HOW CAN I IMPROVE N12 STUDENTS' ABILITY TO WRITE SIMPLE CHEMICAL ENTITIES USING CHEMICAL SYMBOLS AND FORMULAS ON INTRODUCTORY GENERAL CHEMISTRY COURSE-I (CHEM. 101)?

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ABSTRACT

This study an action research intended to improve my own students' abilities to write chemical symbols and formulas correctly while studying Chemistry in the college (KCTE) that I am serving as an instructor. The specific objectives of the study were a) to identify the major difficulties of students in writing the most commonly used chemical symbols and chemical formulae for common inorganic entities, and b) to enable students write the correct chemical symbols and formulas for these common inorganic chemical entities. *[AJCE, 4(1), January 2014]*

THE PROBLEM OF THE STUDY AND ITS OBJECTIVES

From my experience of teaching in the Kamise College of Teachers Education (KCTE) since 2002, I have found that most of my students lack confidence in writing chemical symbols and formulas. This problem was aggravating especially with the first and second year students. It was what I have been confronted from students' different activities like class work, individual and group activities, and tests on different courses of General Chemistry-I,II and Analytical Chemistry –I.

This difficulty has caused paramount consequent problems in turn. For instance, when students were unable to write the correct chemical statements in any consecutive courses that they take, it was difficult for me to measure whether the objective of the course were attained or not. In addition, during assessment and examination, some students lose their confidence and trying to copy from friends, their own short notes or from their exercise books. And this was the major task where I and most instructors get busy especially on final examination that comprises 40% of the complete semester course. Therefore, working with improving students` ability in writing the chemical symbols and formulas for most frequently used species is the point I preferred to start in reducing this problem.

Studies (1-2)) argued that success in studying Chemistry depends upon the familiarity of students with a few basic ideas, conventions, and methods upon which later studies are built. When a student has achieved mastery of them, further studies can be pursued with greater confidence. One of the studies (1) further adds that without mastery of these concepts, students are likely to find higher levels of study in Chemistry difficult. Specially, the use of chemical symbols, formulas, writing chemical equations, calculations involving moles (solids, gases, and solutions) etc are areas where students of chemistry beginners face most challenges.

Majority of the students that join our College face difficulties in chemistry courses. Many of them fear even to join natural science department. As frequent rumours in our college show, most students perceive science subjects such as Chemistry to be the most difficult one. In addition, they may have experienced poor achievement in science subjects and also had misconception of science concepts like that of writing chemical symbols, formulas and the like.

As explained by previous study (2),

> *"A chemical formula is a combination of elemental symbols and subscript numbers that is used to show the composition of a compound. It is a shorthand method for representing a chemical compound. A formula consists of a collection of chemical symbols, telling the kinds and numbers of atoms present in the compound. Today the rules for writing chemical formulae are set by the Nomenclature Committee of the International Union of Pure and Applied Chemistry (IUPAC) and chemical formulae that follow the rules of this committee are said to follow IUPAC nomenclature."(p. 32)*

However, only few students in my class (not more than ten approximately) were able to mention examples for elements and compounds they were allowed to list under the title of classification of substance following their accepted IUPAC rules.

Having these issues in mind, this study takes the following basic questions to be focused on:

- What difficulties do students have in writing most commonly used chemical symbols and simple chemical formulae?
- Can I improve students' ability in writing chemical symbols and formulas of these common inorganic entities?

It has been argued (3) that at the beginning of any course, students start their study with a set of beliefs about the nature of learning and what they intend to achieve. These beliefs are derived from earlier school and learning experiences as well as their current goals and motives.

Therefore, an understanding of how students learn can help teachers to devise effective strategies for teaching.

This requires that research into the learning process is made accessible (4) to facilitate the development of students' views of knowledge, and students need to be supported at the appropriate level. Furthermore, it is stated (3) that a student, who strongly believes that there is only one correct answer for a given question, will find an exercise which shows a multiplicity of possible interpretations confusing and unhelpful.

Here in KCTE, many of my students (especially those of N12 were) facing challenges to classify substances as elements, compounds, and mixtures in class activity while I was teaching them about substances and their classification in General Chemistry-I. For instance, they have categorized methane and ammonia under elements; unable to decide for diamond and graphite; and when asked for water if it is pure substance, some of them answered that it is a mix of foreign matter like dust, fallen leaf of plants and unseen microbial. Due to these and related challenges I faced while teaching this course, this study is considered with the following main objectives to be attained at last:

- To identify the major difficulties of students in writing the most commonly used chemical symbols and chemical formulae for common inorganic entities.
- To enable students write the correct chemical symbols and formulas for these common inorganic chemical entities.

I believe that the study enables students know the basic rules and principles of representing elements with their symbols and compounds with their formulas. Hence, it plays great role in decreasing students` problem (challenges) with respect to writing symbols and formulas of common chemical substances. In this study student's ability implies the knowledge/skill of the student in writing the chemical entities which is revealed through specific achievement test. The chemical entities refer to the chemical substances namely simple chemical elements, compounds; and most common mono atomic and poly atomic ions.

REVIEW OF RELATED LITERATURE

Names and symbols of the chemical elements are parts of the language of chemistry (6). They constitute about 91 naturally occurring elements found on earth. It is further argued that once someone is familiar with the name and symbols of elements, it will be easy to write chemical formulas and to do some chemical calculations too. The symbols of chemical elements are abbreviations that are used to denote chemical elements (6).

The symbols of elements used today were first suggested by the Swedish Chemist Berzelius. The name of the element is usually derived from English, German, Latin or Greek words. Therefore, these chemical symbols are the short hand representation of the full name of an element. This way the symbol of an element represents a definite quantity of that element too, for instance one atom. The symbol of an element is the short way representation for the name of an element (7).

Pictographic symbols were employed to symbolize elements known in ancient time, for instance to the alchemists (6). Some of the earliest symbols were those used by the ancient Greece to represent the four elements: earth, fire, air and water. These were adopted by Plato using the Pythagorean Geometric Solids. As other chemical substances were defined, symbols of the planets were used. Over the centuries, a great many symbols came into use. Although there were many similarities, the secrecy of the alchemists resulted in many variations. For instance, it was stated (8) that Geoffrey Chaucer, in his Canon Yeoman's Tale from the *Canterbury Tales*, related the symbols as:

Gold for the sun and silver for the moon,
Iron for Mars and quicksilver in tune
With mercury, lead which prefigures Saturn
And tin for Jupiter. Copper takes the pattern
Of Venus if you please! ...

A chemical formula is a group of symbols which denote one molecule of an element or of a compound and represent the elements which form that compound and the ratio of their atoms. In writing chemical formulas of compounds, we need first know the valences of elements and different radicals in which valence is known as the combining power of atoms in a chemical formula (7). In fact, valences have more meaning underlying than merely numeric combination of atoms.

Research (9-10) has also shown that university students in Ethiopia misunderstand the meanings of symbols and formulas of solid substances. These researchers then suggested that deriving formulas from demonstrated or self-built structural models would give students the idea that formulas are shorthand forms of structural models or of building units of the structure of molecules or unit cells. After their empirical research on spatial ability in different cultures they recommend that the structural images should be a mediator between the macro-phenomena and chemical symbols (9-10).

Johnstone (cited in 11) argues that chemistry at macro level is what we experience in kitchen and daily situation of our life. But, chemistry, to be fully understood, has to move to the sub-micro situation where the behaviour of substances is interpreted in terms of the unseen and molecular and recorded in some representational language and notation. And I believe that this is where most of concepts are chunked. The majority idea chemists detailed in laboratory, text books, webs, etc in vast pages of paper is now reduced in symbols and formula of compounds to not more than 2-to 3- letter representations. These will be easy to understand and later apply them in chemical computations only for individuals of good chemistry backgrounds and experience. For beginners, even instructors, it seems more challenging and needs devotion.

Other scholars (12) also stated in their study that difficulties in the learning of chemistry can be precipitated by a lack of chemistry language skill. This can have huge implication when students move on to further learning as the lack of an appropriate understanding of fundamental concepts from the beginning of their studies can interfere with the subsequent learning. Still others (2) cited students' problem as follows:

> *Studies conducted by Savoy (1988) and Hines (1990) have revealed that students have difficulties in writing chemical formulae. In his early study, Johnstone (1974) reported that the problem areas in chemistry, from pupils' point of view, persisted well into university education with the most difficult topics being chemical formulae among other topics. The findings from the research of Lazonby, Morris, and Waddington (1982), Schmidt (1984) and Bello, (1988) have shown that students' persistent difficulties in solving stoichiometric problems are partly associated with their inability to write chemical formulae correctly. While, a study conducted by Anamuah – Mensah and Apafo (1986) revealed that students in Ghanaian Senior High Schools have difficulties in learning certain chemical concepts such as chemical combination. According to the study, about 66% of the respondents indicated that the topic chemical combination was either difficult to grasp or never grasped (p. 32).*

In generally, the major problems students face in learning chemical symbols and formulas are summarised as follow:

- In symbolizing elements, we can use first letter only or first and second letter only or first and the second prominent letter in the name of an elements but this over loads students with huge information and need care not to lead students to confusion (12).
- The primary barrier to understanding chemistry is not the existence of the three levels of representing matter (Macro-level, sub micro-level and symbolic level). It is that

chemistry instruction occurs predominantly on the most abstract level (the symbolic level) (13).

- Students do not understand the meaning of Roman numerals that are put in brackets of IUPAC names. Examples Iron (II) sulphide was written as FeS2. Also in the same compound, Iron was written as Fe2, in Copper (II) tetraoxophosphate (V), Copper was written as Cu_2 etc. (2)
- Students have problem with what valences are and do not understand the role they play in writing of chemical formulae (2).
- Writing the correct formula of some radicals and some ions is also a problem to the students. Examples sulphide was written as SO3 and SO_4^{2-}, tetraoxophosphate (V) ion as PO_4^{2-}, PO_4^-, P4, Nitride ion as NO_3^-, NO^- ; trioxocarbonate (IV) ion as CO_3^- etc (2).
- Combination of some cations and anions to form neutral compounds is a big problem to the students due to the problem they have with valence (2).
- The correct names of some radicals are a problem to students (2).

RESEARCH METHODS

In conducting a given study it is necessary to specify the subject of study from which appropriate data could be collected (5). Clearly specifying the sample of study and study methods will help for proper collection and analysis of data obtained.

Due to these facts, this study follows *convenience* method of sampling for many reasons. For one, the subject teacher-student contact probability helps to explore students background of the problem in detail. On the other hand, the suitability of class in collecting, analyzing and implementing the proposed action are seen to choose this approach. Lastly, challenging the time constraint expected while implementing the action is considered in selecting this method.

The subjects involved in this study are all N12 biology class students who took the introductory General Chemistry–I (Chem. 101). The sample contains 13 female and 12 male students in sum which constitutes 25 participants of this class. It was these 25 students from which data were collected through data collection tools.

Studies are based on information that is collected through different instruments or data tools. Here in this study, observation and specific achievement tests are the major methods used to collect data. This gathered information was analyzed and interpreted further to arrive at the possible solution regarding the problem under study. The specific achievement test was delivered to students on the contents of writing symbols and formulas of substances. Students' participation confidence and performing the activity in class was observed while practicing the writing of symbols and formulas.

DATA ANALYSIS

Achievement Test Data

The achievement test was administered to students with the following main objectives:

- To explore students' pre–conception of the problems based on their past experience.
- To identify the main challenges that they face in writing symbols and formulas.
- And lastly to devise the most suitable mechanisms for intervention and taking the action.

With these objectives in mind, a concept test containing seven questions (see appendix I) the last two of which are blank space have been delivered to 25 students and the results of these first five questions are summarized as in the following table.

Table 1: Achievement test summery along with respective percentage

Q .No	**Alternatives**			
	A	**B**	**C**	**D**
1	1(4%)	0	22(88%)*	2(8%)
2	5(20%)	6(24%)	4(16%)*	10(40%)
3	7(20%)*	7(28%)	7(28%)	4(16%)
4	2(8%)	20(80%)*	1(4%)	2(8%)
5	5(20%)	6(24%)	12(48%)*	2(8%)

* represents the correct alternatives to each questions.

The numbers and percentage under each alternative letters represents the number of students who chose the respective letter as answer they assume and the relative percent in the total participants. For instance, for Q.No1, one (1) student has chosen alternative letter A as answer which accounts 4%, twenty two (22) students have chosen alternative letter C as answer which is 88% of the participants and only two (2) students chosen alternative D as answer based on their understanding which is 8% of the participants.

The 7th achievement test question was provided in table as one column containing names of three elements intentionally selected and the second column containing the blank space for students to write the symbols of each respective element. The results of this response are provided as in Table 2.

Table 2: Symbolizing Names of elements

S.No	Elements name	Correct answer	Incorrect answer
1	Boron	17(68%)	8(32%)
2	Barium	8(32%)	17(68%)
3	Sodium	22(88%)	3(12%)
Average		15.67(62.67%)	9.33(37.33%)

These elements were chosen as they are most frequently used by participants in different courses and all are from representative or main block elements. Boron is chosen from elements that can be represented with the first single letter from the name of the element. Barium is chosen from the elements that can be symbolised with the first and other letters from the name of the elements, and Sodium is chosen from the elements that can be symbolised from the name of elements with other than English name and common to students.

On average, as can be inferred from the Table 2, 62.67% of the students were able to symbolize the three chosen elements correctly and the rest need support still even to symbolize the most common elements. In fact there is no short mathematical formula to derive the symbol of elements from their chemical names. However, it is possible to train how to select letters to represent each element with their chemical symbols.

But the 37.33% of the participants, for instance, represented Boron (B) as Bo – by three students, Br – by four students and Be- by one student. In a similar way the element Barium (Ba) was symbolised as Be-by five students, Br-by ten students and Bi-by one student. For sodium (Na) elements, one student symbolised it as Ca, one student as NO_2 and one student as N_2.

In addition to this, students were provided with question (Q.No1, appendix 3.1) to differentiate the formula of oxygen molecule (O_2) from the symbol of the oxygen atom (O). The result of response is summarised by Table 1 on Q.No1, with alternative C is being the correct answer. This implies that majority of the students (88%) were able to separate the formula of molecule, in this case oxygen, from the symbol of an atom. But this is not to say that all students were able to do so. There are students (12%) with misunderstanding or alternative conception of the symbol and formula of elements.

Two questions (Q.No2 and 6) were provided for students to check whether they can write the binary ionic and covalent compounds keeping the appropriate ratio of the involved atoms. Question number 2 was intended to alleviate students' conception of writing binary ionic compounds between magnesium and nitrogen keeping their valence correctly. Based on Table 1 indicated above, only few students (4%) were able to write the correct chemical formula of magnesium nitride as Mg_3N_2. This indicates that either these students were unable to identify the valence of each element or unable to use these valences (criss-cross application) to represent the chemical formula required.

In a similar fashion, Q.No6 was used to explore students' ability to work on the reverse action of binary covalent compounds. That is to test for "if students can represent the chemical compound name with its formula, they can also work on the reverse-they can name the given formula of the compound with its correct chemical name". However, only few students in each (20% for both SO_3 and N_2O_3) were able to name the given covalent compound correctly, see Table 3 bellow. On this base, these students were unable to remember the Greek numerals like mono, di, tri, tetra, etc in naming the covalent compounds which they have learned at the lower grade levels (G7 to 10). And this has its own impact on determination of atomicity of the given compound in writing and naming the chemicals.

Table 3: Writing formula of binary covalent compounds

Compound	SO_3	N_2O_3	Average
Correct Answer	5(20%)	5(20%)	5(20%)
Incorrect Answer	20(80%)	20(80%)	20(80%)

The third question was used to explore students' ability in symbolizing the poly atomic ions and writing their formulas appropriately, specially the appropriateness of valence of ions and proper usage of parentheses. But only few students (28%) were able to properly outline it. Most of the students (72%) faced difficulty as indicated in Table 1 in writing the correct chemical formula of Strontium sulphate ($SrSO_4$). Therefore, this part of the concept is area where students need support on the basics of rules and applications of writing the formula.

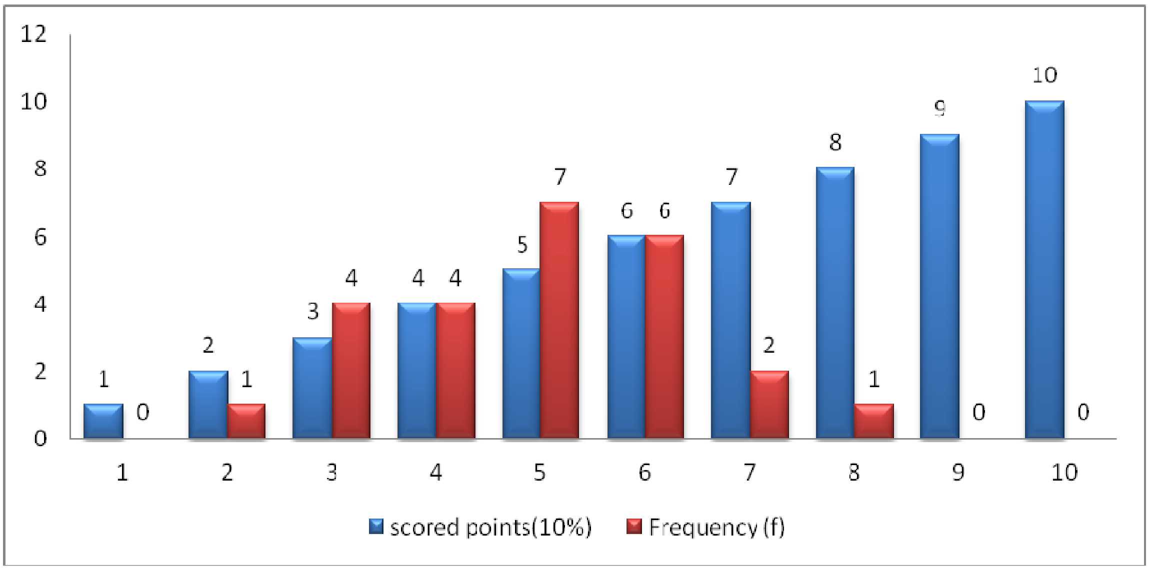
With the fifth inventory question, aimed to alleviate students' ability of the binary acid formula from its given name, only 28% of them were able to name the hydrochloric acid, HCl, correctly. In a similar way, for the sixth question designed to determine students ability in writing the correct formula that can be formed between Hydrogen and Nitrate ion, only one student (4%) answered the question correctly which implies that students were unable to write the symbol of nitrate ion (NO_3^-). For instance, 80% of them gave a response as NO_2^-, 8% as H_3N, and 8% as HN. This also confirms that students need support in identifying the formulas of poly ionic atoms.

In general, from the seven questions administered to students in investigating their achievement on chemical symbols and formulas of different inorganic compounds and marked out of 10%, only 64% of the total students scored 5 marks and above with none scored 9 marks and above . All the rest 36% scored 2 to 4 marks only, see the following frequency table and its respective bar-graph bellow. In sum, the average grade point of 25 participants evaluated out of ten (10%) was found to be 4.92 with standard deviation of ±1.47.

Table 4 Frequency distribution of students` achievement for pre-intervention

Scored points out of 10%	Frequency (f)	Percentage (%)
1	0	0
2	1	4
3	4	16
4	4	16
5	7	28
6	6	24
7	2	8
8	1	4
9	0	0
10	0	0
Total (n)	25	100%

Graphically, students` achievement is illustrated as follow using the frequency distribution of achievement scored in Table 4 above:



Graph 1: Graphical illustration of students' achievements for pre-intervention.

Observation Data

As seen during evaluation for learners' prior concept, majority of them were not voluntary for direct examination saying they had better learn it first. Even though this way response is natural response of all, in this case it can imply to me that they hesitate themselves on this concept. Many of them lost confidence even to sit on the achievement test exam. This was what they have reflected orally to me during assessing for students pre-concept. On the other hand, three students (1F and 2M) took more time to answer the questions provided. For instance when 29minutes was elapsed, almost all but three of these summit the exam. These students wined their work 10min late to their friends of same status.

The majority of students have faced challenges in one or both of the following areas implying that there should be intervention to make them capable of doing the intended activities.

- Some of the students were unable to correctly name or symbolize the chemical elements provided. This was the case for even the most commonly and frequently used elements like Boron (B), Sodium (Na) and Barium (Ba). In addition to this, some of the students were unable to distinguish the difference between the symbol and formula of the diatomic elements (molecules) like that of oxygen.

- Another challenging problem for the students was writing the chemical formula for most common inorganic compounds like that of binary ionic compounds, binary covalent compound and ionic compounds containing poly atomic ions. With this respect students were unable to determine valence of common elements and hence, face difficulty in keeping the appropriate ratio of atoms in the compound(s), which is most often known as atomicity. The use of parentheses was also not an easy task specially when writing the formula of poly atomic compounds.

To overcome the above observed challenges the study focused on two main activities to be accomplished:

i. Practice on Symbols and Formulas of elements

Making students practice more on symbolizing the names of chemical elements and let them recall the origins of names of elements and rules for symbolizing which they were familiar with in the lower grade levels. In this way after the students explore the underlying meanings of symbols, they will be allowed to practice how to memorize them easily as suitable for individual students. Then they would be made to compare the symbol and formula of elements.

ii. Practice on writing the Symbols and formulas of Compounds

Explanation would be made for students on determining the valence and formulas of compounds containing the binary and polyatomic ions. Finally students would practise how to follow the Criss-Cross Method of writing chemical formula which helps in retaining the proper atomicity and parentheses.

Those possible actions to be taken were planed as indicated in table below (all dates are in the Ethiopian calendar):

Table 5: Action plan

No		Activities to be done	Time	Resources
1	Practice on Symbols and Formulas of elements	Naming and symbolizing of elements	Tues day 30-04-2005 4:45-5:35, 8:30-10:00	Sheet of paper with the list of elements name and rules of symbolizing
		Comparative description of symbols and formulas of diatomic elements, chunking the symbol with local memorization.	Thurs day 02-05-2005 3:40-4:30 5:35-6:25	Table containing all the 7 diatomic elements (common) with their symbols and formulas
2	Practice on writing the symbols and formulas of compounds	Determining the valence of elements, mono atomic ions and poly atomic ions.	Friday 03-04-2005 4:45-5:35 5:35-6:25	• Periodic table • Name and formula of polyatomic elements • Table of valence
		Applying the criss-cross Method to write formulas of different compounds.	Tuesday 07-05-2005 4:45-5:35, 8:30-10:00	• Charts of +ve and –Ve charge (as valence) • Table showing criss-cross method

Symbols of three elements that are derived by using the 1st letter, 1st and 2nd letter, and from the corresponding Latin names of the elements were provided to students to name them correctly assuming that if the students can name the symbols, they can easily handle the reverse too. And the final result was summarised using the following table.

Table 6: Naming the symbol of an element

Q14	Symbols of elements			Average
	B	Ba	Na	
Correctly named	13	22	22	19(76%)
Incorrectly named	12	3	3	6(24%)

As can be inferred from this table, majority of the students were able to name the symbol of each element (52%B, 88%Ba and 88%Na) correctly. On average, 76% of the total students were able to give the exact chemical meanings to the symbols of elements provided. This shows that most students can name the elements if they are supplied with their correct symbols. However, the challenge of differentiating symbols and formulas of an element from one another is still with doomed progress. For instance, out of 25 participants allowed to differentiate symbol of Oxygen atom (O) from its formula, only 32% were capable to select O as the correct choice. The rest 68% selected O_2 as the symbol of oxygen atom.

Before writing the formula of the compound(s), each student was supplied with resources like chart of ion name, ion formula, and their corresponding valences for both simple and poly atomic ions in separate sheets. In addition, they were given several examples of binary covalent compounds and practiced much on symbolizing and naming using the Greek numeracy like mono-,di-,tri-,tetra-,etc.

In writing the symbol of binary (ionic) compounds, almost more than half (52%) of them were able to respond correctly. For instance, out of 25 participants allowed symbolizing Strontiumiodide (SrI_2), 13 of them responded correctly while the rest 12 of them responded incorrectly like as SrI_3, Sr_2I_3 and Sr_0I_2. Surprisingly, zero valence has been used by these students to write this formula.

In a similar fashion, tables of polyatomic ions along with their name and valence numbers were given for each student. However, only nine of them were able to symbolize Barium hydroxide correctly as $Ba(OH)_2$. From the rest 16 students, 14 of them still failed to apply valence and 2 of them failed to apply parentheses. For instance Barium hydroxide was written as BaOH and $BaOH_2$ by the students.

Lastly, two binary covalent compounds namely Sulfurdioxide (SO_2) and dinitrogenmonoxide (N_2O) were to be named by students, assuming that if students are provided with symbols of compounds they can name it easily. The resulting summery is provided as the following table.

Table 7: Naming binary covalent compound

	SO_2	N_2O	Average
Correctly Answered	18	17	17.5(70%)
Incorrectly Answered	7	8	7.5(30%)

As one can deduce from the table above, on average, 70% of the students (72% SO_2 and 68% N_2O) were able to name the binary covalent compounds with their correct chemical names and the corresponding Greek numeracy. In a similar fashion to the pre- implementation, a summary table is used to evaluate the achievement test after implementing the action, see Table 8 bellow.

Table 8: Summery of achievement test for post-intervention.

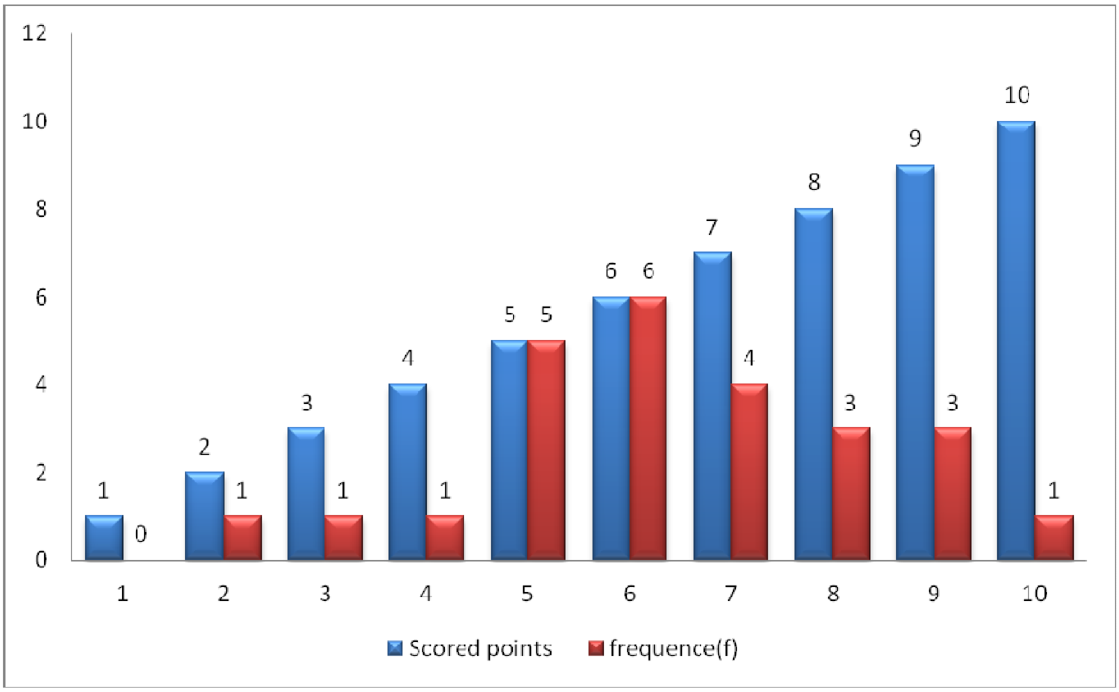
Q.No	A	B	C	D
1	8(32%)*	0	17(68%)	0
2	3(12%)	1(4%)	8(32%)	13(52%)*
3	0	14(56%)	9(36%)*	2(8%)
4	15(60%)*	3(12%)	3(12%)	4(16%)
5	1(4%)	16(64%)*	1(4%)	7(28%)

From the seven items used in investigating students` achievement on chemical symbols and formulas of different inorganic compounds and marked out of ten, 88% of the total students scored 5 marks and above with which16% scored 9 marks and above. The rest 12% scored 2 to 4 marks; see the following frequency table and its respective bar-graph bellow. The average grade point of 25 participants evaluated out of ten (10%) after intervention was found to be 6.36 with standard deviation of ±1.93.

Table 9: Frequency distribution of data for post-implementation

Scored Points out of 10%	Frequency(f)	Percent %)
1	0	0
2	1	4
3	1	4
4	1	4
5	5	20
6	6	24
7	4	16
8	3	12
9	3	12
10	1	4

The graphical demonstration of students' achievement for post intervention is drawn as the following bar graph. As can be seen from the graph, the blue lines show scored points out of 10% and the red lines represent the number of students scored the respective points. From the graph and frequency table, no one scored 1 mark but 2 to4 marks are scored by one student each.



Graph 2: Graphical illustration of students' achievements for post-intervention.

On the opposite extreme, there is one student who scored 10/10 mark and three students who scored nine. And the average students ($\bar{X}$=6.36, S=1.93) scored greater than pass mark.

The observation I made was that majority of the students know that the first letter in the symbol of an element should be capitalized. But their difficulty was which symbol from the name of the elements should be the chemical symbol of the element. For instance, Boron (B) was symbolised as Bo, Br, and B while Barium (Ba) was symbolised as Ba, Be, Br and Bi. Even though there is no single mathematical rule to determine the symbols of chemical elements, after discussing on the underlying rules and principles there were great progress to represent elements with their chemical symbols. Some of them even devised mechanisms of rote learning (memorization) of the symbols locally and individually.

There were some students, tallied to three, with misunderstanding of that there is no difference between O and O_2 saying that both represent oxygen. I have found two students while discussing in class that they are familiar with these O and O_2 but they said it is very challenging to outline their differences. All of them were able to apply the rule to Br and Br_2, Cl and Cl_2, etc after discussing with them on O and O_2.

The problem for the majority of the class was how to determine valence of element and ions. Particularly students were unable to write what the valence of ions, and many of them were confused with the concept of valence and oxidation numbers. No one refused to sit for the exam but one of the students asked me whether they could take the exam tomorrow because they were not ready to take the exam that day?" This implies that they were (at least) voluntary to sit on the exam with great expectation to achieve high.

Immediately after they were out from the exam, some of them took out their personal Periodic Table to check for the symbol of elements (one female). Three other students took out their exercise books and were debating for the way “dinitrogen monoxide” is symbolized (1 female and 2 males). Within 35-48 min, all except three students submitted the exam. The last student stayed for 54 minutes. I have used an astrix (*) to threat this paper individually and she scored 7 out of ten. With major probability, this implies that this student gave attention to score more and not to lose the mark.

Using the observation and specific achievement test, data were collected and analysed about students’ ability of writing the chemical symbols and formulas of most frequently used inorganic substances. In symbolizing elements (like that of B, Ba & Na), the students showed a progressive change from 62.67% to 76%. However, in differentiating the symbols and formulas of elements, they need still an additional support. For instance, from the total participants 68% of them were unable to differentiate the symbol of oxygen (O) from the formula of oxygen (O_2).

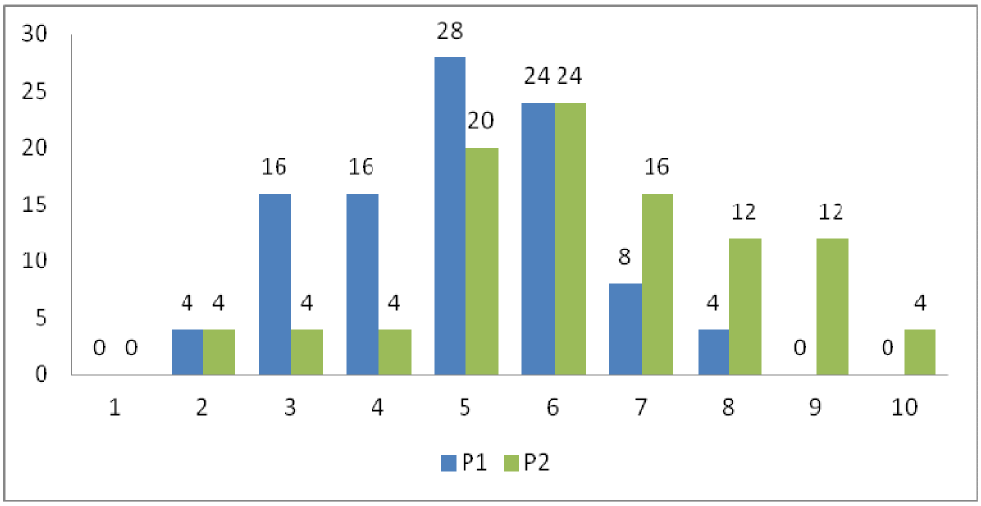
On the other hand, it could be said a better progress was observed in symbolizing the chemical formula of the binary compound like that of $SrI_{2,}$ which showed change from 4% of pre-intervention to 52% for post-intervention. But this is not the sole perfect change as there are almost half-participant still unable to do so. For instance, the same compound was written by others as SrI_3, Sr_2I_3 and Sr_0I_2.

In general, the results of achievement test computed in frequency and percentage which scored out of 10% is presented as in the following table, where F1 and P1 represent the frequency and percentage of pre-intervention and F2 and P2 represent the frequency and percentage of post-intervention.

Table 10: Percentage comparison of students’ achievement

Scores (10%)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
F1	0	1	4	4	7	6	2	1	0	0
P1	0	4	16	16	28	24	8	4	0	0
F2	0	1	1	1	5	6	4	3	3	1
P2	0	4	4	4	20	24	16	12	12	4

As can be seen from the table above, 88% of the students scored 5 marks and above from which 16% scored 9 marks and above, which was not seen in the pre-intervention. In the pre-intervention score, it was 64% of the total population who scored 5 and above marks with no 9 and above scores.



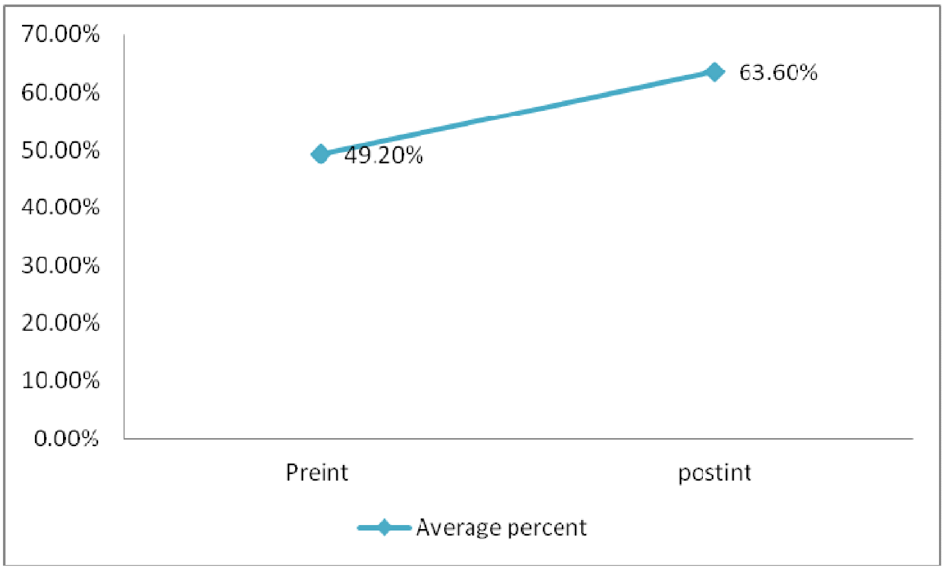
Graph 3 percentage comparison of students' achievement on each score point 1 to 10

In sum, the students' achievement scores showed a mean change from 4.92 to 6.36. The average percent can be illustrated as in the following table.

Table 11: Average comparison of test-scores taken out of 10

Intervention	Average percent
Pre-	49.2%
Post-	63.6%

After intervention and student long practice, student could symbolize elements and write formulas of compounds and creditable improvement was shown in post-test. This can be illustrated comparatively through the following graph.



Graph 4. Percent comparison of test-scores taken out of 10

In addition, students were interested in doing the writing activity given during the discussion in class individually and within groups. For instance, some of them developed mechanism of chunking and memorizing element names with local language (Oromifa) words as follows:

Student A: Lixa Nama Keessani Rabbi Csaasee Froomsefor GIA

Student B: Beelli Magaalaa Cabsee Sareen Baadiyaa Rabse for GIIA

Student C: Health fi Nersii Argannee Karaa Xeenan Ramadamne GVIIIA

RECOMMENDATIONS

This study suggests that students should be made aware of chemistry learning tips of the following nature (with ideas taken from the Wikipedia):

1. **Read the Text before Class**

At least, the students should skim it. If they know what is going to be covered in class, they will be in a better position to identify their troubles and ask questions that will help them to understand the material. It is possible to learn chemistry on their own, but if they attempt this, they are going to need some sort of written material as a reference.

2. **Work Problems**

Studying problems until you understand them is not the same as being able to work them. If you can't work problems, you don't understand chemistry. It's that simple! Start with example problems. When you think you understand an example, cover it up and work it on paper yourself. Once you have mastered the examples, try other problems. This is potentially the hardest part of chemistry, because it requires time and effort. However, this is the best way to truly learn chemistry.

3. **Do Chemistry Daily**

If you want to be good at something, you have to practice it. This is true of music, sports, video games, science, everything! If you review chemistry every day and work problems every day, you'll find a rhythm that will make it easier to retain the material and learn new concepts. Don't wait until the weekend to review chemistry or allow several days to pass between study sessions. Don't assume class time is sufficient, because it isn't. Make time to practice chemistry outside of class.

Finally, it is obvious that students are introduced to formal science and science concepts after they joined schools. Hence, it would be easy for them to learn things starting from what they know previously. This is preferred especially in the case where names of elements and compounds with vast properties are chunked to one or more symbols of letters which remain mystery knowing the properties underlying. In this case students associating the concepts to ideas in their own language could be helpful.

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Appendix I

Observation check list

Instruction: Put "√" sign in the box of the table you are sure of observation

Hint: Y=yes, N=no and Ns = I`m not sure

Finally, put your comment for the one you selected as "N".

Concept Content	Focus of Observation	Y	N	NS	Comment
Elements	1. Can name symbols correctly				
	2. First letter capital				
	3. Second letter small				
	4. Write Correct symbol of the element (mono atomic elements)				
	5. Write correct symbol of the element (for di, poly, etc atoms or molecules)				

Mono atomic ions	6. Write correct symbol of ions(mono)				
	7. Write correct charges on the ion(mono)				
	8. Use valence from oxidation numbers				
	9. Write compound with appropriate atomic ratio				
Poly atomic ions	10. The symbols are correctly represented (all atoms capital)				
	11. Charges on ions are correctly indicated (+tve, -tve and stand for whole atoms)				
	12. Brackets are correctly used in compounds with metals of more than valance.				
	13. Do ions correctly named?				
	14. Do the ion formula match with its name correctly				
	15. Do students know **charge = valence**				

Others (if any):

Appendix II

Pre implementation of action

Age
____
Sex

Kamise College of Teachers Education Department of Natural Science

Investigative Questions for Chemical symbols and chemical formulas on introductory chemistry course –I (chem. 101)

I. Choose the correct answer for the following alternatives

_______1. Which one of the following represents the chemical formula of oxygen?
A. O B. O_3 C. O_2 D. O^{2-}

_______2. Which one of the following chemical formula represents the empirical formula of compound formed between magnesium and nitrogen?
A. MgN B. Mg_2N_3 C. Mg_3N_2 D. MgN_2

_______3. Which one of the following could be the chemical formula of Strontiumsulphate?
A. $SrSO_4$ B. $Sr(SO_4)_2$ C. Sr_2SO_4 D. SrS_2

_______4. Which one of the following alternatives represents the acid name of HCl?
A. Hydrogen chloride acid
B. Hydrochloric acid
C. Hydrogen acid
D. Hydrogen chlorine acid

_______5. What is the formula of compound derived from hydrogen and nitrate ion?
A. H_3N B. HNO_2 C. HNO_3 D. HN

_______6. Write the name of the following binary covalent compounds on the blank space provided:

a) SO_3 : ______________________________

b) N_2O_3 : ______________________________

_______7. Write the chemical symbol for the following elements on the blank space in the table:

NO	Element Name	Symbol of the element
1	Boron	
2	Barium	
3	Sodium	

Appendix III

Post implementation of action

Age ____________

Kamise College of Teachers Education Depa nce

Sex

Investigative Questions for Chemical syml mulas on introductory chemistry course –I (chem. 101)

I. Choose the correct answer for the following alternatives

_______8. Which one of the following could be the symbolic representation of oxygen?

A. O B. O_3 C. O_2 D. O^{2-}

_______9. Which one of the following alternatives indicates the ratio of strontium to iodine in the formula of Stontium iodide (SrI_2)?

A. 1:3 B. 2:3 C. 0:2 D. 1:2

_______10. Bariumhydroxide is an alkali earth metal base. Which one of the following could represent the chemical formula of bariumhydroxide?

A. BOH B. BaOH C. $Ba(OH)_2$ D. $BaOH_2$

_______11. Choose the alternatives that contain hydrobromic acid formula.

A. HBr B. H_3B C. BH_4 D. A and B are correct

_______12. Which one of the following stands for the chemical name of HNO_3?

A. Pernitrate acid

B. Nitric acid

C. Nitrouse acid

D. None

_______13. Write the chemical formula of the following binary covalent compounds on the blank space provided:

a) Sulfurdioxide : ________________________

b) Dinitrogenmonoxide:____________________

________14. Write the name of the following elements on the blank space in the table.

NO	Symbol of the element	Element Name
1	B	
2	Ba	
3	Na	

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