be used to help students' learning. Thus, when a teacher uses tests for formative purposes, students are able to learn what went wrong with their learning and also how to correct their errors. In the Ghanaian classroom, however, the trend appears to be the use of tests to determine the extent of learning rather than the depth of understanding of the topics taught. Experience from the author's teaching showed that students put much effort in their studies whenever time for tests and examination are announced. Testing of students in the classroom has been of interest to researchers and teachers in the science education community nowadays. Much research has been done on how to use tests to improve students' learning in the classroom. Many of these studies report that taking tests in concepts learnt in the classroom improve understanding and retaining of the concepts learnt (e.g. Kayser, 2015; Norton, 2013; McDaniel, Agarwal, Huelser, McDernott & Roediger, 2011). Studies in second cycle institutions and colleges show that students who are tested regularly perform better than other students in

midterm and final examination (Frost, 1999). Nejati (2016) investigated the durability of the effect of frequent quizzes on Iranian high school students' vocabulary learning. The participants of his study were 88 high school students. In the study, the experimental group took 10 weekly quizzes whilst the control group did not take any quizzes. Analysis of results revealed that, the students who took weekly quizzes performed better than those who did not. The weekly quizzes had a positive effect on students' performance on vocabulary. The Students' performance improved and the outcome of the treatment was durable.

Shirvani (2009) investigated whether daily quizzes had a significant effect on students' final exams scores and homework grades. The sample of his study were students in four geometry classes. The experimental group took daily short quizzes and the control group took weekly quizzes. Shirvani found out that daily quizzes had a significant effect on students' final exams scores and homework grades. Momeni and Barinani (2012) in a similar study, examined the effect of testing frequency on language achievement of pre-intermediate EFL learners in Iran. The study comprised of one control group and two experimental groups. The control group did not take any quiz throughout the study but one of the experimental groups took weekly quizzes whilst the other bi-weekly quizzes. The results revealed that, the students who took weekly quizzes performed better than those who took bi-weekly quizzes on the final exam. Those students who did not take any quiz were outperformed by those who took weekly or bi-weekly quizzes. Gholami and Moradi Moghaddam (2013) investigated the effect of weekly quizzes on students' final achievement score. The sample of the study were high school students. The students were divided into two groups with one group taking only mid-term exam and the other group weekly quizzes. The results of the study showed that, the students who took weekly quizzes performed better than those who took only the mid-term exam. In another study McDaniel, Anderson, Derbish, and Morrisette (2007) found that, testing students throughout the semester had positive effects on their performance in the final examination. Marcell (2008) compared the performance of two groups of students in introductory Psychology course. One group were given time limited out of class WebCT quizzes on daily readings and the other group took no quizzes. The results show that frequent quizzes lead to more questions and comments at the beginning of lessons, because students who took quizzes read the material before coming to class and the feedback from the quizzes helped the students to diagnose their learning difficulties. Feedback can be used to encourage students to confront their misconceptions and misunderstandings, and the process itself can be instrumental in helping students move to higher levels of understanding (Gitomer & Duschl, 1995). The results of meta-analysis conducted by Phelps (2012) on the effect of testing on achievement revealed that, testing followed by feedback has a very strong positive effect on students' achievement. This meta-analysis included studies which were done from 1910 to 2010.

The concept of operant conditioning has greatly influenced classroom practices (Huitt & Hummel, 1997). Good & Brophy (1990) assert that people wait until they receive a discriminant stimulus to initiate the desired behaviour. Testing students regularly serve as reinforcement for students to learn. Feedback from regular classroom tests is useful to teachers in assessing whether the students are learning what they are expected to learn giving them more time to work toward reducing the areas of weakness (McDaris, 1984). Regular classroom tests with rapid feedbacks

help to motivate and aid students structure their energies as students learn in ways that they consider they would be tested (McKeachie, 1986; Crooks, 1988). Based on the theory of operant conditioning, students put much effort in learning when tests are announced. Regular classroom testing will develop regular learning habits in students. This is because tests as a stimulus situation would stimulate students to learn as a response. Testing students frequently promote learning and retention of concepts because students will study more often (Karpicke & Roediger, 2008). Students commit and motivate themselves to their studies when they are able to see the results of their studies every week. Also teachers receive essential information on the progress level and development of the students and direct the remedial instruction to the academically weak ones. Students' efforts throughout tests produce test performances that validly permit others to infer student's true level of development (Wise & DeMars, 2003).

Action research has become a common practice in the classroom because of its enormous benefits to the teaching and learning process. According to Kemmis (2001), action research refers to studies by practitioners in order to improve their practice. Meier and Henderson (2007) emphasize that, the issues teachers encounter every day in the classroom are within the remit of action research. Practitioners are not the sole beneficiaries of action research. The learner at the receiving end of the intervention benefit enormously as the strategies employed by the researcher, help them to improve upon their performance. It also allows them to collect valuable evidence about their performance. This present study focused on how to help student learn and understand concepts in chemistry. Action research was chosen for this purpose because, students knowing what the Researcher is trying to do can help the students navigate and develop from the process of self-assessment. According to Lampert (2001) if criteria and goals reflect important aspects of an activity, students start to develop a good sense of how to engage in that activity. Action research was used because the Researcher wanted all the students to benefit from the study, unlike the experimental study where only a portion of students (experimental group) benefits. This study used regular classroom tests as means of assisting students to learn and understand some concepts in chemistry.

## Methods

This study is an action research which aims at improving students' learning and understanding of concepts in chemistry. The study was carried out in three major phases. The first phase consisted of pre-intervention activities. These activities included revision of concepts learnt by students in the previous term and analyses of activities and tasks performed by the subject teacher and the students in the previous term. The second phase of the study was the implementation of the intervention. Students were taught for eight weeks. Weekly lesson plans were developed with respect to the Senior High Schools curriculum for second term. According to the chemistry syllabus for Senior High Schools in Ghana, students were supposed to learn periodicity and chemical bonds in the second term of the second year. Therefore teaching and learning activities about these two topics were developed systematically specifying the instructional objectives to be achieved each week. The lesson plans incorporated the test items to be administered for the week. Test items which were used in the weekly tests were constructed based on the activities and

concepts which were treated within the week and the previous weeks (see **Appendix**). The test items consisted of essay type questions in order to be able to measure complex learning outcomes and also stress on the incorporation and application of thinking and problem solving skills. According to Davis (1993), students preparing for essay tests focus on general concepts, broad issues and interrelationships rather than on specific details and this studying result in better students' performance. The last phase of the study was the monitoring of students' outputs in class. Observation of students' participation in class and analyses of students' responses to questions asked in class, were used as means of monitoring the effectiveness of the intervention.

The accessible population was all science students in the Swedru Senior High School. This school was chosen due to availability of science teaching materials in the school and its status as a science resource center. The sample for the study was a class of second year science students of Swedru Senior High School. Second year science students were chosen through purposive sampling technique. The total sample size was thirty four. A self-developed, student' learning progress monitoring form was used as an instrument. The purpose of this form was to collect information on students' outputs in the pre-intervention exercise and the weekly classroom tests. Students' responses to questions were examined whether they relate to the questions asked, include explanations, describe the situation demanded by the questions and reflect understanding of the concepts learnt. Therefore, answers with correct explanations and examples showing application of principles learnt were classified as 'understanding of concepts'. Responses that were related to questions but with incorrect explanations, together with wrong answers were classified as 'no understanding'.

## Results

### *Teachers Notebook and Students' Workbooks*

The subject teacher's notebook and students work books were analyzed to diagnose the lapses in the teaching and learning of chemistry in the class. The teacher's notes were checked to determine the teacher's scheme of work for the previous term, whether the students were taught with lesson plans and whether evaluation exercises on each lesson were given. Students' work books were checked to determine the number of tests, exercises, assignments and projects the students did in the previous term. Data gathered from teacher's notebook revealed that the students were not taught with lesson plans. Terminal scheme of work was prepared specifying the topics taught for the term. Learning or instructional objectives to be achieved within each week or the term were not stated in the scheme. Teaching and learning activities and evaluation exercises to be performed by students at the end of each week or the term were not stated. Data from students' workbooks showed that students were not given any class exercise and project work in the previous term. They did only one assignment and one mid-term test.

### *Pre-intervention Exercise*

Concepts taught by the subject teacher in the previous term were reviewed with students and at the end students were made to answer four questions. The concepts include atomic structure and mass spectrometry. This activity was done to find out the level of students' understanding of the

concepts they had learnt in the previous term. The arrangement of elements in the Periodic Table was discussed with students. They were also taken through the representations of the structure of the atom and the determination of relative atomic masses of elements. Before the implementation of the intervention, students could not explain some concepts learnt in the previous term. Most of the answers students provided were not related to the questions asked in the classroom. Analyses of the pre-intervention exercise revealed low performance of students in chemistry. Most of the responses student provided in the pre-intervention exercise did not reflect understanding of the concept learnt.

Samples of students' responses to the questions asked in the pre-intervention exercise are analyzed and presented as follows:

**Question 1:** Write the detailed electron configuration of chromium ( ${}_{24}\text{Cr}$ ).

Student 1:  $\text{Cr} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6$

The response provided relates to the question asked but it is incorrect. This is because chromium has twenty four electrons not eighteen electrons. Five of the last six electrons occupy the 3d orbitals and the other occupies the 4s orbital. This arrangement was not shown in the response.

Student 2:  $1s^2 2s^2 2p^2 \cdot 2p^2 2p^2 \cdot 3s^2 2d^6 4s^2 4p^2$

The response provided relates to the question asked but it is incorrect. This is because 2d and 4p orbitals were shown in the configuration. In theory, 2d orbitals do not exist in any atom and therefore are not filled during Aufbau process. Although 4p orbitals exist they are not filled in chromium atom. About 75% of the students could not write the electron configuration of chromium correctly. This shows that students had difficulties or were not with the concept of electron configuration. According to the Aufbau principle when orbitals are being filled, orbitals of lower energies are filled first before orbitals of higher energies. In a neutral atom the order of orbital energy is  $1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p \dots$ . The 4s orbital has less energy than the 3d orbitals so it is expected to be fully filled before the 3d orbitals are filled but in chromium the 3d sub-energy level is half filled in expense of the 4s orbital. This arrangement of electrons in chromium is favoured because half-filled sub-energy level is more stable than partially filled sub-energy energy level. Therefore the electron configuration of chromium is  $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^5, 4s^1$ .

**Question 2:** Briefly describe Rutherford's alpha scattering experiment.

Student 1: *Rutherford's alpha scattering experiment was about electrons scatter in a cathode ray tube (sic). When electrons are passed through a cathode ray, the negative electrons dispersed while the positive ones also pass through a different direction (sic).*

The response is incorrect and does not relate to the question asked. The explanation given does not describe the situation demanded by the question. This is because Rutherford's experiment did not involve "electron scattering" and "cathode rays". Rutherford's experiment was about scattering of alpha particles observed when alpha particles were passed through a thin gold foil.

Student 2: *Rutherford's alpha scattering experiment is an experiment to show how particles scatter. In the experiment, alpha particles are release into the zinc tube. The particles were charged particles. When the particles reach the tube the positive repels with the positive plate and others pass through the tube without bending.*

The response provided relates to the question asked but it is incorrect. The explanation given is not concise. This is because in Rutherford's experiment the alpha particles were not released into a zinc tube but rather passed through a thin gold foil. About 72% of the students provided similar answers to the question which were not correct. In the experiment, Rutherford observed that most of the particles passed through the thin foil without deflection. Some few particles were slightly deflected and still fewer bounced back. This was explained by the fact that majority of the particles went through the foil because they passed through an empty space. Those that were deflected came closer to a positive charged mass and those bounced back collided with a small massive positively charged particle.

**Question 3:** Explain the operation of the mass spectrometer?

Student 1: *The mass spectrometer operates on the isotopes (sic). When electrons are passed in the mass spectrometer the readings are found on the amplifier as peaks. These peaks represent the number of isotope present in the element.*

The response provided relates to the question asked but it is incorrect; explanation given is inaccurate. This is because electrons are not "passed in the mass spectrometer (sic)" or the mass spectrometer does not operate on electrons but rather samples of substances.

Student 2: *The mass spectrometer is a device used to detect the number of isotopes in a particular element. An element placed in the mass spectrometer is to be split open in order to see the number of constituent. The mass spectrometer reads them as peaks. It also helps in finding out the mass and number of the molecules constituting the element atomic mass*

The response provided relates to the question asked but it does not describe the situation demanded by the question. The student wrote the uses of the mass spectrometer instead of how it is operated. About 81% of the students provided similar responses to the question asked. This indicates that majority of the students have difficulties in understanding the concept mass spectrometry. When a sample of a substance is introduced in the spectrometer, it is first vaporized and then ionized in the ionization chamber. The ions produced are then accelerated by electric plates into a magnetic field in the spectrometer. The magnetic field then deflects the particles according to their masses and charges and these are received and recorded as spectrum of electric impulses of different intensities.

**Question 4:** Copper contains 69% of copper-63 ( ${}^{63}\text{Cu}$ ) and 31% of copper-65 ( ${}^{65}\text{Cu}$ ). Calculate the relative atomic mass of copper.

Student 1:  $Mass\ of\ ^{63}Cu = 63(69\%) = 4347$

$Mass\ of\ ^{65}Cu = 31(65) = 2015$

$$RAM = \frac{4347 \times 2015}{100} = 87592.05AM$$

The answer provided by the student is incorrect. The student started well by finding the product of the isotopic mass and its abundance for each of the isotopes. But instead of adding the two products and dividing the answer by 100, he rather multiplied the two figures and divided by 100. The formula used did not work out therefore resulting in incorrect answer.

Student 2:

$$\frac{63 \times 65 \times 69\% + 31\%}{100} = 4095$$

The solution provided by the student is incorrect; he did not use the correct formula to solve the problem. About 68.8% of the students could not calculate the relative atomic mass of copper. Most of them were using wrong formulae in solving the question while others did not attempt solving the question at all. The relative atomic mass (RAM) of copper is calculated as

$$RAM = \frac{(63 \times 69) + (65 \times 31)}{100} = 63.62AM$$

### Intervention Results

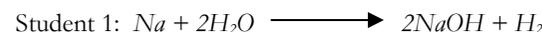
Descriptive feedback given on students' responses in the tests provided students the opportunity to realize their mistakes and what they were expected to provide as responses. It helped the students to learn how to answer questions in class and also in the tests. This was seen in how they organized their thoughts in the responses they provided in the subsequent tests and in lessons. Grammatical errors students were making in their presentations decreased drastically as well as wrong spellings of words and terminologies. Students' performances and understanding in the concepts improved gradually from week to week. Students' performance monitored and samples of responses to the tests are presented weekly as follows:

#### Week One

The first lesson was on the arrangement of elements in the Periodic Table. Students were called to the chalkboard to write the names and the symbols of the first eighteen elements. All the names and their corresponding symbols students provided were correct. Students were then guided to write the detailed electronic configuration of the first thirty elements using the Aufbau process. Students did not find any difficulty with the filling of the atomic orbitals. The terms "group of elements" and "period of elements" were introduced and discussed with students. With the help of the Periodic Table students were able to identify metals, semi-metals and non-metals.

Students' participation in the lesson became immense when the groups of elements in the Periodic Table were introduced. Majority of answers students provided were related to questions asked. Students explained the reason why elements are placed in particular groups using the number of valence electrons in the elements. Students explained why some of the elements are called alkali metals, alkaline earth metals or noble gases. Reactivity of metals was introduced in the lesson. Students explained the trend of reactivity of elements within a given group of elements and along a given period of elements in the Periodic Table. Most of the explanations students gave reflected understanding of what they have learnt. At the end of the week the first class test was administered and marked. Descriptive feedback provided on each test item was discussed with students. Samples of responses students provided to the questions in the test of the week are analyzed and presented as follows;

Question 1: Sodium reacts vigorously with water. Write the equation of the reaction.



The equation provided by the student is correct and related to the question asked. The equation is balanced with the correct coefficients. The student provided the correct products of the reaction. The answer reflects understanding of the concept learnt.

Question 2: Why are alkali metals normally stored under paraffin oil?

Student 2: *This is because they readily tarnish easily in air by reacting with oxygen and water. Paraffin oil prevents contact with air when the alkali metals are stored in them.*

Response from the student relates to the question asked. It includes valid explanation showing understanding of the concept. The answer describes the situation demanded by the question. The explanation shows understanding of the concept reactivity of alkali metals.

#### Week Two

The second lesson was on atomic and ionic radii of elements. The lesson began with the revision of previous lesson on arrangement of elements and their reactivity in the Periodic Table. Majority of the responses students provided to the questions asked showed that they understood what they learnt in the previous week. The concept atomic and ionic radii were introduced and students were brainstormed to come out with the definition and explanation of the concepts. Most of the responses students gave relate to the concepts and were valid. Students' participation in the discussion of the concept was good. Students were able to explain the terms 'effective nuclear charge' and 'shielding effect'. They described the factors that influence the radii of atoms and ions. They related the sizes of given cations and anions to their neutral atoms. At the end of the week, the second class test was administered and marked. Students' performance in the test was quite good. Feedback on each question was discussed with students. Samples of responses students provided to the questions in the test are analyzed and presented as follows;

**Question 1:** Explain why the element helium (He) is in group VIII even though it does not have eight electrons in its outer shell.

Student: *Elements in group VIII are unreactive. This is because they have stable electronic configuration. Helium has only the K shell and it is fully filled with two electrons which is the maximum number of electrons to attain. And helium is unreactive since it has a stable electronic configuration.*

The response provided by the student relates to the question asked and includes explanation. The explanation given describes the situation demanded by the question. The explanation shows understanding of the concept learnt.

**Question 2:** Arrange the following species Cl, Cl<sup>-</sup>, Cl<sup>+</sup> in an increasing order of size and account for your arrangement.

Student: *Cl<sup>+</sup> < Cl < Cl<sup>-</sup>. Cl<sup>+</sup> is smaller than Cl because it has one excess proton over its electron which increases the effective nuclear charge leading to the decrease in size than Cl. Cl is also smaller than Cl<sup>-</sup> because Cl<sup>-</sup> has one excess electron over its proton which leads to the decrease in the effective nuclear charge therefore increase in size.*

The response provided by the student relates to the question asked and includes explanation. The answer describes the situation demanded by the question. The arrangement of the species is correct. The explanation given reflects understanding of the concept.

### Week Three

The third lesson was on the concept of ionization energy. The lesson began with the revision of the previous lesson. Students explained the concepts of shielding effect and effective nuclear charge and how these two concepts vary within a given group and along a period of elements in the Periodic Table. Students explained with illustrations how ions are formed from their respective atoms. The concept of ionization energy was introduced and students were brainstormed to come out with the meaning and explanation of the concept. Most of the explanation students provided were related to the concept. They described and explained how ionization energy of atoms varies from one element to the other in a group and in a period of elements in the Periodic Table. Most of the explanations students gave during the lesson showed that students prepared well before coming to class. At the end of the week the third test was administered and marked. Students' performance in the test was good. Feedback on the test was discussed with the students. Samples of responses students provided to the questions in the test of the week are analysed and presented as follows:

**Question 1:** The first ionization energy of elements decreases down a group in the periodic table. Account for this trend

Student: *Ionization energy is the amount of energy needed to remove one mole of electrons from one mole of gaseous atoms. Down the group more shells are added to the atom and effective nuclear charge decreases. There is also screening effect therefore the energy needed to remove one valence electron decreases down the group.*

The response provided by the student relates to the question asked and includes explanation. The response describes the situation demanded by the question. The student defined ionization energy and explained the reason why it decreases down a group of elements. The explanation given reflects understanding of the concept of ionization energy.

**Question 2:** The second ionization energy of an element is always greater than the first ionization energy. Account for this.

Student: *After one valence electron has been removed thus first ionization energy. There are excess protons over electrons, increasing the effective nuclear charge. Hence much energy is needed as compared to the first to remove another electron.*

The response provided by the student relates to the question asked and includes explanation. The response describes the situation demanded by the question. The explanation given reflects understanding of the concept of second ionization energy.

### Week Four

The topic treated in the fourth week was electron affinity. The lesson started with the revision of the previous lessons. Students were made to explain shielding effect and effective nuclear charge. They were also made to explain how ionization energy varies within a group and along a period of elements in the Periodic Table. Most of the explanations they gave showed sound understanding of the concept of ionization energy. They explained shielding effect and effective nuclear charge correctly. They also explained how ionization energy varies in the periodic Table. The concept of electron affinity was introduced and students were brainstormed to come out with the meaning of the concept. Students explained the concept by relating it to the position of element in the Periodic Table. Students' participation in the discussion of the concept was good. Students explained the factors that influence the electron affinity of elements. They described and explained the variation of electron affinity of elements in the Periodic Table. They arranged given elements in decreasing and increasing order of electron affinity. At the end of the week, the fourth class test was administered and marked. Students' performance in the test was good. Feedback on the test was discussed with the students. Samples of responses students provided to the questions in the test of the week are analysed and presented as follows:

**Question 1:** Define electron affinity. In which corner of the periodic table is it highest?

Student: *Electron affinity is the amount of energy lost when one electron is added to a gaseous atom. Electron affinity is at its highest in the group VII elements at the right hand side of the periodic table. Looking at the trend for electron affinity which is, it increases across the period and decreases down the group. Group VII and VIII are at the last end by group VIII elements have stable electronic configuration therefore adding one electron will only be possible with extreme difficulty.*

The response provided by the student relates to the question asked and it includes explanation. The explanation given describes the situation demanded by the question. The student was able to define electron affinity correctly, and also determined the group of elements that have higher electron affinity values and the corner in the Periodic Table they can be located. The explanation given shows understanding of concept of electron affinity.

**Question 2:** The second electron affinity values of the elements in the Periodic Table are all positive. Explain why this is so.

Student: *Second electron affinity values of element are positive because when the atom gains an electron the electrons become more than the protons and this reduce effective nuclear charge. This in turn increases atomic radius, since repulsion between electrons would be high (sic). This implies that the ability of the element to attract another electron will be low, so the electron is forced to the valence shell, thereby giving a positive value.*

The response provided by the student relates to the question asked and it includes explanation. Answer given describes the situation demanded by the question. The student was able to explain why nuclear attraction decreases leading to repulsion of electrons. The explanation given reflects understanding of the concept of electron affinity.

#### Week Five

The topics treated in the week were electronegativity and atomization energy. The lesson started with the revision of the previous lesson. Students explained the electron affinity correctly. They described the variation of electron affinity of elements in the Periodic Table using given group of elements. Students actively participated in the discussion of the concept of electronegativity and atomization energy when the concepts were introduced. Students defined and explained electronegativity and atomization energy. They explained the factors that influence the electronegativity of atoms. Students described and explained the variation of electronegativity and atomization energy of elements in the Periodic Table. At the end of the week, the fifth class test was administered and marked. Students' performance in the test was good. Most of the responses students gave related to the questions asked in the test. Feedback on the test was

discussed with students. Samples of responses students provided to the questions in the test are analysed and presented as follows;

**Question 1:** State with reasons which element has the highest electronegativity in the Periodic Table.

Student: *Electronegativity increases across the period and decreases down the group in the periodic table. Therefore the group 7 elements have the highest electronegativity. But when we consider the group 7, electronegativity decreases down the group in the order  $F > Cl > Br > I$ . Therefore fluorine has the highest electronegativity.*

The response provided by the student relates to the question asked and includes explanation. The explanation given describes the situation demanded by the question. The student explained why fluorine has the highest electronegativity value by describing the trends of electronegativity in the Periodic Table. The explanation given shows understanding of the concept of electronegativity.

**Question 2:** Distinguish between Electron affinity and Electronegativity.

Student: *Electron affinity is the energy change which occurs when an electron is added to the gaseous atom while electronegativity is the ability of an atom to attract an electron to itself in a molecule.*

The response provided by the student relates to the question asked. The response given describes the situation demanded by the question. The response shows understanding of concept of electronegativity and electron affinity.

#### Week Six

The sixth lesson was on Interatomic bonding. The lesson began with the revision of the previous lesson. Students were brainstormed to explain the concept *bonding* and relate the position of elements in the Periodic Table to the type of bonding they can undergo. Most of the explanations students gave were correct. Students mentioned the three major types of Interatomic bonding (ionic, covalent and metallic bonding). Most of the students said that alkali metals and alkaline earth metals formed ionic bonds with halogens because they easily lose their valence electrons. They also said that the non-metals when they combine with each other they formed covalent bonds. Students described and illustrated the formation of sodium fluoride and water. They mentioned examples of ionic and covalent compounds. They described the properties of ionic compounds and covalent compounds. At the end of the week the sixth class test was administered and marked. Students' performance in the test was good. Feedback on the test was discussed with students. Samples of responses students provided to the questions in the test of the week are analysed and presented as follows:

**Question 1:** Distinguish between simple covalent bond and dative covalent bond

Student: *Simple covalent bond is a type of covalent bond formed between two atoms whose electronegative values are almost the same. Whiles dative covalent bond is a type of bond formed between two atoms, when electrons to be shared are donated by only one atom.*

The response provided by the student relates to the question asked and includes explanation. The response describes the situation demanded by the question. The explanation given reflects understanding of the concepts simple covalent and dative covalent bonding.

**Question 2:** Covalent compounds do not conduct electricity either in aqueous solution or in molten state. Explain.

Student: *Electricity is the flow of electrons. Covalent compounds do not conduct electricity either in molten state or aqueous solution because they do not carry charges. The molecules in a covalent compound do not attract themselves because they share electrons and don't carry charges.*

The response provided by the student relates to the question asked and it includes explanation. The answer describes the situation demanded by the question. The student explained the concept of electricity and related covalent bonding.

### Week Seven

The concepts treated for the seventh week was ion polarization, lattice enthalpy and metallic bonding. The lesson began with the revision of the previous lesson. Students mentioned and explained the properties of ionic and covalent compounds. Students provided explanation showing understanding of what they have learnt in the previous week. The concept ion polarization, lattice enthalpy and metallic bonding were introduced one after the other and students were brainstormed about the meaning of the concepts. Most of the explanations students gave were correct. Students defined ion polarization and explained polarizability of anion. They explained the covalent character in some ionic species. They defined lattice enthalpy and explained its variations in compounds. Students explained the formation of metallic bonding and how the delocalization of electrons promotes conduction of heat and electricity in metals. Students mentioned and explained the properties of metals demonstrating how metals conduct heat in the classroom. At the end of the week the seventh class was administered and marked. Students' performance in the test was good. Feedback on the test was discussed. Samples of responses students provided to the questions in the test are analyzed and presented as follows;

**Question 1:** Explain the reason why bromide ion is more polarizable than fluoride ion.

Student: *Bromide ion is more polarisable than fluoride ion because the radius of an anion affects polarizability. That is, the larger the ionic radius the more the element is polarized therefore comparing bromide ion to fluoride ion, bromide ion has larger radius than fluoride ion.*

The response provided by the student relates to the question asked and includes explanation. The answer describes the situation demanded by the question. The explanation provided shows understanding of the concept ion polarization.

**Question 2:** Which of the following bromides NaBr and MgBr<sub>2</sub> will have higher lattice enthalpy? Explain.

Student: *lattice enthalpy is the enthalpy change to form 1 mole of ionic crystal structure from the ions of the compound. The lattice enthalpy is influenced by the interionic distance, the charge of the ions and the structure. The interionic distance between magnesium ion and bromide ion in the MgBr<sub>2</sub> is smaller due to the smaller size of Mg<sup>2+</sup>. In the NaBr, the interionic distance is greater due to the larger size of Na<sup>+</sup>. The Mg<sup>2+</sup> has a higher charge (+2) than Na<sup>+</sup> (+1). These factors make the lattice enthalpy of MgBr<sub>2</sub> higher than NaBr.*

The response provided by the student relates to the question asked and it includes explanation. The answer given describes the situation demanded by the question. The response reflects understanding of the concept lattice enthalpy.

### Week Eight

The concept treated in the eighth week was intermolecular bonds. The lesson began with the review of the concepts learnt in the previous week. Students described the properties of metals. They explained how metals conduct heat and electricity. The concept hydrogen bonding and van der Waal's forces were introduced and students were brainstormed to come out with meaning of the concepts. Most of the responses and explanation students gave were related to the concepts. Students described the formation of hydrogen bonding in molecules using water and ammonia molecules as examples. Students explained dipole-dipole interactions and dispersion forces using examples on each occasion. At the end of the week the eighth class test was administered and marked. Students' performance in the test was good. Descriptive feedback on each item in the test was discussed with students. Samples of responses students provided to the questions in the test of the week are analyzed and presented as follows;

**Question 1:** Explain the reasons why metals conduct electricity.

Student: *Metals are good conductors of electricity due to their free or delocalized electrons. This happens because the orbitals of neighbouring atoms overlap on each other creating more space for the electrons to freely move from one end to the other end. This makes them conduct electricity easily.*

The response provided by the student relates to the question asked and it includes explanation. The explanation given describes the situation demanded by the question. The answer shows sound understanding of the concept metallic bonding.

**Question 2:** Intra-molecular bonds are stronger and difficult to break than intermolecular bonds. Explain

*Student: Intra-molecular bond which is also known as Inter atomic bond involve the electrostatic force of attraction between ions which are fully charged, equal but opposite (that is ionic bond) and or the overlapping of two or more atoms (also covalent). This makes the intra-molecular bond to be stronger than that of the intermolecular bond because, the intermolecular bonds exist between partial, equal but opposite charges. The intra-molecular bond is therefore stronger and difficult to break because of the full charges and as well as the overlapping whereas the intermolecular which is of partial charges become less difficult to break.*

The response provided by the student relates to the question asked and includes explanation. The explanation provided shows understanding of the concepts intermolecular and intra-molecular bonds.

## Discussion

Analyses of the data collected on students' outputs in the pre-intervention exercise as shown in **Table 1** clearly shows that students' performance in chemistry before the intervention was low. Most of the responses students' provided in the pre-intervention exercise were not correct. Some of the responses students gave were without explanations. The quality of students' responses in the pre-intervention exercise and the weekly tests were also compared. Before the introduction of the intervention students could not explain most of the concepts they had learnt in the previous term. Data from **Table 1** shows that most of the responses students provided to the questions in the pre-intervention exercise did not reflect understanding of the concepts they have learnt. About 75 % of the students could not write the electron configuration of the element chromium and about 72 % of them were not able to describe Rutherford's alpha scattering experiment. About 81 % of the students could not explain the operation of mass spectrometer and about 74 % of them were not able to calculate the relative atomic mass of copper. This result indicated that most of the students were having little or no understanding of the concepts they learnt in the previous term. At the initial stage of the implementation of the intervention, students' performance were a bit low but encouraging. As students became adjusted to the intervention strategies, their performance in class gradually improved from week to week. The subsequent tests after the first week recorded higher percentages of students providing quality responses to the questions asked. The weekly tests administered to students provided students the opportunities to learn for understanding as questions asked demanded students to give an account or explanation to a situation. According to Sutherland and Wehby (2001) Students who are actively engaged and provided with frequent opportunities to respond to academic tasks demonstrate improved academic skills.

Data from **Table 1** clearly shows that most of the responses students provided in the tests 1 to 8 reflected understanding of the concepts learnt. Most of the students exhibited sound understanding of the concepts periodicity and chemical bonds. Students explained the periodic properties and their variations in the Periodic Table. They described the types of chemical bonds and their properties. Based on the quality of responses students provided for the questions in the weekly tests it became clear that regular or continuous learning of concepts results in deeper understanding of concepts. The findings of the present study are in line with Nejati (2016), Shirvani (2009), Momeni and Barinani (2012), Gholami and Moradi Moghaddam (2013), and Marcell (2008) studies which confirmed that weekly quizzes improve students' performance in the classroom. The intervention regular classroom tests helped students to learn and understand concepts taught in the classroom. Results from these weekly analyses of the students' outputs in class also support the findings of McDaniel et al. (2007). They found out that students' performance in a web-based college course improved significantly at end of the semester when the students were quizzed frequently throughout the semester. The quality of responses students provided during lessons and in the weekly tests showed an improvement in students' learning of chemistry.

**Table 1.** Percentages of students' responses showing understanding of concept in the pre-intervention exercise and weekly tests

| Test             | Question 1 (%) | Question 2 (%) | Question 3 (%) | Question 4 (%) |
|------------------|----------------|----------------|----------------|----------------|
| Pre-intervention | 25.0           | 28.1           | 18.8           | 31.2           |
| 1                | 30.3           | 69.7           | 72.3           | 42.4           |
| 2                | 82.4           | 67.6           | 44.1           | 55.9           |
| 3                | 90.9           | 81.8           | 93.9           | 57.6           |
| 4                | 65.5           | 65.5           | 72.4           | 82.8           |
| 5                | 87.9           | 66.7           | 75.8           | 69.7           |
| 6                | 87.1           | 64.5           | 96.8           | 67.7           |
| 7                | 66.7           | 63.6           | 60.6           | -              |
| 8                | 72.7           | 69.7           | -              | -              |

## Conclusion

The introduction of the intervention weekly tests produced a significant improvement in students' learning and understanding of concepts in chemistry as compared to the previous term. Answers most of the students provided in the lessons and in the weekly tests relate to the questions asked and were with explanations. Students' understanding in the concepts taught in the classroom was immense. They related concepts they had learnt in the classroom to other similar situations. The class tests stimulated students to learn concepts in detail, details that would not otherwise be learned for an examination. This makes examination questions relating to class test material more easy to recall. Regular classroom tests made the students revise throughout the

term instead of all at the end the term. According to the criteria for success, it can be said that the intervention strategies were successful. It can be concluded that regular classroom tests improved students' performance in chemistry. Moreover it also motivated students to learn and retain what they have learnt.

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## Appendix

### Test 1

1. Sodium reacts vigorously with water. Write the equation of the reaction
2. Why are alkali metals normally stored under paraffin oil?
3. Alkali metals and alkaline earth metals are in group I and II respectively. Which of these two groups of metals are more reactive and why?
4. Arrange the following metals in increasing order of metallic character and give reason for your arrangement. Potassium (K), Magnesium (Mg) and sodium (Na)

### Test 2

1. Explain why the element helium (He) is in group VIII even though it does not have eight electrons in its outer shell.
2. Arrange the following species Cl, Cl<sup>-</sup>, Cl<sup>+</sup> in an increasing order of size and account for your arrangement.
3. Write the balanced equation for the reaction between potassium and water. State whether its reaction will be faster or slower than that of sodium.
4. Predict with reason whether magnesium atom will have smaller atomic radius than sodium atom.

### Test 3

1. The first ionization energy of elements decreases down a group in the periodic table. Account for this trend.
2. The second ionization energy of an element is always greater than the first ionization energy. Account for this.
3. The first, second and third ionization energies of a certain element A is 587KJ/mol, 1027KJ/mol and 8478KJ/mol.
  - a. How much energy is needed to take two electrons from the atom of the element?
  - b. Predict the group in which this element is likely to belong in the periodic table.

### Test 4

1. Define electron affinity. In which corner of the periodic table is it highest?
2. The second electron affinity values of the element in the periodic table are all positive. Explain why this is so.
3. How are atomic radii, ionization energy and electron affinity related?
4. The first electron affinity of the element Z is -82KJ/mol. Write a chemical equation to represent the information above

### Test 5

1. State with reasons which element has the highest electronegativity in the periodic table?
2. Distinguish between electron affinity and electronegativity
3. a. What is the meaning of "screening effect"
  - b. How does screening effects change in the first three elements in Group I?

### Test 6

1. With the aid of a diagram describe how lithium fluoride is formed
2. Distinguish between simple covalent bond and dative covalent bond
3. Write the electron dot structure for the following species
4. Covalent compounds do not conduct electricity either in aqueous solution or in molten state. Explain

### Test 7

1. Explain the reason why bromide ion is more polarizable than fluoride ion.
2. Which of the following bromides NaBr and MgBr<sub>2</sub> will have higher lattice enthalpy? Explain.
3. State and explain whether C<sup>4+</sup> cation is formed in ionic compounds or not. Explain

### Test 8

1. Explain the reasons why metals conduct electricity.
2. Intra-molecular bonds are stronger and difficult to break than intermolecular bonds. Explain