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Exploring Students' Level of Conceptual Understanding on Periodicity

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ABSTRACT

Nowadays, many scientific studies motivated on addressing the conceptual understanding particularly in chemistry that soon may affect students' academic performance. This study covered the level of conceptual understanding of the trends of the periodic table of elements and the type of conceptual change before and after the exposure of interventions. The qualitative and quantitative research method was used in the study. Respondents were Grade 10 high school students. Frequency, percentage, and t-test were the statistical tools applied to answer specific questions. Results revealed that most students have an ambiguous conceptual understanding. The trends in ionization energy (*I.E.*) noted the highest misconception statements followed by the trends in atomic radius (*A.R.*). The trends in electron affinity (*E.A.*); formation of cation and anion (*I.R.*); and electronegativity (*E.*) were also least understood by the students. After interventions, there is a marked increase in students who progressed from misconception (*MU*) to full understanding (*FU*). This is prevalent on the trends in atomic radius, followed by the trends in electron affinity and the formation of ions. The use of varied activities such as visualizing and multimedia tools; small-group discussions; and concept mapping have a vital positive outcome in their progression. Ergo, science teachers should vary their teaching strategies to address and correct students' conceptual obstacles in learning chemistry concepts.

Keywords — Chemical education; conceptual understanding; descriptive; remedial activities; Philippines

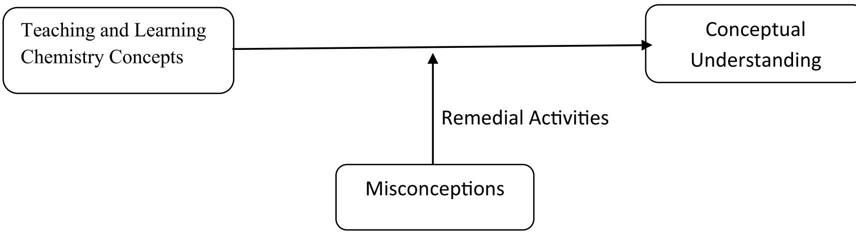
INTRODUCTION

General chemistry is commonly perceived to be more difficult than other subjects. This subject has a very specialized vocabulary, and most of the concepts are abstract. In spite of the best efforts of Chemistry teachers, students do not easily comprehend the fundamental concepts covered in the class. Some smart students can give the right answer. However, these students revealed a lack of understanding and failed to explain the underlying concepts fully. In the study conducted by Kind (2004) and Horton (2004), it was stated that students often use algorithms and memorized equations to solve numerical problems without completely understanding the underlying concepts. Lythcott (1990) also reported that some high school students who were able to balance an equation could not even draw a diagram in the molecular level. In the study of Peterson, Treagust, and Garnett (1989) to secondary school students, about 74% were unable to answer underlying concepts about electron repulsion in valence shells. Schmidt (1997) also added that some students could do well on standardized tests using algorithms and formulae without understanding the concepts that underlie the problems they have solved. It is then an effort of a teacher to offer helpful examples and information leading to algorithmic and conceptual understanding. Blosser (1987) cited that teachers should provide more structured opportunities for students to talk through ideas at length, both in small and whole class discussions, begin with known and familiar examples and introduce some science topics into the curriculum at earlier ages.

The conceptual change is the creation and alteration of mental representations that correspond to words. Chi, Michelene & Roscoe (2002) believed that conceptual change is often related to restructuring, revision or accommodation of new conceptions to the learners' existing systems of beliefs and knowledge. Thagard (1992) suggested that conceptual change is produced by mental processes that create and alter mental representations. The conceptual change will also develop children's thinking in the field of science and even mathematics; influences how students learn new scientific knowledge; play an essential role in subsequent learning and become a hindrance in acquiring the correct body of knowledge (Özmen & Kennan, 2007). Özmen and Kennan further believed that conceptual change could promote students' interest, curiosity, and understanding. It is therefore imperative for the teacher to know what conceptions that student brings to class. A diagnostic test could be one way to identify the preconceptions of the students. This should be administered prior to the teaching of a unit to find out students' ideas so that lessons could be planned to address these preconceptions. Various teaching strategies were recommended to address these preconceptions of the students to dissatisfy their existing conceptions (Locaylocay, van den Berg, & Magno, 2005). Moreover, Locaylocay et al., (2005) suggested that the most effective strategies in promoting conceptual change are the use of discrepant and the use of analogies in learning chemical equilibrium. She suggested giving more examples and extensive follow-up to convert anomalies into lasting conceptual change. Such follow-ups could include small and large group discussions and conceptual exercises.

Several researchers documented misconceptions about many topics in chemistry. These include misconceptions in stoichiometry, balancing chemical reactions, atoms and molecules, electrochemistry, thermodynamics, atomic structure, and chemical bond, and chemical equilibrium have been documented (Horton, 2004 & Kind 2004). However, Horton (2004) suggested that alternative conceptions concerning the periodic table of elements have to be evaluated. The periodic table of elements (or periodicity) is considered to be one of the important topics in basic chemistry to explain the chemical and physical properties of elements across a period and down a group. Elements' physical and chemical properties depend on its group or family due to its atomic radius, ionic radius; ionization energy; electron affinity; and electronegativity. Students often think of the trends as only an increase and decrease across the period and down a group except they fail to explain the underlying concepts of the trends. Hence, this study was conducted to investigate conceptual understanding and to address their preconceptions.

FRAMEWORK



The diagram above shows the conceptual framework of the study. The top left rectangle shows the students' preconceptions based on the different strategies and learning experiences held by the students in dealing with science ideas, particularly chemistry. After learning science concepts, students may now apply the concepts learned, and the different misconceptions may occur (as shown in the top right rectangle). Misconceptions will then be identified as to the basis of designing remedial activities to lessen or to correct misconceptions prior to discussing the succeeding topics.

OBJECTIVES OF THE STUDY

This study aimed to identify the level of conceptual understanding on the trends of the periodic table of elements along the following topics: atomic radius, ionic radius, ionization energy, electron affinity, and electronegativity among Grade 10 high school students. It also intended to design various remedial activities to address the misconceptions of the students. Lastly, to classify the type of progression based on the results from pretest to posttest of students into unchanged conception and change for the better.

METHODOLOGY

This study used both qualitative and quantitative research methods. The qualitative part involved the analysis of the students' explanations of the Chemistry Conceptual Understanding Test (CCUT). The quantitative part was data collected from the pretest and posttest scores on the Level of Conceptual Understanding Ability Rubric (LCUAR).

The CCUT is composed of 15-item with four options and explanation. The 49, one-intact Grade 10 students were chosen as respondents for the research. The CCUT was given immediately after their chemistry teacher finished discussing the topics. Consequently, students' level of conceptual understanding was transcribed and analyzed as full understanding (*FU*); partial understanding (*PU*); misconception understanding (*MU)*; and no understanding (*NU*).

After which, the respondents were then exposed to different remedial activities prepared by the researcher. These include computer-generated activities; cooperative learning; concept mapping; and games. After the respondents took the CCUT, students' responses were carefully transcribed and analyzed to determine the level of concept evolution of the students from the pre-test to post-test results. An inter-rater also rated scores. Percentage (%) of students' level of understanding was used to determine students' concept progression after interventions.

Research Instruments

a) Chemistry Conceptual Understanding Test (CCUT).

The instrument developed in the study is the Chemistry Conceptual Understanding Test (CCUT). The score of a student in this test was interpreted as his/her conceptual understanding. The topics included in the test were: atomic radius (*AR*); ionic radius (*IR*); ionization energy (*IE*); electron affinity (*EA*); and electronegativity (*E*). These topics were chosen based on the content or coverage outlined in the Basic Education Curriculum for Chemistry. This test was used as pretest and posttest.

The CCUT is composed of fifteen (15) multiple-choice items with four options. Each question has an open-ended portion for the students to write their explanations for their choice. The researcher prepared the test. The questions were obtained from existing test question banks. The test was validated by the chemistry education experts prior to administering the test to the respondents. A sample item test is shown in Table 1.

Table 1. A Sample Question in the CCUT.

Sodium (Na) and Aluminum (A*l*) atom are both metals. Which do you think is more reactive when placed in water (H_2O)? A. Sodium is more reactive than Aluminum when added to water. B. Sodium is less reactive than Aluminum when added to water. C. Both elements do not react when added to water. D. The same reactivity will happen to sodium and aluminum when added to water. Please explain your choice.

b) Level of Conceptual Understanding Ability Rubric (LCUAR)

In scoring the CCUT, a Level of Conceptual Understanding Ability Rubric (LCUAR) was developed and used. This scoring rubric probed the conceptual understanding stated by the students. A LCUAR used in the study is presented in Table 2.

Table 2. The Level of Conceptual Understanding and Criteria of Scoring.

Level of Understanding/(Score)	Criteria for Scoring
Full Understanding (FU) 2- points	• Responses include all components of the validated responses, both the correct choice of option and explanation
Partial Understanding (PU) 1-point	• Responses include at least one of the components of the validated response but not all the components. • correct option, wrong explanation or wrong option, correct explanation • correct option but an incomplete explanation.
Misconception Understanding (MU) 0-point	• Responses include illogical choice and incorrect explanation
No Understanding (NU) 0-point	• Non-sense response • Unclear response • No response/Blank

During these analyses, the levels of conceptual understanding were identified using a point system. As a guide, acceptable scientific explanations were written for each question. Students' response was categorized as full understanding (*FU*); partial understanding (*PU*); misconception understanding (*MU)*; and no understanding (*NU*). According to Nakiboglu (2003), this scheme is appropriate in which the ideas of students' response to each question was identified first:

some response might contain one or more ideas linked together, but extended lists of ideas in response to each question was organized as much as possible to attain mutually exclusive categories. The degree of understanding of the students was rated by the other rater. After students' responses had been categorized, frequency distributions were calculated based on percentage (%) responses. Moreover, the post-test results were then compared to the pre-test results, and the level of conceptual understanding and frequencies of responses classified were then analyzed as shown in Table 3. To ensure reliable and valid analysis, each answer was independently checked by the researcher and another chemistry teacher.

c) Students' Progression

The students' progression was also transcribed and analyzed after taking the posttest. Their progressions were transcribed based on frequency distributions (percentage, %) responses as shown in Table 3.

Table 3. Criteria in Classifying Students' Progression before and after Interventions

Category of Conceptual Change	Students' Progression (%)
Unchanged Conception	Remained in any of the Level of Understanding as: FU, PU, MU, NU
Changed Conception	Change which occurred from: a. NU to FU; NU to PU; NU to MU b. MU to FU; MU to PU c. PU to FU

The results of the pretest and posttest (CCUT) on periodicity was subsequently analyzed using the Hake factor test (normalized gain). It was used to measure the change in various interventions in promoting conceptual understanding in learning periodicity. Descriptive equivalents and verbal description for Hake Factor Test results are presented in Table 4.

Table 4. Descriptive Equivalents for the Hake Factor Test Results

Formula	Scale Range	Verbal Description
$h = \frac{posttest\text{-}pretest}{1 - pretest}$	0.71-1.00	High Gain
	0.31-0.70	Medium Gain
	0.10-0.30	Low Gain

RESULTS AND DISCUSSION

Table 5. Level of Conceptual Understanding on Periodicity on Pretest/Posttest Results

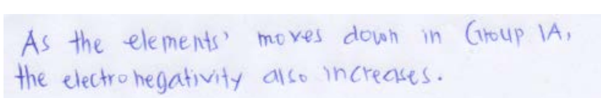
Concept	Full Understanding				Partial Understanding				Misconception Understanding				No Understanding			
	Pretest		Posttest		Pretest		Posttest		Pretest		Posttest		Pretest		Posttest	
	f	%	f	%	f	%	f	%	f	%	f	%	f	%	f	%
Atomic Radius	20	41	27	55	18	37	20	41	10	21	2	4	1	2	0	0
Ionic Radius	11	23	41	84	16	33	7	14	16	33	1	2	6	12	0	0
Ionization Energy	2	4	7	14	16	33	36	73	27	55	6	12	4	8	1	3
Electron Affinity	19	39	15	31	7	14	27	55	20	41	5	10	3	6	1	3
Electronegativity	1	2	32	65	24	49	16	33	23	47	1	2	2	2	0	0

During pretest, about 21% of the students have many misconception statements in the trends of Atomic Radius across the period and down a group. About 33%, 41%, and 47% of the students have many misconception statements in the trends in Ionic Radius, Electron Affinity, and Electronegativity, respectively. Consequently, the trends in Ionization Energy garnered the highest misconception statements of about 55%. It is then imperative for the teacher to know what are the conceptions that student could bring to the class using a diagnostic test to address these preconceptions. After interventions, there was a high progression from misconception to partial and even to full understanding. This is prevalent in Electronegativity, Ionic Radius, Electronegativity, and Atomic Radius. However, about 73% of the students still have a partial understanding of the trends in Ionization Energy. Some of the common misconception statements were shown in Table 6 and Table 7. The misconception statements are mostly shared ideas or communicated by many students after they have studied topics in chemistry (Schmidt, 1997). Schmidt further suggested that standardized tests and multiple-choice formats should be replaced. Subsequently, the use of an open-ended question is highly recommended to know the conceptual understanding held by the students.

Table 6. Misconception statements about the trends in Atomic Radius.

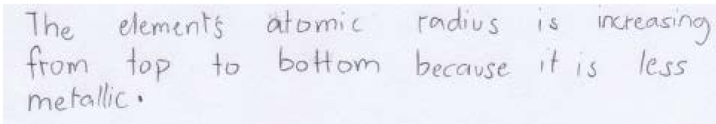
Concept	Misconception Statements (21%)
The atomic radius is increasing down in group IA because…	• the electronegativity is increasing • the atomic weight of the atom is increasing • the elements are becoming less metallic • the elements have lower energy level • the number of protons decreases • is decreasing so the number of protons (+) cannot attract the electron • The greater is the atomic energy; the lower is the energy level • Arranged in the quantity of atomic radius. • The bigger the atomic radius, the easier the atom to attract. • Atomic radius decreases down a group. • Effective nuclear charge increases because of the more metallic the element, the higher the nuclear charge. • The lesser the energy its atomic weight also increases. • Down a group, valence electron increases.
The atomic radius is decreasing from left to right, across the period because…	• the atomic weight is increasing. • Cl has the small atomic radius because of the low energy level. • Cl has a high atomic number • decreasing nuclear charge.

Table 6 shows lists of misconceptions by the students about the trends in Atomic Radius across the period and down a group. It revealed that many students hold misconception statements.


As the elements' moves down in Group IA, the electronegativity also increases.

Student no. 17 showing misconception statement.

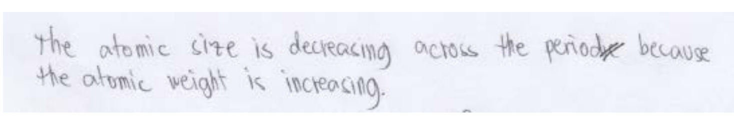
Student no. 17 stated that electronegativity of the elements is increasing from top to bottom (within a group or family) is adjudged as a misconception. Chang (2010) explain that electronegativity is the ability of an atom to attract to itself while atomic radius is the effective nuclear charge attraction of the atom to its nucleus. Thus, electronegativity has no relation to the sizes of atoms. Student No.33 also believed that as the elements go down, it is less metallic.


The elements atomic radius is increasing from top to bottom because it is less metallic.

Student no. 33 showing misconception statement.

The metallic property of the elements, from top to bottom is increasing as its atomic sizes are increasing due to the additional principal quantum number. Thus, the student no. 33 answer adjudged as misconception statement.

Periodic trends are evident across the period. Consider the second-period. It's effective nuclear charge increases from left to right, the added valence electron at each step is more strongly attracted by the nucleus than the one before. Therefore, we expect that the atomic radius decreases from Li to Ne because of additional valence electron/s (Chang, 2010). Thus, the statement of student no. 11 found to be a misconception because atomic weight does not correlate with its atomic size though atomic weights are increasing across the period.


The atomic size is decreasing across the period because the atomic weight is increasing.

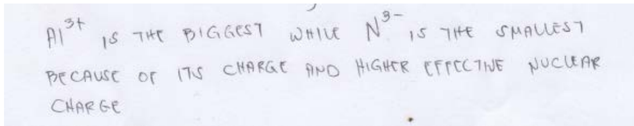
Student No. 11 showing misconception statement.

Table 7. Misconception statements in Ionic Radius

Concept	Misconception Statements (33%)
Biggest and smallest ions (Al^{3+}, Mg^{2+}, N^{3-}, O^{2-})…	• Exponential, the bigger its ionic radius • The smaller the electrons, the bigger it's ionic radius. The bigger the electron, the smaller it's ionic radius. • Al^{3+} has the biggest ionic radius than N^{3-}. • The bigger the atomic radius, the bigger it's ionic radius. The smaller the atomic radius, the smaller it's ionic radius. • Al^{3+} increases its ionic radius while N^{3-} decreases its ionic radius. • N^{3-} easily transfers its electron. • N^{3-} receives ionic radius while Al^{3+} gives ionic radius. • The greater the exponential, the smaller, the lower the • Al^{3+} is the biggest ion while N^{3-} is the smallest ion.
Formation of cation and anion from a neutral atom.	• Anion has no change in ionic radius while cation is becoming bigger. • Cation has the biggest ionic radius than anion. • Cation has no change • Cation has big energy than anion. • The atom that receives electron, the bigger it is because it needs more space. • Anion has a smaller ionic radius because of the charges that were used. • An Anion is bigger in the gas phase. • The positive charge needs more energy. • An anion has a smaller ionic radius than cation. • Anion is electronegativity. • Cation releases more electron affinity. • An anion is an ionic radius while cation is an electronegativity. • The size of ionic radius changes because it is a non-metallic.

Chang (2010) explains that Ionic Radius is the radius of a cation or an anion. When an atom forms an anion, its size (or radius) increases while forming cations, its size (or radius) decreases. Brown *et al.,* (2012) further explain that ionic radius decreases with increasing nuclear charge as the electrons are more strongly attracted to the nucleus. Thus, the cation is smaller than its atom.

Chang (2010) likewise explain the formation of the anion is due to the nuclear charge. He suggested that the nuclear charge remains the same, but the repulsion resulting from the additional electron(s) enlarges the domain of the electron cloud. Student no.4 however, believed in a different way. This misconception may be attributed to mathematics. If the charge is positive, the higher its value while the lower the charge, say negative charge, the lower it's value. As figured-out in the exponential form.



Student no. 04 showing misconception statement

As a general rule, a tri-positive ion (ions that bear three positive charges) has a smaller ionic radius, and tri-negative (ions that bear three negative charges) has a bigger ionic radius.

Table 8. Classification of Students' Progression before and after Interventions

Topics/Categories	Atomic Radius		Ionic Radius		Ionization Energy		Electron Affinity		Electrone-gativity	
	f	%	f	%	f	%	f	%	f	%
Unchanged Conception Remained in any of the Level of Understanding as: FU, PU, MU, NU	5	11	2	4	11	23	4	8	3	7
Changes for the better Change which occurred from: NU to FU; NU to PU; NU to MU; MU to FU; MU to PU; or PU to FU	44	89	47	96	38	77	45	92	46	93
Total	49	100	49	100	49	100	49	100	49	100

Results showed (Table 8) that there are still students who maintained the same conceptual understanding from pretest to posttest. About 23% of the students are resistant to the same concepts after interventions. This resistant is very evident on the trends in *I. E.* The same is through with the trends in *A.R.; I.R.; E.A.; and E.* On the other hand, there is still high increase in the change of conceptions after interventions.

In the study conducted by U. Turgut, Gürbüz, and G. Turgut (2011), some misconceptions that are resistant to change may be caused by the country's culture, language, and teaching strategies. Punzalan (2007) believed that these misconceptions may deeply penetrate the students' minds and can resist change. Both Kind (2004) and Horton (2004) further agreed that in spite of intensive teaching in chemistry, many misconceptions are still occurring during assessments. They further suggested that language and teaching activities should be given into consideration. Finally, they pointed out that the students generalize the ideas fairly quickly and teaching has to be supported with different activities.

Hake Factor Test results in Table 9 shows that, *I.E*. and *E*. both in high gain, followed by *A.R*. and, *I.E.* both in the medium gain and *E.A.* in low gain. Take note that in *E.A*., though it has low gain, it means that some students already have understood this topic before administering the CCUT. To determine if it is statistically significant, a t-test was performed based on the pretest/posttest mean scores. It shows that the t-value is -5.61521 at alpha=.05. It revealed that there is a significant difference between the mean scores of pretest and posttest. It signifies that the interventions are successful in enhancing the conceptual understanding of the students in learning the trends of the periodic table of elements (Take note that the students already finished the discussion of the periodicity before administering the pretest). Moreover, scores of inter-rater and the researcher were also statistically analyzed using t-test. It shows that there is no significant difference at *alpha*=.05 with *t*-value=1.61559.

Table 9. Descriptive Equivalents for the Hake Factor Test Results in the pretest/posttest

Topics	Mean	Verbal Description
Atomic Radius, *A.R.*	0.54	Medium Gain
Ionic Radius, *I.E.*	0.84	High Gain
Ionization Energy, *I.E.*	0.46	Medium Gain
Electro Affinity, *E.A.*	0.25	Low Gain
Electronegativity, *E.*	0.61	High Gain

Myers, Oldham, and Tocci, (2000) cited that the use of technology would deepen students' understanding to promote optimal insights into the cognitive level of the students. Using appropriate and relevant materials along with the latest and varied teaching strategies gives the students the solid grounding in the basic chemical principles and skills. They also cited that instructional goals should develop greater conceptual understanding when students actively participate in the learning process; meaningful learning in the context of their lives and an environment, and encourages reflection and comparisons with the teachers and peers. These strategies would help the students to focus on mastery of chemistry content, and experience scientific inquiry.

As shown in Tables 10, 11 and 12 are misconception statements held by the students about the trends in Ionization Energy, Electron Affinity, and Electronegativity.

Table 10. Misconception Statements in Ionization Energy

Which element (aluminum and sodium) is more reactive when added to water?	• Na is a very soft silvery-white metal; Al is more metallic than Na. • Na is very soft and 80% present in water. • Al is more reactive in the air while Na is a liquid metal and it is used as a heat exchanger in a nuclear reactor. • Metals are not water conductors. • Na is used to preserve vegetables. Na is a constituent in plant tissues. • Na is less reactive than Al because Al has a greater melting point of 66°C than Na 97.81°C. • Na has the highest melting point than Al. Al has less melting point than Na. • Al easily accepts heat than Na. Al is more reactive than Na. • Na attracts water. Na is a pure metal while Al is a non-metal. • Na has a lower atomic radius. • Na's oxidation state is smaller than Al. • Na has greater ionization energy than Al. • Na and Al do not react to the water because they are both metals and metals are hard and non-reactive. • Na and Al have the same reactivity when added to water. • Na easily melts than Al.
Which element (Beryllium, Carbon, Lithium) has the highest 2nd ionization energy (I_2)?	• C has the highest I_2 because the larger the electronegativity, the higher its ionization energy. • Li belongs to the noble gas, and it has a big atomic radius • Be has the highest I_2 • Li is nearer to the noble gas • The same I_2 because all elements have 2 valence an electron • C has the highest I_2 because it has high atomic weight and valence. • C has the highest I_2 because it is metalloids and have a high valence electron • Li has the highest I_2 because of the small an electron. • C has the highest I_2 because C is more negative.

Table 11. Misconception Statements in Electron Affinity.

Why Oxygen readily exist an anion as to compare to Selenium?	• Oxygen has high bigger atomic radius than selenium • Oxygen is used in the chemical industry while selenium is used in electric cells, photocopiers, and semiconductors. • Oxygen has a negative charge and has high valence electron than Selenium • Oxygen exists as anion because it tends to release an electron
Why is metallic property always associated with low electron affinity?	• Metals have more electrons that attract electron. • Metals have a weak attraction and unstable. • Metals easily accept electron. • The more metallic, the more electron affinity is lost. • Metals have low electron affinity because metals are solid. • Electron affinity is a negative charge and metals are positive charge because metals are solids. • Metals have low electron affinity because metals are good conductors. • Metals have low electron affinity because metals have high ionization energies. • Metals have low electron affinity because metals have a small number of electrons. • Metals have low electron affinity because metals lost some atoms. • Metals have high electron affinity because metals have low energy level.

Table 12. Misconception statements in Electronegativity.

Which is more electronegative, Fluorine or Nitrogen?	• Fluorine has more tendencies to release an electron. • Fluorine absorbs more energy. • Fluorine has high atomic weight than nitrogen. • Fluorine has high atomic size. • Fluorine has high atomic number than nitrogen. • Halogen is a non-reactive element. • Fluorine and nitrogen have the same ionization energy.
Which pair of elements (Ca, F, N, Na) has the highest and lowest electronegativity?	• Fluorine has the highest electronegativity value because it has the highest atomic weight. • Fluorine has the highest electronegativity value because it has the highest nuclear charge. • Fluorine is a nonmetal while sodium is a metal. Nonmetals are not reactive while metals are reactive.

CONCLUSIONS

The students' level of conceptual understanding in the trends of the periodic table of elements was mostly in misconception and partial understanding. Students' preconceptions about the trends in the periodic table of elements were abstract. They believed that the trend is simply an increase and decrease across the period and down a group. Nevertheless, they fail to explain the underlying scientific concepts. The remedial activities were found to aid in the promotion of their conceptual change. The progress of most students' level of conceptual understanding moved from misconception to partial understanding or even to full understanding. However, there are still resistant to their concepts as adjudged as misconception statements.

Conceptual change is produced by mental processes that create and alter mental representations. This affects thinking influences how students learn, play an essential role in subsequent learning, and may a hindrance to acquiring an appropriate body of knowledge in the scientific world. It is, therefore, imperative for the teacher to know what conceptions that student brings to class. Through this, a teacher should look into different remedial activities to enhance the conceptual understanding. In this study, a graphical representation, concept mapping, cooperative learning, games and online videos are remedial activities imparted which in turn an effective in conceptual understanding.

TRANSLATIONAL RESEARCH

This study may help curriculum developers and course program writers in planning courses and sequencing topics. From the given misconception statements, it is concluded that most students do not understand the underlying concepts in the trends in the periodic table. Most of them only rely on the trends as decrease or increase across the period and down a group. However, they fail to explain the underlying concepts. Hence, these identified preconceptions may help in the diagnosis and remediation activities. The remedial learning activities developed in this study could be useful to high school and college chemistry instructors and their students. It will also lead students to understand other concepts such as chemical bonding; intermolecular forces; physical properties of solutions; chemical reactions; activity series; and redox reaction. This will also help chemistry teachers in improving various activities. Finally, the developed test was very useful to the researchers who plan for further investigation on the students' misconceptions of the trends of the periodic table of elements.

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